Nechmad ve-Na'im

נחמד ונעים

(1743)

by David Gans (דוד בן שלמה גנז), 1541–1613

Translation by Scott Weisman

Ars Astronomica

2026

"Nechmad ve-Na'im (נחמד ונעים)," published in 1743, is in the public domain. All translations, original additions, including illustrations, commentaries, and summaries, are copyright.

The source text was obtained from HebrewBooks.org and is available at https://hebrewbooks.org/20763.

Translation © 2026 Scott Weisman. All rights reserved.

Licensed under CC BY-NC-ND 4.0. Share with attribution; non-commercial; no derivatives.

Published by Ars Astronomica

Translator Version beta

Upright reason dictates that the recipients of the good, of whatever type and level of beneficence it may be, must show gratitude and blessing to the beneficent person in every way possible, commensurate with the value of the beneficence. And one who has benefited all the people of the world — for example, one who invented a new instrument for the good of the world, or a good book — it is fitting for every discerning person, out of the obligation of love of fellow beings, to at least purchase it, so that the man will profit and his heart will be encouraged thereby to invent yet more good instruments in the world. And similarly, all other wise-hearted people will likewise strive and exert themselves to invent good things and instruments needed for the repair of the world and its perfection.

And therefore, whoever says: "What do I need this new instrument for?" — he does not act well towards the world. For if not for the man who invented it, where would you be? And what would your city do? And more than this, if the man did not exert himself, what would the world do?

— R. Pinchas Eliyahu Hurwitz, *Sefer HaBrit HaShalem* (1797)

If you find this translation useful, consider supporting Ars Astronomica.

ArsAstronomica@protonmail.com

A note on the work

A Hebrew textbook of astronomy that presents the Ptolemaic model of the heavens for a Hebrew-reading audience, weaving the cutting-edge European science of its day together with the medieval Jewish cosmological tradition — its author having personally visited the Danish astronomer Tycho Brahe. Organized into twelve sections and 305 numbered paragraphs. First and only printed at Jessnitz in 1743, more than a century after it was written, it stands as a remarkable monument to Jewish engagement with the science of the age.

A note on the translation process

This translation was produced with the translation-pipeline. See the linked repository for details on the process.

This text is the product of a highly refined automated translation process. It has undergone only cursory human review and should not be treated as an authoritative or scholarly rendering. It is offered solely as a reference and reading aid — a way to make an otherwise inaccessible work approachable — and any passage of real consequence should be checked against the original source.

Acknowledgements

Translated with the assistance of Claude. The translator thanks the Anthropic team for making this work possible.

Nechmad ve-Na'im

Title Page

[Stamp, upper center of text block: "www.hebrewbooks.org" — modern digital-library mark, not part of the original print.]

Nechmad ve-Na'im ["Pleasant and Delightful"]

[A note beside the title, in small type: שנת תס"ח — "the year 5468" [= 1707/08 CE; 5468 − 3760 = 1708]. This appears to be a chronogram or dating note; flagged for verification, since the imprint at the foot gives a later printing date. [?]]

A composition of pleasant knowledge, in fine and becoming language, expounding clearly and lucidly the whole science of astronomy — the measurement and surveying of the stars, the sanctification of the New Moon, the knowledge of all the climes, and an understanding of the map of the world called the *Land-charte* [German: *Landkarte*, "map"] — together with the configurations of the constellations as they appear, and many wondrous matters that are heard and seen therein.

These things were composed and arranged by the perfect sage in the celestial sciences — the science of geometry, of measurement and astronomy, and of the [calculation of the] courses of the stars and the constellations — the divine philosopher, the great rabbi and teacher, the Gaon Rabbi **David Gans** (דוד גנז), author of the work *Tzemach David* and the work *Magen David* [?] [the text reads "מאור הקטן" and "פרוזדור" — see uncertain readings], of blessed and saintly memory, whose [manuscript] was found in his own handwriting, hidden away and concealed since the year 5373 [שנ"ג; reading as part of a fuller date — 5000 + 373 = 5373 AM = 1612/13 CE], unseen by any eye until this day.

It was brought to the printing house by the esteemed Rabbi **Mamon** [?] [ממון], son of our teacher Rabbi **Yoel** [?] (יואל), [grandson of] our teacher Rabbi **Yekutiel** (יקותיאל) of blessed memory, Av Beit Din of the holy community of Austerlitz [אויסטרליץ], a native of [the holy community of] Greater Glogau [גלוגא רבתי], to bring merit and honor to the public.

[In the oval cartouche at the foot:]

May he be remembered for good, and his memory for a blessing — the philosopher, the exalted [patron], the officer **[name]** [?] of the holy community of Halberstadt [הלברשטט], who in his time let his money flow freely to bear the full

cost of the printing and paid out his hand to defray the costs of the press. May the Lord repay his deed; may his recompense be perfect, his charity full and forgiveness [be his]; and may we together merit, speedily, the building [of the Temple], forever and ever.

Printed here in the holy community of **Jessnitz** [יעסניץ].

[At the press] of the worthy Rabbi **R. Yisrael bar Avraham** [ר' ישראל בר אברהם], of blessed memory.

[At the very foot, in Yiddish/German cursive type: "Gedruckt zu Jessnitz" or similar — partly legible imprint line. [?]]

Scanning-service notice

[This page is a modern (non-original) notice inserted by the digitizing library. It is bordered by a decorative dotted-and-floral frame.]

בס"ד [B"H — "With the help of Heaven"]

This sefer was scanned and processed by "Judaica Image — Otzrot HaTorah Ltd." Permission has been granted to "HebrewBooks Org," through Chaim Rozenberg, to upload it to the website and distribute it for individual use only.

And this is to be made known: No one has permission to print it or copy it, in any manner or by any means whatsoever, whether free of charge or for payment, whether to an individual or to the public.

A copy of this book and other books, as well as the integrated "Otzrot HaTorah" software (combined with "Otzar HaPoskim"), may be obtained from: Beit Sifriyat Morgenstern, 14 Rava Street, P.O.B. 3620, Ashdod. Telephone 08-866-0821, fax 08-866-5059.

[English text reproduced on the page:]

> OTZROT HATORAH — THE MORGENSTERN LIBRARY, 14 RAVAH STREET, P.O.B. 3620 ASDOD, ISRAEL. Email: kidosheypolin@bezeqint.net
>
> This sefer has been provided by Judaica Image OTZROT HATORAH for individual use only. All rights reserved by Judaica Image OTZROT HATORAH. Permission is only granted to Hebrew Books Org. No Permission is granted (in any form to distribute these books) to anyone else even if they don't sell them.

The Publisher's Apologia [התנצלות] — The Words of the Rabbi Who Brings [the Work] to Press

The Words of the Rabbi Who Brings [the Work] to Press

I behold the works of the Lord — He who set names upon the earth — for the sake of the knowledge of the righteousness of the Lord, whose names are [signs of His] dominion. He stretches out the north over empty space, and hangs the earth upon nothing [cf. Iyov 26:7]; who fashioned it and brought it into being. And who can teach as He does? The footsteps of the One who sees the darkness upon the east [?] — their goings and their comings, their growth and their setting — they are one. He who created us, the Necessary Existent, the Cause of all causes, without weariness and without fatigue [cf. Yeshayahu 40:28]. To conclude with praise to Him: of [my] thanks — my silence is fairer than speech; I am of stammering lips, I have set my hands over my mouth. Yet the discourse of a servant like me may find favor, though my words are scant. What roused me has brought me here, to ascend to the heavenly bodies, to declare the inheritance of the Maker of all in the Beginning, who wrought wonders.

For from time immemorial, the desire of my Living God has been with me — to satisfy my will. Parched and thirsting [I was] for many a day; for some days now have I dwelt with wisdom, and from it knowledge of light was opened to me [?]. I have come to know the courses of the stars in their orbits, their conjunctions and their crescents [?] [literally "moon," סהר], and the bringing-forth of light in their distances — to know how to interpret what befits us, the words of Moshe our teacher [משה רבינו]: what he built and what he stretched out, and what He set over us — in the laws of the sanctification of the New Moon. Full and abundant [are these matters], which the earlier authorities did not [adequately] expound; and I went over all sides of them, to understand from the books of instruction, to say, "Where is the seer?" — and there is none among us who knows how long [this will be] [cf. Tehillim 74:9].

And since the time the lands were shaken and the settled country thrown into turmoil — kings contending one with another — we made ourselves vessels of exile [cf. Yirmeyahu 46:19]; one was driven out [and] another consumed. From my birthplace, [from] the place of my death [?] [reading uncertain], to seek out a dwelling-place for myself in the land of my birth, I came to the city of **Breslau** [ברעסל = Breslau/Wrocław]. There I made my home; like a bird I lodged in clefts of the rock [cf. Yirmeyahu 49:16], until the Lord should look down and behold [cf. Eichah 3:50]. And it came to pass that the Lord pitied me; and I encountered,

before me, those who dwell in [the academy of] Tachkemoni [cf. II Shmuel 23:8], and they taught me and made me wise; and their wisdom raised me up. By the way of a ladder set up on the earth with its top reaching the heavens [cf. Bereshit 28:12], I came to receive [the teaching of] the heavens — matters [recorded] as they are written, and words [explained] item by item.

[Thus] I came into possession of [the book] *Nechmad ve-Na'im*, which the investigator composed — on the sciences of astronomy, together with all the relevant diagrams, [matters] worthy of being expounded; and the verification of the words of the sages, both of the sages of Israel and from the words of the gentile [?] sages who innovated in these matters. The whole is well explained in fine [language], in language pure, brilliant, and clear, etc. One who wishes to approach the inner court will find a satisfying answer there. And grace and favor [were] required of old from God [?] — the great rabbi, the author, the possessor of *Tzemach David*, a collar upon his neck like bracelets upon my hands. His words were hidden, [for] this was a hundred and thirty years [?] [reading uncertain] that no eye had beheld them, to see them in the city of **Prague** (פראג) — the capital. [Reading partly uncertain.]

Then I gave thanks [to God] and offered acknowledgment — that it might be remembered — and "there is a time to speak" [cf. Kohelet 3:7], for the honor of the author: that I merited to copy out his words, by his chapters, by his orders [i.e., its arrangement], and to bring [the work] up upon the altar of the press, to magnify the Torah and make it glorious [cf. Yeshayahu 42:21], so that the reader may run [therein] — his tongue's purity sweeter than honey to his palate, and his discourse [a delight] in the science of astronomy, and to make its face clear to them: students who seek [to be] perfect, who have not [trodden] the way of the ancient investigators [philosophers], the way of the ancient investigators.

The way of the ancient investigators [philosophers]: they hung upon themselves laws and dominions, by way of riddles and conjectures; and in the lowliness of our generation, in the smallness of our heart and the shortness of our understanding, [our] descent went down — until now have we labored, and it is yet far from us. We have not reached the center, nor opened up the [matter of] creation [?]; the gates of knowledge and vision are shut. [Aramaic: טעמא מאיתא — "the reasoning has come" [?] — reading uncertain]; and their tracks have gone crooked and astray. But behold, the windows of heaven are opened, and the surfaces and concavities are stretched out; [a table] is laid in order, in the vessel [?], showing the way to the stars [?] by his words — correct, clear, and restful; and all who wish to take [hold of] the [Name —]

The Apologia [התנצלות], continued

— the Name, and the portion of [those who] hasten [?]: by the grace of the Lord shall he be exalted [cf. Devarim 33:23]; and who created these [cf. Yeshayahu 40:26]? He shall gird up the loins [?]. To draw near to this work — a paved [highway] in beauty — to make known the entirety of the Lord, the great and the small alike, "as the waters cover the sea" [Yeshayahu 11:9]: the highway is near. In but a little time [the reader] will gain much, "how pleasant" [is it]; and these are the words of the later authorities. [Better] than gold and fine gold are these hidden treasures of delight, and "treasures concealed" [cf. Yeshayahu 45:3], a honeycomb [?] of [the words of] those who look out [?], pleasant plantings [cf. Yeshayahu 17:10]; [the words of the sages,] strong as oaks [?], [a face] turned to every quarter; "and a difference emerges between the lesson of one's youth" [Aramaic, cf. Avodah Zarah 19a: גירסא דינקותא — "the learning of one's childhood"]. There it is, [a place] to understand the words of the Maimonidean [i.e., Rambam], [to plant] with but a little study, and the One who forms its fruit [cf. Yeshayahu 27:6] will eat it.

[The publisher here turns to a specific talmudic discussion concerning the directions of the world and the position of the sun, raised in connection with the work. The passage is dense, lacunose, and in places severely degraded; the legible portions follow, with gaps flagged.]

By the way:... he will inherit an exalted possession... to explain the [single?] one [?] in its time... by an intermediate and true course, the righteous one is not diminished [?]... the righteous walk in them [cf. Hoshea 14:10], and a man [walks] in his ways... a way mighty and southward [?]... and they shall break through the way [eastward?] and northward, [cf. Yeshayahu 54:3] — east and north [?].

Now, then, I have begun [in] my standing, in the lowliness of my spirit, a broken [spirit], in [my] poverty and lowliness; and I am humbled [?]; the One who knows my low estate, and to whom my erring is not hidden, [knows that] I have not withheld [it] [?]. I have not done my [own] work; [rather] my hands have grasped my Master's [path] — to approach the chambers of the Torah [Aramaic: כתדרי אורייתא], in the halls and porticoes, the rooms and ante-chambers [Aramaic and Hebrew: אדרין, אכסדרין, היכלין]. Without finding [it on my own?], I saw fit [to render it] for my colleagues — that my words might shine forth: to settle the language of the Gemara [in] tractate **Tamid** [מסכת תמיד], "the ten things that Alexander of Macedon [אלכסנדרוס מוקדון, Alexander the Great] asked" [Talmud Tamid 31b–32a].

[He proceeds to discuss the talmudic exchange:] [Alexander] said to the elders of the Negev [South]: "From here to heaven, [is it] a near distance, or [to go] from east to west?" [Talmud Tamid 32a]. I wished to copy [here] the author's resolution of this aforementioned innovation, [the question being:] which is the greater [distance], etc. The elders' answer was that he had cut short [his question]; and the first difficulty that must be scrutinized is precisely why he asked of the elders of the Negev — and not, [for instance,] of [elders elsewhere].

[The discussion turns to the Negev as the south, and to whether the western and eastern extremities can be known:] For it is impossible to know the point of the western extremity by setting the [southern?] point... There is support for his words [in] what is explained in the first chapter [of the tractate], in the dispute between Rabbi Meir [ר"מ] and Rabbi Yehudah [ר"י] — that a person errs [as to the sun's position]; and the Gemara there resolves [it], that "in the fifth [hour] the sun is in the east and in the seventh in the west" [Talmud Pesachim 94a, paraphrased]. And Rashi's [comment] is to be consulted [עיין פירוש רש"י]. And this is the difficulty raised against Rashi's language: it would have been better to say "six hours" [שית שעי]... "six hours by the [horns of the] cup" [Aramaic: שית יומא בי קרנתא — cf. the talmudic idiom]; [Rashi] asks why it [reads] "six" too... between the midpoint of the south [and...] — for the matter is circular and curves around as far as the midpoint of the south, and likewise [for] the other quarters.

[He continues regarding determining the western point and the place of sunset:]... it is curved, going round, even [reaching only] as far as the midpoint — [so] it is impossible to discern the point of the [true] west; for the matter is spherical, going round and round... and it is not [possible] to know its place, etc.... from where the encompassing [circle reaches], up to the western extremity. And in truth it appears plainly [that] from this scrutiny we can know — according to the meaning of the verse "[the wind] goes toward the south and circles toward the north" [Kohelet 1:6], as is explained in [tractate] Eruvin; and [the case] of the sun at its [solstitial] tequfah... it rises in the south-eastern corner and sets in the south-western corner [at the winter solstice]; and then we can discern, by signs, to know the point of setting — the western extremity, [namely] the place of the sun's setting at the tequfah... [for] those who dwell in the north, [as do] we; but this matter cannot be discerned for the totality of the climes... discerned only for the dweller in the south, and not for the dwellers in the three other quarters; and this is [why] this question was [put] to the elders of the Negev — [namely,] the difference [between] the dweller in the south [and the] dweller in the north. And see the **fourth section** [שער הרביעי], **siman 136** [סי' קל"ו], in the *Sefer ha-Chilufim* [ספר החילופים, "Book of Differences"] [?], regarding this.

[On the verse and the author's text:]... [the verse] "[the sun] goes toward the south and circles toward the north" [Kohelet 1:6] — [as] from the Rabbi the author, of blessed memory; and his words [stand] above the words of [other commentators] [?], and are verified.

Behold, then, O reader: after you have heard... I took great pains in the transcribing of this book — for it came into my hands like raw, smudged matter [literally, "clay"] — to remove every distortion [introduced by] the earlier copyists [?], the errors of [other] copies, [matters] that were unrecognizable; and a triple-folded [thread is not quickly broken] [cf. Kohelet 4:12]... to add yet further [corrections]. And let my words be trusted: it is a small thing, perhaps; [whether] a matter [had a] superfluous expression or a missing one — in adding or omitting a thing — I am not at fault, since I did not do as I [pleased]; for surely with the hidden things [I dealt] in good faith, as **R. Shmuel ibn Tibbon** [ר' שמואל אבן תבון, Samuel ibn Tibbon] wrote in his introduction to [the translation of the] tractate Avot, [warning] of the matters copied [and] transmitted [imperfectly] — that an error of [a single] letter or word, or an excess or deficiency, or an error of [a copyist]... lest it be concealed and lost [?].

And as for my labor in repairing the diagrams [הציורים], where a great error had fallen — [I worked] by [the principle that] "writing is decisive" [נראה כתיבה?] [?] — [for the diagram] is determined [only] from its [proper] place. But for this, I would not have raised my hand to alter any matter, [be it] a thing or [even] half a thing, of the author's words. And where the author begins [a passage], at the close of his book, he writes [וז"ל, "and these are his words"], as follows, etc.; and I saw fit to set this forth first, for it is the source [from which the rest flows]:... is it not [recorded] for us, [in the] note... [partly illegible].

[He addresses how he handled the author's own polemic:] [Even where the author] pushes away with both hands [the views of] those sects [of philosophers] who confess and acknowledge [points] desirable in his words, and who learn through demonstrative proofs... that astronomy is — [as] he brings their words and demonstrations and their statements; and behold, "upon the head of all the ancients" [?]... that he might bring [their words] to the fore in the great hall; and every reader and investigator who has trouble [in some matter], let him not bring forth... "to bring out into the light the hidden treasure" [cf. Iyov 28:11]... in the destroyed [?]... and with the diligence of one... [partly illegible]

[At the foot, the printer's colophon/date line:]

[Aramaic/Hebrew colophon line, partly degraded: "...for the [edition]; and may we merit..."] — printed [or completed] in the year **תק"ג לפ"ק** [5503 by the minor reckoning = 1742/43 CE; 5000 + 503 = 5503 AM, 5503 − 3760 = 1743 CE]. [?] [final line partly degraded]

[Yiddish/German imprint line at the very foot: "Mintz [/ printed] to [in] Jessnitz, year [תק"ג] lpk" — partly legible. [?]]

Index to the Paragraphs (מפתחות לסימנים)

The chapters of the book *Nechmad ve-Na'im*, to find every matter and topic readily.

(This is the running table of contents listing each siman/paragraph with a one-line summary of its subject. The index runs right-column-first, then left column, on each page. The numbering is by Hebrew numeral; entries are rendered here in their printed sequence. Heavy ink bleed and compositor garbling throughout — many entries reconstructed from context and flagged where uncertain.)

Siman 1. In which it is explained that beneath the sphere of the Moon there are four elements, as will be clarified further above [i.e., below], with an elucidation of the matter.

The First Element

Siman 2. An elucidation of the Second Element: that it is the waters, which together with the Earth join to form a single sphere — **the Earth.**

Siman 3. That there is no objection [to be raised] regarding the reason why the body of the Earth rests at the center of the air without any [external] support.

Siman 4. An elucidation of the Third Element, which is the air, and it divides into three parts.

Siman 5. That the air divides into ten different aspects [?]; and the difference between *nefesh*, *ruach*, and *neshamah* [the three terms for "soul/spirit"].

Siman 6. An elucidation of the Fourth Element, which is fire, and the property by which these elements cling to one another [?].

Siman 7. That the moderns [later authorities] raise an objection regarding the element of fire [being] entirely above [?].

Siman 8. The names of the seven planets [lit. "wandering stars"], their order, and the time of their revolution.

Siman 9. That each one of the planets is set in a firmament of its own; and why they are called "wandering stars" (kochvei lechet) and "perplexed/erratic stars" (nevuchim) [?].

Siman 10. Concerning the eighth sphere, called the "starry sphere" or the sphere of the constellations (mazalot), and its motion.

Siman 11. That the seven planets, together with the stars of the constellation-sphere, all revolve by means of their spheres from west to east.

Siman 12. Concerning the ninth sphere, called the *galgal ha-yomi* [the diurnal sphere], whose motion is the reverse of [that of] the eight aforementioned spheres.

Siman 13. It will be explained how it is possible for a single body to have two distinct motions.

Siman 14. How one may conceive of a single body revolving while bearing other bodies within it [lit. "bodies within this body"].

Siman 15. In which a fitting resolution is given to the two perplexities [difficulties] cited.

Siman 16. A further resolution to the two aforementioned perplexities.

Siman 17. Why the ninth sphere is called the *galgal ha-yomi* [diurnal sphere], and that it has but a single motion.

Siman 18. Making known different and varying [?] views concerning the existence of the ninth sphere.

Siman 19. Some elucidation of the adjoining diagram.

Siman 20. That the bodies of the spheres are like the form of a sphere of glass [?], in which there are no empty gaps between them — they [are] transparent like crystal [?].

Siman 21. The "bolt" [axis-pin] and the diameter of the sphere, and the two poles (tziri) of the sphere, and the two poles of the world [universe].

Siman 22. That the northern pole, and likewise the southern, just mentioned, are by themselves the poles of the ninth sphere.

Siman 23. That there are also those who raise an objection regarding the ninth sphere [?], saying that one should rather call it the *galgal ha-yomi* or the supernal motion.

Siman 24. That every star makes, each day, a single circle about one of the poles [?]; and the time of their revolution.

Siman 25. Whether a star is fixed and its sphere rotating, or [whether it is] a fixed sphere and a rotating star.

Siman 26. To find in the eighth firmament the present [?] point [marked] for the northern pole that is in the ninth sphere.

Siman 27. The figure of the Great Bear and the Little Bear, and that the aforementioned pole [?] is not [the true pole] but only the southern [?] axis opposite the true pole.

Siman 28. The proof from observation that the heavens are spherical, and that there is no form like the spherical form.

Siman 29. That the circular shape is the strongest of all shapes [?].

Siman 30. That the sphere of the constellations divides into 360 parts [degrees] along the length of the world, and likewise along its breadth.

Siman 31. The nature of the spherical body [?] of the eighth sphere — [the body of] its [?] points [?].

Siman 32 and 33. [?] The circular [bodies?] of the glass-sphere [?], and its forms [?] just mentioned.

Siman 34. [entry continues — see next page]

Siman 34. An elucidation of the first circle, called the *meshvarah* [the equinoctial / celestial equator] [?].

Siman 35. An elucidation of the second circle, called the "horizon" (ofen) [?] of the [observer/astronomer], or the horizon, or the visible circle, or the *chug* [ring/circle] of the Earth.

Siman 36. An elucidation of the third circle, called the *chatzi ha-yom* [the midday/meridian circle] [?].

Siman 37. An elucidation of the fourth circle, called the circle of the constellations [the ecliptic].

Siman 38. An elucidation of the fifth circle, called the *ofen* [circle] of the four poles, or the station of the sphere.

Siman 39. An elucidation of the sixth circle, called the *ma'amad* [station], or the *kav ha-shaveh* [the equator / equinoctial line].

Siman 40. An elucidation of the seventh circle, called *amid* [the perpetual/ever-visible] — the summer [circle], or the Tropic of Cancer.

Siman 41. An elucidation of the eighth circle, called *amidit* [perpetual] — the winter [circle], or the Tropic of Capricorn.

Siman 42. An elucidation of the ninth circle, called the northern circle.

Siman 43. An elucidation of the tenth circle, called the southern circle.

Siman 44. An elucidation of three circular distances [arcs] [along] the straight line [?]: Cancer, and its northern [counterpart], from one to the other [?].

Siman 45. An elucidation of the [method] for correcting the half-day *ofen* [meridian/horizon circle] by another method, with its great benefit.

Siman 46. To carry out southern [?] measurements upon the sphere — one [?] measurement [of] the distance of the stars.

Siman 47. From which we find that the line of the horizon, and likewise the meridian [?] line, are shared by two persons distant from one another.

Siman 48. How far the Sun is from the equator toward the north [?]: by that much is its northern [declination] distant, or the elevation of the pole above the horizon.

Siman 49. That all the stars near the northern pole [are at?] [a distance of?] [?] degrees [?] from [our?] eyes [?].

Siman 50. To find [?] [?] the four [?] aspects [?] by observation [?].

Siman 51. [?] [?]: with one instrument [keli] called a *machzeh* [observation-instrument / quadrant], a square instrument [?], called in Latin a *koviadrant* [Latin: *quadrans*, "quadrant"].

Siman 52. To find the altitude of the Sun, and likewise the altitude of any [other] star — how far it is above the horizon.

Siman 53. To find how much the northern pole is elevated above [?] the horizon, and the place of the point [pole] [?] of the second firmament [?].

Siman 54. To find the moment and time of midnight on every night of the year.

Siman 55. Proofs and demonstrations that the Earth is spherical.

Siman 56. That many people have circumnavigated the whole sphere of the world and returned [back] to the place from which they had set out.

Siman 57. That the Earth stands at the very center of the sphere of the constellations, like a point within a circle.

Siman 58. That the sphere of the Earth, on account of its smallness, has no [perceptible] magnitude or measure that would be perceptible to the sight of our eyes against the vast breadth of the sphere of the constellations.

Siman 59. That every supernal celestial circle that is above [us] — they are all marked [reflected] [?] correspondingly upon the [lower] sphere of the Earth below.

Siman 60. That the sphere of the Earth, too, is divided into 360 degrees, both in longitude and in latitude; and from which point this reckoning begins.

Siman 61. Whence it is known to the ancients [?] that the length of the line of dry land [the inhabited longitude] is [equal to] half the line of the sphere of the Earth — [namely] 180 degrees.

Siman 62. How many *parsa'ot* [parasangs] there are below [around] the sphere of the Earth; and accordingly, that one degree against [one] of the 360 parts of the sphere [equals] [?] degrees [?] [a given number of parasangs].

Siman 63. The measure of the sphere of the Earth and its circumference [?]; and how many days a man would need to travel around the sphere.

Siman 64. A refutation of the view of the ancients [?] in what they said: [the rubric heading reads] "**that half the sphere of the Earth is uninhabited [?]**" [— see siman 65].

Siman 65. [entry continues — see next page]

Siman 65. Whether the Earth rests upon the water, or the water [rests] upon the Earth [?].

Siman 66. A refutation of the view of the ancients, who said that adjacent to the equator [the straight line] there is no habitation on account of the great heat, and adjacent to the northern circle there is no habitation [on account of the cold]; with an elucidation of the seven climes (akalimim).

Siman 67. The reason why the ancients divided the inhabited [region] into seven climes.

Siman 68. The configuration of the forms [?] of the whole sphere of the Earth, together with the inhabited [region], [organized] by all the aforementioned divisions [?].

Siman 69. [?] [Concerning] the diagrams (luchot) [?], and an elucidation of some [?] of these matters [?].

Siman 70. A clearer and more thorough depiction of the Earth, [showing] how it resembles a perfectly round sphere [?].

Siman 71. That the ancients [divided] the inhabited [region] into three parts [?] — even though [?] they are [?] [Asia, Africa(?), Europe(?)] [?].

Siman 72. [?] That Noah's sons [?] settled there [?], and divided its parts among them [?] [into] the three parts of the world [?].

Siman 73. [?] [Concerning] the discovery [?] of the New World (olam chadash), called [—] [the rubric reads:] "**[?] in the year 5000-something [?] from Creation**" [?]. [Numerical impossibles — see report.]

Siman 74. [?] [Concerning] the fifth part [?] of the sphere of the Earth as well [?]: it is [?] separate [?], and that part is called [?] [a place-name] [?].

Siman 75. [?] The [?] [region] removed from [?] [the aforementioned] [?].

Siman 76. [?] What [?] is [the part called] [a name] [?]; there Solomon, peace be upon him, sent his ships [?] [— cf. the fleet of Solomon, I Melachim 9–10].

Siman 77. An elucidation of the [?] part of the sphere of the world, called [?] [a name] [?].

Siman 78. The seventh [?] part of the sphere of the world, [called] the northern world [?].

Siman 79. That this southern part of the world is [?] [—] the greater part [?], larger than [all] the other parts of the world [?].

Siman 80. [?] What is reported [?] to the [investigators] [?] [concerning] the lands [?], the [?] places of the world, and its [?] boundaries [?].

Siman 81. How and whence it is known to the investigators the measure of the latitudes of the regions between [their] north and south, and the measure of their longitudes between east and west.

Siman 82. To find the longitudes of the regions, apart from [?] [matters of] degrees [?] [— i.e., by means other than degree-reckoning].

Siman 83. To find the longitudes of [overseas] islands [?] of the sea, apart from [?] [matters of] degrees, and apart from [?] [?].

Siman 84. To determine the longitudes of the regions according to the time [?] [of an eclipse] of the Moon, by means of [?] its true motions [?], and the [?] in calculating [via] the place [bayis?] of the diurnal sphere [?].

Siman 85. In which directions [?] the four winds [directions] of the world begin, and where [they end] [?].

Siman 86. That the ancients [?] [established?] the method that divides [?] the horizon (ha-ofen) into the twelve winds [directions of the compass].

Siman 87. That one [method] divides the *chug* [ring] of the Earth — a method by which there are [?] winds [directions] [?].

Siman 88. [?] A wind [direction] [established] by the order of the alphabet (alef-bet) [?] [as] the ancients [arranged?]; many [places] of the inhabited [region], and also part of the islands of the seas — how many of them [there are] in longitude and breadth [?].

Siman 89. [Concerning] the settled [region] [?], in accordance with what Chazal [our Sages of blessed memory] said: that "Jerusalem is the center [navel] of the world" [— cf. Yechezkel 38:12; Tanchuma Kedoshim].

Siman 90. [Concerning] the inhabited [region] [?], in accordance with what our Sages of blessed memory said, that the Land of Israel (Eretz Yisrael) is higher than all [other] lands [— cf. Talmud Kiddushin 69a, Zevachim 54b].

Siman 91. Why the reason that the later [authorities] gave for what the earlier [authorities] received [as a tradition] — [that one begins?] [reckoning?] at the start of the [?] degrees [?] of the sphere of the world [?].

Siman 92. An elucidation of the [divisions of] the times [calendar], that they are, in general terms, five — and at their head will be explained the [definition of the] period of a year and of a [new] month.

Siman 93. That there is no fixed [solar] [new] month at all, and the Moon [the lunar reckoning] has no [fixed] year at all.

Siman 94. Concerning the times of the days that are "natural" — that they are [reckoned] from moment to moment [?].

Siman 95. Concerning the times of the hours of the day, and upon what [— cf. "what is the name of the L-rd?"] [?] they are natural [?].

Siman 96. The reason why the measure of the parts [hours] of the natural day [is divided] into 24 hours.

Siman 97. The reason for [there being] the seven days of the week — seven days.

Siman 98. A table for the dominion [rulership] of each of the seven planets over each hour of all the days of the week.

Siman 99. [Concerning] the dominion-time of each of the planets, [why] the "perplexed/erratic" [star, i.e., Mercury?] [?] rules not only the first hour of the day [?] but only [a given] day rules [?].

Siman 100. The reckoning of "straight" [equal] hours, from the natural day [reckoned] from these equal [hours] [?].

Siman 101. The reckoning of the "temporal" hours (sha'ot zemaniyot), which are [also] called *zemanim* — they are always twelve hours in the daytime and twelve hours at night.

Siman 102. Upon what basis [sod, "secret/principle"] were the [calculations of the] temporal hours founded.

Siman 103. That the reckoning of the *ibbur* [intercalation], the *tekufot* [seasons/solstices], and the *moladot* [lunar conjunctions] were founded upon the temporal hours.

Siman 104. The cause of the night [being] night, and the shadow of the Earth [?].

Siman 105. The meaning of the word "day" (yom) — the distinction between the "workday" (yom melachti, the daylight portion) and the "natural day"; and from which time [reckoning?] [?].

Siman 106. That the time of the natural day exceeds [?] [?] the measure of the [?] diurnal [period] [?].

Siman 107. Concerning the names of the constellations and their figures [forms], and why they were called by the [particular] names that are known.

Siman 108. For what reason the sages of astronomy assigned to the circle of the constellations [the ecliptic] the aforementioned planet [?].

Siman 109. That the ancients agreed, with a good and proper reasoning, to place the constellation Aries (Taleh) at the head [beginning] of the constellations.

Siman 110. [That] the figures [forms] that are in the sphere of the constellations are reckoned by [in] two aspects [respects].

Siman 111. That the figures of the twelve constellations that are in the eighth sphere are not [really arranged] in order, this one against [next to] that one [?], as their names [imply], nor [?] [are they actually shaped] [?].

Siman 112. That all the stars of the firmament are divided among the twelve constellations.

Siman 113. That the divisions of the sphere of the constellations are reckoned by [in] seven respects.

Siman 114. The six constellations that are above [the horizon] from [?] [the left side] [?] — [the *ofen* / horizon] [?]: not found [?] like them [?] to the east, three to the east and three to the west [?] only [?] to those who dwell under the equator (kav ha-shaveh).

Siman 115. That every constellation, in its rising upon the horizon, takes [?] two hours [?].

Siman 116. That on every [equinoctial] day [there] rise six constellations, and likewise at night [?] — whether the day be [long?] [or short], whether the night be long or short [?].

Siman 117. An elucidation of the "paces" [rising-arcs] (mitz'adei) of the constellations: there is a constellation that rises over a great [arc?] [?], and a constellation that rises [in?] [a short arc] [?] [—] [the time?] it rises [?].

Siman 118. An elucidation of [the fact] that the four places [points] of the constellations [the cardinal points] [correspond] with the [four corresponding] divisions of the equator (kav ha-yashar).

Siman 119. The rules of "precedence and recession" [advance and retreat] (ha-kedimah ve-ha-achor), by the order of the four quarters of the sphere.

Siman 120. A small table [showing] how many degrees and minutes, and also how many hours and minutes, the rising of each constellation [takes], by [the measure of] the [straight?] equator [?].

Siman 121. The rules of "precedence" and "recession" in the rising-arcs (mitz'adei) of the constellations, for those who dwell under the equator [?].

Siman 122. A table [of] all the risings and settings of the constellations, and their ascensions and descensions [?] for us, the inhabitants of the city of Prague (Prag).

Siman 123. That for some people, on every [equinoctial?] day, of the twelve constellations [set?] on the horizon, eleven constellations are seen [?] — then half of them are above the horizon [?] and half [?] below the horizon [?].

Siman 124. That when the aforementioned axis of the constellations inclines [?], [over] the heads of the people who dwell under the northern circle [pole], as above [?].

Siman 125. That we find three constellations [?] [?] [?] [?] [—] and three [?] to the horizon [for] dwellers [?], and six [?] [seas?] [?] their opposites [?].

Siman 126. That four constellations remain [?] [?] above [?] [—] they do not [set] [?] below their horizon, and for some of them [?] six [?] degrees of [?] [their?] horizon [?] [—] never below [?].

Siman 127. The reckoning of the rising of the constellation upon their horizon — [the entry continues].

End of batch coverage (siman 127 continues into the next batch).

This batch is a continuation of the **Index to the Simanim** *(מפתחות לסימנים) — the sequential list of all paragraphs (simanim) with their one-line summaries. Each page is set in two columns; the entries run down the right-hand column first, then down the left-hand column. This batch covers simanim 128 through 255 (the list continues beyond this batch).*

(Right column first, then left column.)

Siman 127 — On the rising of the twelve constellations during the year, and that this does not [vary] with the revolution of the sphere of the constellations.

Siman 128 — The rising-arcs (mitz'adei) of the aforementioned constellations are not equal throughout the year for all the inhabitants of [the same] clime.

Siman 129 — On the revolution (mazon [recte: mezon/swing]) of the sphere of the constellations.

Siman 130 — Why we cannot tell that the stars [positions] have shifted over the course of several years.

Siman 131 — On the host of the sixth [sphere].

Siman 132 — On the matter of the sun's departure from the line of the equator (kav ha-shaveh), called in their tongue [Latin] *declination* [דיק״לי = *declinatio*], and the encircling [path of] circles that the sun makes [several] times in the year.

Siman 133 — We explain and make known that most of the orbits (gelilei) of the sun are shared in common (these correspond to one another).

Siman 134 — In explaining that the orbits of the sun are not perfect circles.

Siman 135 — We explain that the shared orbits of the sun are not [the same] shape by exact reckoning, only at their starting point.

Siman 136 — In explaining that the aforementioned orbits of the sun have no [equal] approach and recession; this is equal to that and like it.

Siman 137 — *(entry runs over; see siman 138 below — the listing here reads "siman 137"; content abbreviated)* [?]

Siman 138 — In explaining that for those who dwell beneath the line of the equator, the measure of the day and the measure of the night are always equal.

Siman 139 — In explaining that on the two [equinoctial] solstice-points of the year, day and night are also equal for most of the rest of the inhabitants of the world.

Siman 140 — In explaining that the daytime-measure of the equinox of Nisan exceeds the daytime-measure of the equinox of Tishrei.

Siman 141 — We make known that the natural days are not equal in their measure.

Siman 142 — We make known the cause of the lengthening and shortening of the days for those who dwell in the north throughout all the days of the year. Further on this [siman 142]: According to what was stated above [HaNa"l], the days of Tevet — their daytime is not equal to their nighttime, and likewise the reverse; and so the daytime of Tevet is never equal to its nighttime.

Siman 143 — In explaining [the case] of some people for whom the measure of the daytime will be 24 hours.

Siman 144 — I make known that in some lands the measure of the day is one month or two months or more, and likewise the measure of the night.

Siman 145 — That in some places the measure of the daytime is several months, and likewise the measure of the night.

Siman 146 — That those who dwell beneath the northern pole have a daytime of [several] months, and a nighttime of [several] months.

Siman 147 — To inquire and to know, by means of an instrument, the length of the days and their shortness for all the days of the year, in every place and at every time.

Siman 148 — The differences found among the inhabitants [of different places] at the beginning of each day, and the moments and times of midday — a general rule.

Siman 149 — The law of precedence and recession (ha-kedimah ve-ha-achor) for those who dwell beneath the line of the equator (kav ha-yashar).

Siman 150 — For those who share the same latitude (rochav), the measure of daytime is equal for all of them.

Siman 151 — Places that share the same longitude (orech) — for all of them midday is at the same time, by [the same] measure; nor [does it vary] for this one and that one, day and night, except on the days of the equinoxes of Nisan and Tishrei.

Siman 152 — Places that do not share — that differ in latitude — concerning them there are several laws and judgments, this one above that one.

Siman 153 — That there are some western lands in which the sun rises later, [though] the sun had risen earlier for the eastern [ones].

Siman 154 — That the sages have agreed to relate the times [...] according to the times of midday and midnight.

Siman 155 — The reason and precision in knowing the aforementioned differences.

Siman 156 — The variation of summer and winter, and that for those who dwell beneath the line of the equator (kav ha-yashar) there are two summers and two winters.

Siman 157 — For those who dwell at the line of the equator, there are also, on account of the equator, reversals [of seasons]; and rules [governing this].

Siman 158 — The quality of the sun, summer and winter, for those who dwell beneath [the circle of] Cancer and beyond it [northward]. [סרטן = Cancer]

Siman 159 — *(entry continues onto the next page)*

(Right column first, then left column.)

Siman 159 — Why at midday the daytime [heat] is greater in the west, and why in the west it is hotter than in the morning, and why it is colder at the time of summer than at the time of winter. [?]

Siman 160 — That the cause of day and night, summer and winter, and the rest of the seasons of the year — all of them — is also bound up in [matters of] free will and necessity [in the divine governance]. [?]

Siman 161 — From which place on the earth each day begins to be reckoned [as beginning] in itself.

Siman 162 — He who circumnavigates the globe of the earth sometimes loses one of the days of the week, and sometimes gains one day.

Siman 163 — An explanation of what is found with respect to the planet [Mercury], and likewise concerning the rest of the wandering stars (planets), [their] variations and many matters that vary.

Siman 164 — The definition of the solar year, and how long is its duration.

Siman 165 — To know how much the sun travels in a single day, relative to the horizon of the constellations.

Siman 166 — That [if] we reckon the time of the year by the revolution of the sphere of the fixed constellations and not by the constellations of the figured [zodiacal signs] — the measure of the years differs, one from another.

Siman 167 — That the sun's sphere has two intertwined spheres [encircling] the globe of the earth.

Siman 168 — From the two aforementioned solar spheres, which are intertwined, [it follows that there are] three [?] spheres.

Siman 169 — The form and configuration of the fourth firmament, which is the sphere of the sun; how its thickness is divided into three distinct [parts].

Siman 170 — That the middle [sphere] is the white [eccentric circle]; the sun itself — both of them touch the sphere of Mars.

Siman 171 — An explanation of the path of the sun, which revolves [in a manner] not deficient nor excessive for the world.

Siman 172 — The five circular lines (kavim) found in the overall depiction of the aforementioned solar sphere, and the center [of the] eccentric (yotzei) [circle], a circle around the center of the world (markaz olam).

Siman 173 — How great is the measure of the thickness of the [eccentric] sphere.

Siman 174 — The reason why the three solar spheres differ, each one from its companion. [?]

Siman 175 — An explanation of the saying of [the Sages], of blessed memory [za"l], that the sun and the moon are in the second firmament.

Siman 176 — That the three aforementioned spheres [each] have [...]; each of them has its own center.

Siman 177 — That the middle sphere is the [true] solar sphere; the eccentric center, and by it alone, the measure of the year is reckoned.

Siman 178 — That the sun draws near and draws away [...] from the earth.

Siman 179 — That the encompassing sphere (galgal ha-domeh) [the parecliptic] in its entirety consists of two spheres, the black ones [?] in figure, according to the view of [...], and it has a motion of its own, and it carries the sun's apogee (govah) at [a certain] point [...].

Siman 180 — That the center of the eccentric sphere (galgal ha-yotzei) is itself also displaced from its place.

Siman 181 — That the sun's sphere has four motions.

Siman 182 — Which is the position of the mean sun in the constellations, and which is the true position; and the difference (chiluf) [equation] between them at the [solstice/apsidal] points.

Siman 183 — That sometimes the mean motion (mahalach emtza'i) precedes the true [motion], and sometimes it lags behind.

Siman 184 — That the sun revolves with [an] equal motion in two times [...] differing [...], or in two times [...] equal [as] two differing motions.

Siman 185 — That the four equinoxes of the year, by the true motion of the sun, are not equal one to another.

Siman 186 — That, for four reasons that are mentioned, the natural days also differ in their measure.

Siman 187 — A great explanation of the difference between the time of the true equinox and the mean equinox.

Siman 188 — An explanation of the sphere of the diameter (galgal yarid [recte: galgal qoter?]) and the like of its spheres. [?]

Siman 189 — That the carrying-sphere (galgal ha-nosei) of the moon [...] and the sphere [inclines/leans] toward the north side and the south side.

Siman 190 — *(entry continues; concerns the inclination [netiyah] between the inclined sphere and the inclination of the sphere of the constellations)* — On the inclination between the inclination of the sphere [...] and the inclined sphere of the constellations. [?]

Siman 191 — The head [ascending node, rosh] [...]; the end (ketzeh) [...].

Siman 192 — *(continues on next page)*

(Right column first, then left column.)

Siman 192 — That in [whatever] place the moon's positions in the constellations are reckoned by longitude (orech), [so too is] the firmament also [reckoned] by the latitude (rochav) of the firmament.

Siman 193 — How much is the measure of the inclination of the moon's carrying-sphere (ha-nosei) from the encompassing sphere (galgal ha-domeh).

Siman 194 — An explanation of the matter of the epicyclic sphere (galgal ha-hakafah) which is [proper] to the moon and to the other five wandering stars (planets). [נבוכה = wandering stars/planets]

Siman 195 — That the epicyclic sphere (galgal hakafah), and likewise the [planets'] wandering stars, [move] within a sphere above it and below it.

Siman 196 — That the moon's motion in its epicyclic sphere (galgal hakafah) is the reverse of its motion in the rest of the epicyclic spheres, and [therefore] the moon's motion is called [a motion] of difference (chiluf). [?]

Siman 197 — From the orbits (gelilei) of the moon and the orbits of the other wandering stars (planets). [?]

Siman 198 — On the difference found in the moon between its mean position and its true position in the constellations.

Siman 199 — The difference between the mean constellation [position] and the true constellation [position].

Siman 200 — That all the differences (chilufim) found in the sun [arise] from the cause of the eccentric sphere (galgal ha-yotzei markaz); all of those found in the moon [arise] from the cause of the epicyclic sphere (galgal hakafah).

Siman 201 — That the moon's spheres have [several] motions.

Siman 202 — From the [calendrical] cycles (tekufot) and conjunctions (moladot) that [the Sages] of blessed memory reckoned for us, according to the mean motion (mahalach emtza'i). [chazal ze"l]

Siman 203 — On the time of the moon's revolution in its sphere and the time of [its] revolution [...]; the [time of revolution of] its epicyclic sphere (galgal hakafah), and the time [of the moon's circuit — i.e., the lunar month].

Siman 204 — The reason for the difference between the time of the moon's revolution in its sphere and the time of the [lunar] month.

Siman 205 — That the moon revolves in two times [as] two differing motions [...].

Siman 206 — That from the causes of the moon's revolution around the world, the moon itself makes [its] circular path a strange and most confused orbit (maslul).

Siman 207 — That the moon traces circles [that are] many distinct [...] entangled [...] exceedingly [...], most of which have no number [are innumerable].

Siman 208 — The difference that arises from [the line] going forth from the center of the earth, and the line [of sight of] the eye of the observer standing upon the surface of the globe of the earth [i.e., the difference of parallax].

Siman 209 — The definition of the conjunction (molad) [new moon], its quality, its time, and the many causes of the variations found in the moon [in] all the days of the [lunar] month.

Siman 210 — The shapes of the moon's waxing and waning [the phases], its magnitude and its smallness, and how long it remains visible all night above the horizon.

Siman 211 — That the hours we have reckoned in the [foregoing] are precisely [in accord] with the reckoning of the temporal hours (sha'ot zemaniyot), and the reasons for fixing these hours.

Siman 212 — On the time of the moon's concealment (setirah) [conjunction] each month, and the recession and precedence (achor ve-kedimah) of its visibility.

Siman 213 — That the measure of the lunar month, which is 29 [days,] 12 [hours,] 793 [chalakim] [כ״ט י״ב תשצ״ג], does not become known to us [empirically]. [Standard halachic lunation: 29d 12h 793 chalakim]

Siman 214 — Concerning which place upon the earth the reckonings of conjunctions (moladot) and cycles (tekufot) were arranged.

Siman 215 — What the moon is [its phase] when it is seen newly [renewed] above the horizon, for the world, by [a certain] measure [of one day]. [?]

Siman 216 — That no [other] star makes a revolution [back to its starting point] in the time of the revolution of the diurnal sphere (galgal ha-yomi). [?]

Siman 217 — To see the [proper] motion (tenu'ah retzonit) [voluntary/own motion] in all seven wandering stars (planets). [נבוכה = planets]

Siman 218 — That there is not found [any] sphere [with a] reverse motion, nor an epicyclic sphere (galgal hakafah) eccentric (yotzei markaz). [?]

Siman 219 — How great is the moon's altitude (govah) above the center of the earth, and the difference between its near[est] and its far[thest] [distances].

Siman 220 — On eclipse (likui), darkening (kadrut), and [...] [?].

Siman 221 — The shadow (tzel) of the earth, which goes on and diminishes; how it is needed for the entering [of the moon into it], so that the moon is eclipsed (yilkeh).

Siman 222 — The shapes of the carrying-circle (agul ha-nosei) of the moon, which [show] that every eclipse (likui) is [either] at its head (rosh) or at the portion of its tail (zanav). [ascending/descending node]

Siman 223 — Why the moon is not eclipsed every month when its center is opposite the center of the sun.

Siman 224 — That sometimes a darkening (kadrut) [eclipse] is found in the moon only in part of its body, and at times the moon escapes [emerges] from the eclipse [...].

(Right column first, then left column.)

Siman 224 *(continued)* — [...] from the eclipse entirely.

Siman 225 — That the early astronomers [ha-kadmonim] divided the times of the moon's eclipse (likut) into five times [phases].

Siman 226 — The sources of [solar] eclipses are many, and there are several differences between [the eclipse of the sun] and the eclipse of the moon (bein kidrutah... kidrut ha-yareach).

Siman 227 — That the cause of the eclipse of the sun is that the moon stands before the sun and cuts off its light. [The moon is what stands before the sun]

Siman 228 — How the moon, in its smallness, prevents the sight of one greater than it more than sixfold. [?]

Siman 229 — Why an eclipse (kadrut) does not occur to the moon every month.

Siman 230 — That a solar eclipse (likui) appears wholly in one place, and in [another] place only partially [obscured from it], and in a third place not at all.

Siman 231 — How long a time is found between [one] eclipse and [another] eclipse, and how many eclipses are possible in a single year.

Siman 232 — The reason that the wandering stars (planets) [ha-nevucha] sometimes move forward, sometimes backward, and sometimes stand still [stationary].

Siman 233 — The reason why we see a star standing still in its place, not wandering (lalechet) here and there.

Siman 234 — That all the stars are hidden beneath the light of the sun, and the manner of their setting (bo'am) [going in] and their rising (tze'tam) [coming out] from beneath its light.

Siman 235 — Why the planet Venus (Nogah) sometimes appears before the sun, sometimes after it, and sometimes is not seen at all. [נוגה = Venus]

Siman 236 — That the planet Mercury (Kochav) [also] behaves like the planet Venus (Nogah), and one law and ruling [applies] to both of them. [כוכב = Mercury]

Siman 237 — How the three upper wandering stars (planets) — which are *Sha-tza-mem* [שצ״ם = Shabtai (Saturn), Tzedek (Jupiter), Ma'adim (Mars)] — are [positioned] beneath the light of the sun.

Siman 238 — Whether the light of the planets [ha-nevucha] is intrinsic to them (mi-tzad atzmam) or acquired from the light of the sun.

Siman 239 — How great is the magnitude of the bodily thickness of each one of the seven wandering stars (planets), in proportion to the body of the globe of the earth.

Siman 240 — The table of the times in which the carrying-sphere (galgal ha-nosei), and also the epicyclic sphere (galgal hakafah), of all seven wandering stars (planets) revolve around the globe of the world.

Siman 241 — How great is the inclination (netiyah) of the seven wandering stars (planets) from opposite the middle line of the constellations toward the breadth of the firmament, to the north side and to the south side.

Siman 242 — On the first of these instruments — the instrument called the quadrant (keli ha-rova) [Latin: *quadrans*] — for measuring the altitude (govah) of the [polar] axis (tzir) and the altitude of the stars.

Siman 243 — That the quadrant (keli ha-rova) is based upon the "examinations" (bechinot), and an explanation of the first examination (bechinah rishonah).

Siman 244 — How the measuring with the quadrant (keli ha-rova) is done.

Siman 245 — That everything found in the line of sight (kav ha-nitzotz) [sighting-line] — even though one is far greater than the other, even by a thousand parasangs — is reckoned to both of them as [the same] one altitude (govah). [?]

Siman 246 — The quality of the making and the setting-right (tikkun) of the quadrant (keli ha-rova), according to the second examination (bechinah shenit).

Siman 247 — The shapes and forms of the quadrant (keli ha-rova) [drawn] by hand, its rules and its laws.

Siman 248 — To find the altitude (govah) of the sun, how high it is above the horizon.

Siman 249 — That the inquiries [methods] for [finding] the altitude (govah) of the stars are of one [kind, comprising] three aspects.

Siman 250 — To find how much the northern axis (tzir ha-tzefoni) [celestial pole] is elevated above the horizon, in every place and at every time.

Siman 251 — Another way of finding the altitude (govah) of the axis (tzir) in any place, more swift and easy.

Siman 252 — To find the altitude (govah) of the northern axis (tzir ha-tzefoni) by day itself, by means of the sun's motion, and on the days of the equinox of Nisan and Tishrei, in every place between [...] on dry land. [?]

Siman 253 — To find the altitude (govah) of the axis (tzir) in any place, by means of the sun's motion, on every single day of all the days of the year.

Siman 254 — That the setting-right (tikkun) of every viewing-instrument (keli machazeh) [observing instrument], in every place, must be according to the altitude (govah) of the axis (tzir) there.

Siman 255 — To make, upon the face (daf) of the instrument, three bows (keshatot) [arcs]; [their] heads (rashei) [continues on next page] [?]

[Index to the Simanim continues beyond this batch.]

Index to the Simanim (continued)

[The index resumes mid-entry; the right-hand column of this page continues the listing of simanim that began in the previous batch.]

- **Siman [?]:** Heads of [the constellations?] Aries (טלה), Libra (מאזנים), and Capricorn (גדי); and one for Cancer (סרטן), and how much the sun's altitude amounts to in each one of them.
- **Siman 256 (רנ״ו):** How to construct, on this quadrant instrument, the line of half the day [the meridian, "midday line"].

- **Siman 257 (רנ״ז):** How to make, with a compass, a circle or an arc that will pass through any three given points, however they may be positioned — provided only that the three do not all lie on a single straight line.
- **Siman 258 (רנ״ח):** To determine the sun's altitude at the head of each zodiacal sign — that is, in [each of] the twelve signs of the firmament.
- **Siman 259 (רנ״ט):** The nature of the quartering of the arc of the zodiacal signs, and [the use of] this quadrant instrument.
- **Siman 260 (ר״ס):** Finding the sun's position among the zodiacal signs by means of the quadrant instrument, at any time throughout the days of the year.
- **Siman 261 (רס״א):** To find, throughout all the days of the year, how far the sun has receded — or [how far] any other [body] is — from the upright line [the meridian or the line of true east].
- **Siman 262 (רס״ב):** To determine the distance of any star from the zenith point (נקודת קדקדך).
- **Siman 263 (רס״ג):** To determine, when the sun enters the head of any sign, how great the altitude of each sign above the horizon is at each and every hour of that day.
- **Siman 264 (רס״ד):** Computing the daytime hours with the spherical instrument (כלי הכדור), and that their beginning is reckoned from the [hours] of the day.
- **Siman 265 (רס״ה):** Correcting the arcs of the hours on the quadrant instrument.
- **Siman 266 (רס״ו):** That not every hour-arc is always drawn according to all the arc-heads mentioned [above].
- **Siman 267 (רס״ז):** To determine the time of the sun's rising and its setting, and the measures of the lengths of the days and the nights throughout the days of the year.
- **Siman 268 (רס״ח):** To determine, on any given day, whether the time is before midday or after midday.
- **Siman 269 (רס״ט):** To determine, at any given time, how many hours of the day have already passed.

- **Siman 270 (ר״ע):** To determine the altitude of the [celestial] axis [pole] above the horizon of the place where the quadrant instrument is made.
- **Siman 271 (רע״א):** Herein is explained the matter of an upright star [a star at the zenith].
- **Siman 272 (רע״ב):** [Heading partly illegible] [?] — [content uncertain].
- **Siman 273 (רע״ג):** Herein is explained the construction of the sighting instrument (כלי מחזה).
- **Siman 274 (רע״ד):** Herein is explained the method of measuring the breadth of a surface (רוחב השטח) that lies on level ground (בארץ המישור).
- **Siman 275 (רע״ה):** Herein is explained how to lengthen the upright line (קו הניצב) so as to refine the measurement.
- **Siman 276 (רע״ו):** Herein is explained the method of measuring the height and elevation (רום וגובה) of the zodiacal signs or of other things.
- **Siman 277 (רע״ז):** Herein is explained how the pointer (המורה, the sighting-pointer) cuts off the upper axis of the instrument.
- **Siman 278 (רע״ח):** Herein is explained how one measures the height and elevation of a large tower when one cannot approach near to the tower, and also cannot see its base or its foundation.
- **Siman 279 (רע״ט):** Herein is explained the manner of measuring [the height of] a mountain down to a valley.
- **Siman 280 (פ׳ [recte ר״פ?]):** Herein are explained the various kinds of measurement from a mountain down to a valley. *[The printed numeral here reads "80 = פ׳; in sequence it should be 280 = ר״פ. Flagged as a probable compositor omission of the resh.]*
- **Siman 281 (רפ״א):** Herein is explained measurement [done] when you cannot walk behind [the object], as when measuring from a tower down to a valley.
- **Siman 282 (רפ״ב):** Herein are explained the refinements of measurement by means of the sighting instruments (כלי מחזים) when they [the objects] are lying down [horizontal], together with the great usefulness of these [methods].

- **Siman 283 (רפ״ג):** Herein is explained how to measure by means of [several] positions [stations] in this manner — likewise [for] height and elevation.
- **Siman 284 (רפ״ד):** Herein is explained how to determine the distance between two points [marking] the tops of two towers, even when you cannot [physically] reach the tops of those points.
- **Siman 285 (רפ״ה):** Herein is explained how to determine the height of a tower or [other object] very easily by means of its shadow (צילו).
- **Siman 286 (רפ״ו):** Herein is explained the knowledge of [the] height of a tower or [the like] by means of [a method] other than measuring its shadow (its shadow's length).
- **Siman 287 (רפ״ז):** Light and simple measurements of altitude for the builder, requiring no [knowledge] whatsoever of the science of mensuration (חכמת המדות).
- **Siman 288 (רפ״ח):** To find the height of a tower or a tree, or [the height of] another structure, by means of a spear or staff (חנית או מטה), without any instrument.
- **Siman 289 (רפ״ט):** A discourse [ma'amar] on the matter of comets — the stars called *kochvei shavit* (כוכבי שביט) — within [a study] of the comets (כוכבי דשביט [Aramaic-flavored: "of the comet"]).
- **Siman 290 (ר״צ):** Where, in the firmament, the location of the comets is.
- **Siman 291 (רצ״א):** The cause from which a comet comes and is generated [born], [namely] from that which is suddenly revealed and, little by little, ceases and grows faint, until its cause too is healed [dissipated]; and the nature of thunder and lightning will be explained to you incidentally (אגב גררא).
- **Siman 292 (רצ״ב):** [Herein] are [explained] the courses [motions] of the comets.
- **Siman 293 (רצ״ג):** How long a comet stands [remains] and is seen.
- **Siman 294 (רצ״ד):** From what region of the firmament the comets are accustomed to stand [appear].

- **Siman 295 (רצ״ה):** That in most of the years the comets are seen [?]. *[Right-hand-column entries 290–295 partly degraded; readings reconstructed from context.]*
- **Siman 286 (רפ״ו) [duplicate numeral — see note]:** Herein is explained the knowledge of the height of a tower or [the like] by means of [something] other than its shadow, [or] by means of the measure of your own [shadow's length]. *[This entry repeats the numeral רפ״ו already given above on the prior column; it appears to be a compositor doubling. The content overlaps siman 286 above; recorded as printed and flagged.]*
- **Siman 287 (רפ״ז):** Light and simple measurements of altitude for the builder, [such] that he requires no [knowledge] whatsoever of the science of mensuration.
- **Siman 288 (רפ״ח):** To find the height of a tower, a tree, or another structure, by means of a spear or staff, without any instrument.
- **Siman 289 (רפ״ט):** [A discourse] on the matter of the comets called "tailed stars" (כוכבי הזנבות, "stars of the tails") — comets (כוכבי דשביט).
- **Siman 290 (ר״צ):** Where in the firmament the comets are located.
- **Siman 291 (רצ״א):** The cause from which a comet comes and whence it is born; how a comet is suddenly revealed from [the matter] that is disclosed, then little by little weakens and dissolves, its cause [also] healing [dissipating]; and the nature of thunder and lightning will be explained to you incidentally.
- **Siman 292 (רצ״ב):** [On] the courses [orbital paths] of the comets.
- **Siman 293 (רצ״ג):** How long a comet stands and is seen.
- **Siman 294 (רצ״ד):** In what region of the firmament the comets are accustomed to stand.
- **Siman 295 (רצ״ה):** That in most years two comets [or "two at a time"] are seen [?]. *[Reading of the count uncertain.]*
- **Siman 296 (רצ״ו):** Whether it is possible that the astronomers [the *tochniyim*] knew and discerned [the appearance of] comets before [they] came [appeared].

- **Siman 297 (רצ״ז):** Whether eclipses of the luminaries (לקוי המאורות) herald or portend evil decrees.
- **Siman 298 (רצ״ח):** Whether the predictions [visions] of the astronomers come about [literally] face-to-face [i.e., are fulfilled exactly], or whether [something] is found in them [amounting to] vain falsehood and deceptions.
- **Siman 299 (רצ״ט):** A small [brief] gathering and a little [account] concerning the matters of the twenty-eight stations of the moon (כ״ח מחנות הלבנה), which are called [Italian:] *mansioni della luna* (מאנצי״אנוס לינ״א [recte mansioni della luna, "mansions of the moon"]). *[The Hebrew transliteration is garbled; identified from context as the lunar mansions.]*
- **Siman 300 (ש׳):** The tribes [groupings] of the zodiacal signs, which are called [Latin:] *aspectus* (אשפעקטו״ם [aspectum, "aspects"]).
- **Siman 301 (ש״א):** On the usefulness of the aspects [literally "the gazings"] of the stars (מבטי הכוכבים).
- **Siman 302 (ש״ב):** That in the squaring [creation/foundation] of the spheres [or "of the universe"] there is for us, together with [knowledge of] them, some usefulness beyond [knowledge of] them themselves. *[The phrase בורא המרובע is degraded; rendering tentative — possibly "the Creator of the four[fold]," referring to the four elements or the four aspects. Flagged.]*
- **Siman 303 (ש״ג):** [That] many nations and kings raised up [established] [policies?] according to the share [portion] that Europe [Europeans] allotted [to] them — what was the beginning, and under which constellation [mazal] they are governed. *[Reading of מלכים יסקומו/יתקומו uncertain.]*
- **Siman 304 (ש״ד):** Whether the nation of Israel — God forbid (חס ושלום) — should be subject to the rule of the stars [planetary determinism]. *[The line reads "האומה הישראלי תחוג נהוגה… לעמוד ממשלת הכוכבים" — whether Israel is governed and stands under stellar rule.]*
- **Siman 305 (ש״ה):** A list [tabulation] of the thirty-six figures [forms] of the heavens (ל״ו צורות השמים) and the count of their stars.

The simanim of the Index are herewith concluded (סליה סימני המפתחות / סליק סימני המפתחות, "Completed: the entries of the index"). *[The closing colophon-formula "סליק" marks the end of the index.]*

The Author's Introduction, in Clear Language [Plain Speech] (הקדמה להרב המחבר בשפה ברורה)

He said: I saw fit to disclose to the ears of my reader who the men were who first set out to grow wise in this matter — namely, this science: the science of the stars, the zodiacal signs, and the threefold [arrangement of the heavens]. [I trace it] from the days of the earliest men down to this very day. **They are of the children of Israel — yea, the children of the One Hundred [generations?]** [reading of "הן מבני ישראל אל הן מ אה" uncertain — likely "they are of the children of Israel," with the closing words degraded].

I found written, in a book of genealogies [yichus] assembled by an eminent scholar [?], that the first to grow wise in this science — as the Sages testified concerning him — was our father **Abraham**, peace be upon him. This is the book called *Pirkei Rabbi Eliezer* [Pirkei de-Rabbi Eliezer], whose words are wondrous and well-founded. We likewise find among the words of our Sages, of blessed memory: "Great was the astrologer's craft (אצטגנינות, *itztaganinut*) that our father Abraham possessed." For the Sages of the Talmud said [Talmud Bavli, Bava Basra 16b]: that Abraham said before the Holy One, blessed be He, "Ribbono shel Olam, I have looked into my astrological art (אצטגנינות), and I am not fit to beget a child." [The Holy One] said to him: "Go forth from your astrology (צא מאצטגנינותך), [for Israel is not subject to planetary fate]," and so forth.

And after our father Abraham, peace be upon him, we find that of the sons of Issachar it is written, "men who had understanding of the times" (Divrei HaYamim I 12:33 [I Chronicles 12:32 in Christian numbering]) — that they were expert in calculation [the *tashbetz*, computus], and in the fixing of the festivals [the calendar], which cannot [be done correctly] except [through] knowledge of the science of the celestial motions.

After this, our teacher **Rabbi Isaac Abarbanel** [R. Yitzchak Abravanel] — may [his memory be a blessing] — in his commentary on the Torah portion "HaChodesh" [Parashat HaChodesh, Shemos 12], wrote [the following], which I found written: beyond what is written concerning King **Solomon** (Shlomo), peace be upon him, that he was preeminent in this science. Of him it is said in Melachim I [I Kings] chapter 3, that the Holy One, blessed be He, said to him, "I give you a heart [so wise]… that there was none like you before you, nor shall any arise like you" [I Melachim 3:12], and [later], in chapter 7 [recte chapter 4 or 5], it is said, "and he was wiser than all men" [I Melachim 5:11], and so on. From this it appears that he was preeminent in this science in particular, for I have found

written in a book that Solomon's wisdom is one of the books that were lost to us [from] among the nations — found in their hands, [removed] from our [people]. [Abarbanel says:] "In chapter 7 [of his words]: I sought… and it [this wisdom] was [more] precious to me than all kingdoms, and all riches were as nothing before it, and all precious gems [could not compare] to it… the gold [was as] dross beside it, and the silver as [worthless] beside it [Mishlei 8 / Iyov 28, paraphrased], as ash [or refuse]," and so on, up to "the light emanating from it does not diminish," and so forth. He said, up to this point: "And I saw [literally: that God gave me] knowledge, and I perceived that I know the structure of the universe — the measures of the elements, the nature of the periods of time, the beginning, middle, and end of [the] seasons, the lengths of the days and their shortness [variation], the cycle [tekufah] of the year, and the standing [positions] of the stars" — thus far his words. *[The interior quotation is from a passage Abarbanel ascribes to Solomon's lost "Wisdom"; cf. the apocryphal "Wisdom of Solomon" 7:17–21, which Abarbanel cites. Several phrases are degraded in the print and rendered tentatively.]*

And the **Ramban** [Nachmanides], in the introduction to his commentary on the Torah, brings this matter — the very subject — in the name of "the Book of the Wisdom of Solomon," though in a somewhat [different] phrasing. The Ramban [there], in his introduction, said, of blessed memory: "[There is] a book called *The Great Wisdom of Solomon* [Chochmata Rabta de-Shlomo]," and so forth, up to: "It is He, the Giver of knowledge, who [made it known] to the son [of David], that there is none who can comprehend the standing of the world [universe]: the zodiacal signs, the [planetary] heads [nodes], and the lunar [stations], and what the sun will do; the ordering of the seasons (תריצות הזמנים), and the fixing of the [calendar?] which I have set down here" [paraphrasing Ramban's citation]. — Both versions [Abarbanel's and Ramban's] rise upon one stem [agree in substance] and embrace the whole science of astronomy (חכמת התכונה). And although the "Book of the Wisdom of Solomon" is not like the rest of the Holy Writings [Kitvei HaKodesh] — for the [versions in the hands of] the nations are not trustworthy, since they are not under our hands [control], and they may perhaps have laid their hands upon them, [introducing] alteration by addition or by deficiency [diminution] — nonetheless, you should observe that the Ramban, of blessed memory, testified concerning this matter in his introduction mentioned above, and it is fitting to rely [on him]; nor [need we] depend [on it alone] for support in this. Our Sages, of blessed memory, [say] in Midrash Tanchuma, Shir HaShirim Rabbah, chapter 6 [or §6], on the verse "I planted for myself vineyards" [Koheles 2:4], where they said: "He who [planted] knows the

foundation of the world [universe] entire" — [literally: "from its very foundation, the foundation of the whole world"].

And in our Talmud [the Babylonian Talmud], in the [matter brought by] Rabbi Eliezer (R"A) [?], and we likewise find in the [first] chapter of Rosh Hashanah [Bavli, Rosh Hashanah, ch. 1], [things that are] very sealed and obscure (חתומים וסתומים מאד); [for example, the matter] of the shapes [diagrams] of the phases of the moon [literally "the form of the moon"] that Rabban Gamliel [R"G] had [drawn] upon the wall in his upper chamber, with which he would show [demonstrate to] the laymen (הדיוטים), [asking them,] "[Was it] like this [that] you saw [the moon], or like this?" And we [also] find, in the Tosefta, that Rabban Gamliel said: "I have a tradition from the house of my father's father (מקובלני מבית אבי אבא) that the renewal [conjunction] of the moon is not [less than] twenty-nine days, twelve hours, and seven hundred ninety-three [chalakim] (תשצ״ג, 793 =)" — that is, that Rabban Gamliel said it sometimes comes [arrives] at length [late] and sometimes comes [arrives] briefly [early]. *[The figure 29 days, 12 hours, 793 chalakim (1/1080 of an hour) is the classical molad interval. The numeral תשצ״ג = ת400 + ש300 + צ90 + ג3 = 793; verified.]*

And in the days of Rabbi Akiva [R"A] there were two great scholars in the science of [calendar] reckoning and astronomy — namely, Rabbi Eliezer ben Chisda [Chasdai?] and Rabbi Yochanan ha-Sandlar [the cobbler?] [?] — who knew [how] to estimate [calculate] [astronomical quantities], as is brought in [Tractate] Horayot. And our holy teacher [Rabbeinu HaKadosh, R. Yehudah HaNasi], who was Samuel [Shmuel?] — [reading uncertain] — he himself would take pride and say: "I am as well acquainted with the paths of the firmament (שבילי דרקיע) as with the lanes of [the town of] Nehardea (שבילי דנהרדעא)," as is found in the chapter "HaRoeh" [Bavli Berachos, ch. 9]. This is Rav Adda [Rav Adda bar Ahava] [?], of whom Rava said: "I saw [literally: as I observed]..." — [a remark about the Tevet equinox (תקופת טבת) drawing near, that] it [had] passed [into] Nisan [by] sixteen [days?], and one does not reckon [account] it to him [as an error]. *[This dense passage cites several Talmudic astronomical traditions; the chains of names are partly garbled in the print and tentatively identified.]*

The conclusive proof [that the Sages were expert in astronomy]: that our Sages, of blessed memory, were expert in the science of astronomy [is shown by the fact that] they bequeathed to us [established for us] the measure of the solar year and [its] seasons [tekufot] according to the view [calculation] of Rav Adda, and the measure of the lunar month, and the [nineteen-year] intercalation cycle (מחזור) of nineteen years, and the fixing [of the calendar], and the rest of the reckonings of

the intercalation [ibbur] — not one of which has changed or been altered in its mixture [proportion] from their days down to this very day. [This is so] in such a manner that we have no need to repair [adjust] our years and to alter [our] reckoning, as the sages of the nations did [as] the sages of the *akum* (עכו״ם) [worshippers of stars and constellations] did, seven times — as I [explained] in my smaller book, *Magen David* [or: in my small composition], the book *Sh'nat… [Tzemach David?]* [?]; and I have likewise found [this] among the sages of the [calendar] intercalation themselves [of old]. *[The reference to the author's "smaller book" is to one of Gans's own works; the title is degraded — likely Magen David or Tzemach David. Flagged.]*

From the ancient great astronomer Albategni [אברג״י — al-Battānī?] [?], mentioned above, down to the astronomers of the [gentile] *akum* [today], in our own time — all of them have given us, in this [matter], praise and glory and exactitude, marveling at us, [at the fact] that we have stood firm upon a single reckoning, without [any] change or correction, for more than a thousand years and more, [a reckoning that] will [yet] remain [accurate], with [its] precision and exactness, [free of] error or even a [single] degree [of drift], down to this very day. Behold, this proves [demonstrates] the [soundness of the] view of our Sages, of blessed memory, in this science. *[The astronomer-name אברג״י is garbled; from context — "the ancient great astronomer mentioned above" — this is most plausibly al-Battānī (Albategnius); flagged as uncertain.]*

[Yet some hold a contrary view:] that the matter found in the Talmud is not agreed upon by all; this science [astronomy] [in their view] has been [demonstrated] by the [exact] proofs [demonstrations] [drawn from] the structure of the heavens — by [observational] proofs visible to the eyes. And the Rambam [Maimonides], of blessed memory, wrote in *The Guide of the Perplexed* [Moreh Nevuchim], Part III, chapter 14, the following: "Do not ask of us [require us] to make everything that the Sages, of blessed memory, mentioned concerning astronomy agree [with the truth]; for in truth you will find that the mathematical [astronomical] science in those days [was deficient — they did not have it] by tradition from the mouth of the prophets," and so forth. And the great [authority], the *Baal HaAkeIdah* [R. Yitzchak Arama, author of *Akeidat Yitzchak*?] [?] wrote in his language [in] sha'ar 36 [gate 36] [the following]; and he added and said, [referring to] what the Sages of blessed memory said — that since [the Sages] were diligent and engaged in the labor of the Torah, [the science of astronomy] was [merely incidental to them]; they did not require that science except for [the purpose of] knowing [how] to intercalate [and to compute] the seasons of the [year], and to reckon the times of [the new moon's] birth [molad]; and since

[pursuing it further] would have been wearisome and a loss [waste] of time [for them, they left it aside]. They also brought there [in those sources] sayings of [the Sages], of blessed memory, in the chapter "Mi shehayah tamei" [Bavli Pesachim, ch. 9?]: that the sages of Israel themselves [yielded the matter] of [calendar reckoning?] to the sages of the nations [conceded that the gentiles were more diligent in it] — look there in its place [for the fuller treatment], in such a manner that you should know that there were men [who were] wise and learned [in these matters]. *[The chain of Rambam → Baal HaAkeidah is partly degraded; "Baal HaAkeidah" / sha'ar 36 is the likely reading. Flagged.]*

The Author's Introduction (continued)

there are those who say that the words of the Sages, of blessed memory, concerning the science of astronomy are not [to be taken as definitive], because their words [in such matters] — [some say] they spoke them by tradition (בקבלה), and [others say] they did not [speak them by tradition], (apart from the matter's [practical] need), but only according to their own reasoning [conjecture]; [that] the sight of their eyes [observation], and not the way of prophecy or [received] tradition [governed them]. [Even] the Sages themselves, of blessed memory, admitted [confessed] the deficiency [limit] of their knowledge in [this] science. A proof [example] of this they bring [from] *Bereishit Rabbah*, parashah [chapter] 6, where they said: Rabbi Shimon ben Yochai said, concerning the matters of the courses [motions] of the heavenly [bodies]: "We do not know whether they fly through the air, or whether they glide [scrape] along the firmament, or whether they [move some other way]; the matter is exceedingly difficult, and it is impossible for [mortal] creatures to comprehend it" — thus far his [R. Shimon's] words [literally "on his tongue"].

And the pious one [he-Chasid], our teacher Rabbi Moshe [?], may his memory be for [a blessing for] the life of the World to Come — he too was aroused [to address] this [matter] in his book *Torat HaOleh* [*Torat Ha'Olah* of the Rema, R. Moshe Isserles], Part II, chapter 20, of the first portion, the following: "And if anyone should say that the words of the Sages, of blessed memory, are received [by tradition] — I do not dispute [contend] with him on this; for if it is a [genuine] tradition (קבלה), we accept it, even though it [seems] far [removed] from [human] reason. But [where] there is [room for] an answer [explanation], and everything that it is possible to explain so as not to dispute the words of the Sages [we should explain], and to draw them near to reason — [how] good and pleasant that is!" And he added and said there: "Anyone who possesses [common] sense —

out of [regard for] our [own] honor and the honor of the Sages, the masters of the Torah — will certainly scrutinize their words, [confident] that there will surely be found among their words [a kernel of truth]; [for] they knew the secret of astronomy better than the sages of the *akum* [the gentiles]," and so on, [in] the eighth chapter of that same Part II [of *Torat HaOleh*], and [in other] chapters. There [Isserles] brings [other matters] besides these — words such as these, [taken] from the words of the Sages, of blessed memory, which at the beginning [of inquiry], [when viewed] against the famous, manifest astronomy that is visible to the eye, appear at first glance wondrous and astonishing, [seemingly] far from the truth and from reason; [yet] of these it is written: "[Like] apples of gold in settings [filigree] of silver" [Mishlei 25:11] — a fine [worthy] interpretation and a sound [satisfying] resolution [settles them]. **Moreover,** [Isserles notes] that already great and renowned wise men have labored [taken pains] to expound these [matters] of [this] science, [striving] to settle [reconcile] the words of the Sages, of blessed memory, properly, so as not to set them at odds with the famous truth [the established science]; among them Rabbi [Avraham] ibn Ezra (ראב״ע) [R. Avraham ben Meir], and Rabbi [Avraham bar Chiyya?] [?] the *Baal HaMaor* [author of *HaMaor*, R. Zerachiah HaLevi?] [?], and the great astronomer Rabbi Isaac the Israelite (ר' יצחק הישראלי) [Isaac Israeli], and after him men [of] Jacob [scholars of Israel], and others besides them. Also in our own time, the great Rabbi, our teacher **Rabbi [Yehudah] Liwa [the Maharal of Prague]** [Rabbi Liwa, "Liva," son of Bezalel] [?], in his book *Be'er HaGolah* [*Be'er HaGolah*], in the sixth elucidation [be'ur], went to great lengths [discoursed at length] concerning many matters found in the words of the Sages, of blessed memory, which at first reflection appear wondrous, astonishing, and far from the truth and from reason — [matters] of which it is written: "a fine interpretation and a sound resolution." *[The chain ibn Ezra → Baal HaMaor → Isaac Israeli → Maharal is partly degraded; the Maharal of Prague ("Rabbi Liwa," author of Be'er HaGolah) is the clear reading at the end.]*

And the men known among our people to be enlightened in this science — and [whose] men [composed] books and authored them [literally "from whom books issued, and they composed them"] — [include] the great Rabbi, the Rambam, of blessed memory, in [his] Hilchot Kiddush HaChodesh; the great scribe-sage [Rabbi Avraham] ibn Ezra (ראב״ע) — though I have not seen his composition [on this]; and Rabbi Avraham bar Chiyya (רבי אברהם בר חייא), [author of works on] the science [of astronomy], who composed *Sefer Yesod Olam* [*The Foundation of the World*] [recte: *Tzurat HaAretz* / *Sefer HaIbbur*; "Yesod Olam" is by Isaac Israeli] [?], and the *Sefer Sha'ar HaShamayim* [*The Gate of Heaven*]; and Rabbi Isaac the Israelite (ר"י הישראלי) — who composed the book *Yesod Olam* [*The*

Foundation of the World], the first [of his works]. The **Ralbag** [Gersonides, R. Levi ben Gershom] too went to great lengths in this [science] in the first Part of his book *Milchamot HaShem* [*The Wars of the Lord*], chapter [?], the Fifth Treatise [the astronomical book]; [but] the printers omitted it and left it out, saying that it is too large a book [to print], and they set it aside. I myself have not seen it [in print] until now [literally "until here"]; and there is no doubt that compositions by [authors] other than these exist, [only] I have not seen them. *[The attribution of "Yesod Olam" oscillates between Avraham bar Chiyya and Isaac Israeli; "Yesod Olam" is in fact by Isaac Israeli (the Younger), while bar Chiyya wrote Tzurat HaAretz and the Sefer HaIbbur. The print here is garbled; recorded as printed and flagged.]*

Now, henceforth, I shall reveal to my reader what I have found in other books — the chain of transmission [shalshelet ha-yichus] of this science from the first man [Adam]. Behold, [it is] as I found in the book… [printed] now [recently], and [as] I have [also] found written in the book of **Joseph ben Gorion** [*Sefer Yosippon*, attributed to Yosef ben Gurion], who wrote that **Adam** the first man (אדם הראשון) was a preeminent sage and a great astronomer in the science of astronomy; and he was preeminent in it and excelled, in [the keenness of] his perception. And so too the genealogy [traces] this science [as descending] to him [Adam].

Down to Abraham our father, peace be upon him: just as it is written in the *Yosippon*, that when [Abraham] went down to Egypt on account of the famine, [it was] in those days [that] he stayed and dwelt among them, and taught the sages and the wise men [literally "the diviners," ha-chartumim] there the science of number [arithmetic] and the science of astronomy. And [the Egyptians] all marveled [were astonished] at the [greatness of his] genius [the abundance of his intellect] in these two sciences. The words of our Sages, of blessed memory, also lend support to this — as they testified concerning this [matter] in [the chapter] "Bava Batra" [Bavli, Bava Basra 16b]: "Great was the astrologer's art (אצטגנינות) that our father Abraham [possessed]," peace be upon him — as we explained nearby [above]; and so [too] his son and grandson, [namely] Isaac and Jacob [received] the science. They [the Sages] further wrote that **Job** [Iyov], who lived in those same days, also was preeminent in this science; and this is something credible [easy to believe], for in his book [the Book of Job] there is mention, incidentally [by the way], of [matters] in the science of the stars and the zodiacal signs — as in [the verse] "[He] makes the Bear (עש), Orion (כסיל), and the Pleiades (כימה)" (Iyov 9:9), and likewise "Can you bind the chains [sweet influences] of the Pleiades (כימה), or loose the cords [bands] of Orion (כסיל)? Can you bring forth the constellations [Mazzaroth] in their season (תוציא מזרות בעתו)?" (Iyov 38:31–32).

See there [Iyov, ch. 38] concerning all of these. Even though these verses [are spoken] by the Holy One, blessed be He — "Did not God [Himself] speak to Job [these] things, which a man could not build [comprehend]?" [paraphrase] — [it is nonetheless evident from them that Job possessed this knowledge]. And from that point onward [from Abraham] the chain of [astronomical] transmission [shalshelet ha-yichus] was set down [in writing], as I shall explain.

The Egyptians [for their part] received the science of number [arithmetic] and geometry (הנדסה) — by way of the [astronomical] tradition [transmitted to them] — from Jacob and his sons (מיעקב ובניו) when they went down to Egypt; [thus they had] astronomy [as well], in addition to what they had already received [in part] from our father Abraham, peace be upon him, and from [what] they [received] from their forefathers Abraham and Isaac. And in [the course of] the long exile there, this science was forgotten [lost] from among the children of Israel and remained there among the Egyptian magicians [chartumim of Egypt], who increased it [developed it] and magnified it greatly, exceedingly. To this [point] too the sayings of our Sages, of blessed memory, lend support, with the mention of [Pharaoh's] magicians [in] the [story of] Pharaoh in several places. They also wrote, among the inquirers [scholars], that the Egyptians were earlier than [preceded] all the peoples of [other] lands in this science, and that they were preeminent in it more than all the other peoples of the lands and tongues under heaven. [This is so] for three reasons. **The first:** the tradition received from our forefathers Abraham, Isaac, and Jacob and his sons, as mentioned [above]. **The second:** that it is already known that the Nile (ה[יאור]) [the river] rises every year — [as] the year grows old [comes around] — and overflows upon their land, the land of Egypt, raising it up [covering it] with [a deposit of] mud [silt] and clay [mire], confounding [obliterating] the boundaries, the markers [signs], and the bounds, and the [original] portions [allotments] of the land of the inhabitants [each man's field] — so that it is impossible for each and every one to recover [recognize] and reach his own [plot of] land except by means of the science of number [arithmetic] and the science of measurement (חכמת המדידה), which is called *geometria* (גיאומיט״ריא [Greek/Latin: *geōmetria*, "earth-measurement"]). [That is its name;] its [literal] meaning is "the measurement of the land [earth]." So [the Egyptians], from [their need for] the science of measurement of the land, [grew] wise, and rose in their understanding higher and higher, until they came to [the study and] contemplation of the courses [motions] of the seven planets (שבע כוכבי לכת) and the motions of the [fixed] stars [the zodiacal signs] — [an inquiry] which, to this very day, [governs] the measurements and investigations of the stars and constellations [as] called by [in] the mouths of the astronomers in all lands, by way of [the term] *geometria* — [whose] meaning is "the

measurement of the land [earth]." **The third [reason]:** that in the other lands the astronomers have no [means] to establish [verify] the investigation of the stars [their observations], for when the clouds fill [the sky] they see no star whatsoever; whereas in the land of Egypt it is not so [the sky is clear]. From there [over there] no rain is found — as those who pass by on the road [travelers] tell us — for, as it is said in [the Torah portion] "Eikev": "[a land] not like the land of Egypt" (לא כארץ מצרים) [Devarim 11:10], "[which you watered with your foot,] like a garden of herbs (כגן הירק)," and so forth; and concerning this matter, Scripture is emphatic in its [phrasing], as it says…

knew [that there were?] [?] and commentaries [?] from of old, among the children [of Israel?] [?] and the science of the constellations.

From Egypt our science came [next?]. The Greeks received this science [from there], and there were among them sages of old. The Greeks gave Greek names [to the planets / to many things?]; for a long while the Greeks [held this knowledge]. At the time of the Trojan War — those who were in their land — there was a mighty [sage?]; he was קילו״ן [Kilon = perhaps Chiron?] [?], a renowned astronomer, who was [a judge / counselor?]. He lived in the days of Daniel; and the Greek [?]. [There follows mention of] the heavens of [?], who was in the land of Greece [?]; he is [?], the disciple of [?], by Cyrus [כור״ש = Koresh / Cyrus] [?].

The sage [who was] first to write of the orbits of the luminaries and their [paths?], the great and renowned one whose wisdom surpassed all the men of his generation, was called שו״לין [Sholin / Solon?] [?]. There were also found two wise men, famous and well known among the astronomers: the first, פיטאג׳ריס [Pythagoras]; the second, חט״פירוס [?] [perhaps Hipparchus, but uncertain — flagged]. They acknowledged that they received this science from the Jews. The aforementioned sages [were?] [?] honored and [?]. All of them dwelt in the great and famous city in the land of Greece known as אטינ״י [Athens] — that city which from the day it was founded was [a place of assembly?] for all the [?]. From it went forth all wisdom [?], and the houses of assembly of its established sages [were?] always there. This city is mentioned in tractate Nedarim [Nedarim 50a?] [?], where R. [?] and Tzadok [?] said two things [?] [— "I went up from Athens"? — "I went up from Babylon to Athens"? — text degraded] [?].

[The text now turns to the Chaldeans:] The הילדים — that is, the כסדס [Kasdim = the Chaldeans] — the men of [Chaldea?] and all its environs received and learned this science from the Egyptians. The Greeks are younger; [whereas] the ancient Chaldean sages who were in the land [are?] the first. The first [was] named

טיאזקד״וש [?] [unidentified — flagged], and the second was named ארימולוש [?] [Aristobulus? unidentified — flagged]. They lived about fifty years before the reign of Alexander, near the year 400 of the fourth millennium [AM]. They were the first [diligent observers] who scrutinized [the matters of?] the fixed stars [?], [recorded] over many years [in writing] by אכרכו״ש [Abkharkhush = Hipparchus] and by [טו״למיאזס = Ptolemy] [?]. The Chaldeans practiced this science for many days, and went very far [in it]. They [are mentioned?] [by Chazal] z"l in [the matter of] the Chaldean visions, at the end of the chapter [?] of [Bava] Batra [?]. Know that of all these aforementioned sages, no [complete?] book has been published [?]; only the [traditions?] [?] concerning some of the sages [have reached?] us.

[Therefore] we shall now further expound some of the sages by their names — the great ones who were in the land in the days of the First Temple until now, who themselves scrutinized and observed the courses of the luminaries and wrote down the records of their deeds [their works], which have been published among us.

[The First Temple-era and Greek sages:]

In our own day there is אקלידי״וס [Euclid] — that sharp-witted, learned man [?], the keen-minded one who surpassed in the abundance of his intellect all who came before him among the nations, and also [those who came] after him to this very day. There never was his like. He composed the renowned book known by his name [after] אקלידו״ש [Euclid], whose depths cannot be fathomed — so much so that all the great sages, the ancients and the Greeks, all of them judged [it] [?] [that there is none like it]; in no nation is there found any book under heaven greater than it, or one equal to it. And in [the matter of?] [?] [his?] mathematical studies — even though [?] he did not exhaust [?] all the matters of astronomy [?], but only a little taste of the matters of [?] [—] he surpassed [?] in his [?]. We have not found by our own hand [or] foot in the matters of mathematical science [?] [— text degraded —] astronomy at all [?] [...]. And [as] the ladder is lacking, there is no way to ascend [?].

This sage too lived in אטני [Athens], the city of wisdom in the land of Greece. According to the words of Sefer Yuchasin, folio 13 [Sefer Yuchasin, fol. 13], this [Euclid? — "Yoanes"?] [?] lived in the time of Mordechai and Esther, near the year 400 of the fourth millennium [AM].

The sage חי־קתידו״ש [?] [unidentified astronomer — flagged] — whose companions too are [renowned], and who in our own day are found among us [?]

— was learned in all the sciences, an outstanding astronomer among the [scholars] of mathematics and geometry. He held [?] that the whole world is supported [centered] upon a [point?] at the center of the earth [?]. [He held?] [?] on the sphere [?] [— text degraded —] a great [?]; and in his building [?] [there was] depicted upon it [?] the centers [?] [and the?] paths of the planets [?]. He dwelt in the city of קוצ־א [Kotza / ?] [?] in the land of Greece, near the year 500 of the fourth millennium [AM]. Near his time [there was] one called אריסט־ק סרי [Aristarchus?] [?] [— Aristarchus of Samos? flagged], who held [?] [that the?] sphere [of the?] [...?] moves [?]; he is אכונ״ס [?] [unidentified — flagged].

The great astronomer renowned among them, called כיפיקוס [?] [unidentified — flagged] — the man whom Ptolemy praised, saying of him that he was a man of [great wisdom?], skilled and sharp in the craft of all the [investigative?] matters with which they occupied themselves — as עוצם [the author of?] [?] wrote in the [third] book [?], [section?] 3, [naming] him a second [Hipparchus, אברכו״ש]. According to what the author of Sefer Yuchasin wrote of him, folio 17 [Sefer Yuchasin, fol. 17], and the author of Me'or Einayim, [chapter?] 7 [Me'or Einayim, ch. 7]: he investigated all the ancient calculations [?] [over] some 400 years, until [?] he fixed [the values of?] [?] the [lunar?] phases [— hours, chalakim, regaim?] [— text degraded —], minutes and seconds and thirds and fourths [דקין ודקי דקין = minutes and minute-fractions], such that the sum of his calculation accorded with the reckoning of Chazal z"l regarding the law of the lunar month, which is 29[d] 12[h] 793[ch] [29-12-793, the molad interval]. He also wrote there a secret [a mystery] — which is [the law?] that the moon returns to its [place?] in the seventh year of the [intercalary?] cycle [the cycle of intercalation — שנת העיבור].

This sage dwelt in the city of חל״י [?] [Halei? — place uncertain] in the land of Greece [?] [Ionia?]. And in his time [?] [there is room to question?] [?]; for according to the words of the author of Sefer Yuchasin, folio 116 [Sefer Yuchasin, fol. 116], and likewise the words of the author of Me'or Einayim, [chapter?] [?], he lived in the year 534 of the fourth millennium [AM] [= 534 + 4000 = ד"א תקל"ד 4534 AM]. But from his composition it is proven [otherwise]: that he lived in the year 694 of the fourth millennium [4694 = 694 + 4000 = ד"א תרצ"ד AM] [?], in the days of [?] [— text degraded —] which was the year 176 [of?], the year 227 to the era of contracts [Seleucid era, לשטרות] [?], in the second [Temple?]. [Some?] [?] 196 years before [— text degraded —], and [?] 294 years before the beginning of their reckoning [?] [— heavily degraded — flagged].

After Hipparchus [אברגו״ש], near the year 70 [?], there was the emperor יוליחו״ס [Julius (Caesar)] [?]. There [his name?] [?] [— and there were?] two wise men,

[astronomers?], the first named קלופ״ו [?] [unidentified] [?] and [?] called סוסי״געש [?] [Sosigenes? — Caesar's astronomer — flagged]; by them he [arranged?] the [solar?] year [— so that the first day of [the month?] [...?] and the fourth [?] [day?] [— heavily degraded, calendar-reform context: the Julian calendar — flagged]. From his time [?] [the count?] is the year 1726 [= אלף ותשכ״ו 1726?] [?] [— numeral uncertain, flagged]. We have already expounded at length on this in our [seventh?] section [שער ז, ch. 9?] [?] [— "the lesser luminary" — concerning the calendar?] [?], and there is no [need to repeat?] his matter here.

The great sage who beheld [observed] [— בטו… חיאוס = Ptolemy, בטולמיאוס] [?], the wondrous and outstanding one — of whom there was none like him among those before him, nor even among those after him to this very day — gathered and collected from the books of the Christian [?] [Roman/Greek?] sages, the Greeks, the universal [scholars], and from the fruit [the works] of the rest of the sages who lived before him. He composed many new investigations and lofty laws [?], and went to great lengths in writing in this science [more than] all who lived before him. He set all of this down in [one] book — the famous, accomplished work known as אלתגו״סטא [the Almagest]. He composed it in the great city of אלכסנדיריא״ה [Alexandria], according to his studies and all the appearances [observations made there] by [reckoning of] the [meridian / horizon] [— the latitude/longitude] [?] of that city, as is explained in his book.

[The completion / dating of] the aforementioned [work] was in the year 900 of the fourth millennium [4900 = 900 + 4000 = ד"א תת"ק AM], which is the year 140 to the Christians [140 CE], in the days of the pious [?] emperor אנטונינו״ס [Antoninus] — about 285 years [265 = ?רס"ה?] [?] [— numeral uncertain] after the great astronomer Hipparchus [אנר"כס] mentioned above. In our possession is [a copy of] Ptolemy [שבטולמיאו], [whose?] [?] year is [— possibly?] 5171 [אלפי שעי"א?] [?] [— numeral heavily degraded, flagged] [— in the year that is the year [?] [...]].

learned the matter [from?] [our?] Sages of Israel. For [?] [it has been told?] [?] [— text degraded —] in Alexandria there was a great and mighty people of Israel, and an enormous, mighty community. [And there were?] [seventy?] [?] [Egyptian?] [?] [— degraded]; there was there [also] a [house of] Sanhedrin [— in the synagogue at Alexandria?] [?] [— the great double-colonnade synagogue of Alexandria, tractate Sukkah], which Israel [built?] [— so that they should not be profaned?] [?] [— text degraded]. From there [Ptolemy?] received many things; therefore the said Ptolemy was called by his name קלזדית״ה [?] [Claudius?] [?]. And so the name "Ptolemy" [— according to what?] [?]: from the time of

Alexander, [the kings of Egypt?] were named "Ptolemy," [a name] proper to the kings of Egypt — just as in ancient times Egypt's kings were called "Pharaoh" [פרעה], the Philistines' [kings] "Avimelech" [אבימלך], and Persia's "Darius" [דריוש]. [This was?] [because?] [— degraded]. Since [it was?] from the days of Alexander [— degraded], the kings of Egypt of [his?] lineage called themselves "Ptolemy" after his [Alexander's] name. [— this Ptolemy the astronomer was of that royal line / named after it —] [?].

For the Romans had already seized all the kingdom of Egypt by force — this being about 170 years before [?] [the time of?] this astronomer-Ptolemy. On account of this the great investigator טימא [?] [Timaeus? — unidentified] [— bar Hei (?)] [?] [— degraded] arose [?]. After the Romans by force took the kingdom of the forefathers of Ptolemy [— degraded], they [the Ptolemies] went ever downward, growing poor and low, until they lost their kingdom altogether. But this [astronomer-]Ptolemy [— turned?] to a different [and better?] kingdom: [an empire of?] thousands upon thousands [?] [— degraded — flagged] [— which he took into his hand many times — that he conquered as it were] all three parts of the lower world [?], under his dominion — and all this [achieved] not with an army and a host, not as armed warriors with sword nor with [scale-armor?], nor with bow, but with his pen [his quill] alone. Yet even this did not suffice him, until his intellect ascended on high — onto all seven heavens [the seven firmaments], to the highest heaven — [whence] the [?] [— degraded — onto?] [?]. And he recorded for us in a faithful writing [in true script] the [exact?] forms of all the constellations [the configurations of the zodiac belt] and the rest [of the stars], [in the manner of] the [book?] of Ptolemy — [showing] the figures and configurations of the heavens. And the ruler [— Ptolemy's intellect ruled?] over the lower [bodies] and over the upper [bodies], and this [— his kingship?] ever ascends higher and higher; it endured in his hand, and all the inhabitants of the earth, the kings and rulers of the world, the enlightened ones, [are?] subdued under his dominion, and they place [his work?] as a crown upon their heads — from that day to this, and to the end of all generations.

[The Arab astronomer al-Battani:] [There was] אלבתאינו [al-Battani], the great Arab sage, called by the astronomers "the Great." [Al-Battani?] [— אלבתי"גניאוס?] [?] walked in the footsteps of Ptolemy, and went very far [excelled greatly] in this science, made pillars [foundations] for it, and [introduced] precious and pleasant novelties. He devised and discovered precious tables [luchot] and [methods of] reckoning and counsel for the science of astronomy — tables by which they conduct themselves to this very day. I have also found, in the Laws of Sanctification of the Month [Hilchos Kiddush HaChodesh] of the Rambam z"l, that

he [the Rambam] founded most of his calculation according to the calculation of al-Battani [אלבתי"ני]. So too [the commentator?] [Me'iri / Maggid?] [?] explained this in the Laws of Sanctification of the Month, [chapters?] 11–17 [chs. 11–17, רא"ש פי"א-י"ב?] [?]. The time of al-Battani's composition of his tables was in the year 880 to the Christians [880 CE], which is the year 640 of the fifth millennium [5640 = 640 + 5000 = מ"תר א"ה AM] [?] [— numeral check: 640 AM-of-5th-millennium → 5640 AM; 5640 − 3760 = 1880, inconsistent with 880 CE — flagged as numerical issue], and this [is?] 718 years [תשי"ח] after the composition of Ptolemy.

[The astronomer-king Alfonso:] אצפונ"סי [Alfonso (X)], king of Spain and Sicily [צי'ציל'אה = Sicily?] [?], was outstanding in the science of astronomy. He maintained a great house of assembly for the sages, to examine with him the courses of the luminaries. It is written of him that he spent on this science more than four times one hundred thousand gold pieces [400,000 gold zehuvim]. He too newly arranged and ordered tables [luchot] for the science of astronomy. The time of his composition was in the year 15 of the sixth millennium [→ ה"א ט"ו 5015 AM] [?], which is the year 1225 to the Christians [1225 CE]. The author of Sefer Yuchasin, folio 132 [Sefer Yuchasin, fol. 132], wrote: "R. Yitzchak ben S"D [— ש"ד?] [?] composed the tables of astronomy" — [these being] the [Alfonsine] tables, [for?] צי'ל [?] [— degraded].

פונס"י [Afonso?], king of Portugal [פורטג"ל], who [reigned?] in the year 11 of the sixth millennium [5011 → ה"א י"א AM] [?] [— text degraded]. [He is?] called [?] [— קמ?] [?] to this very day [— degraded]. I saw this book [— the Alfonsine tables?] copied [translated] from the language [— from Alfonso's tongue?]; it was translated from the Spanish language into the holy tongue by R. Yaakov al-Korsi [אלקר"סי] [?] in the year [?] of the sixth millennium. And I myself [the author, David Gans] translated from this book into the German [Ashkenazic] language, [sending it?] to the great investigator [Tycho Brahe — טיח"א השר?] [?] [— "bo'ayah"?] [— degraded], who [— let his name be remembered for good?] [?] [— text degraded].

[The astronomer Copernicus:] [There was] the man Niqol [Nicolaus] קופרניק׳^וס [Copernicus], a man of Prussia [פרוסיא], great and outstanding [?] in the science of astronomy beyond all the sages of his age. The sages of our own time, too, all testify with one accord to the sharpness of his intellect, [his?] [?]; and they say of him that since the time of Ptolemy there has not been found a man like this in the depth of his wisdom and the eminence [of his attainments]. His mind was so bold [?] that he set his heart to prove [the thesis?] that the sphere of the earth revolves

in a great revolution continually [— that the earth-sphere itself rotates]. And this is not a thing invented from nothing [a fresh fabrication], for it had already arisen in the minds of the ancients thousands of years [before] — as I found in the book *De Caelo et Mundo* [ספר השמים והעולם = "The Heavens and the World," Aristotle's *De Caelo*], in the second chapter of the [fourth?] part [— or: Book II, ch. of part 4?] [?], that this was the opinion of the wondrous sage Pythagoras [פיטוגורו"יס] and his party [his school]. Copernicus [קיפרניקו"ס] composed concerning this matter a wondrous book of [profound?] and deep [?] reasoning [קמאל?] [?] [— degraded]. He completed his wondrous composition in the year 1500 [1500 = אלף ת"ק] by their count [CE], which is the year 5298 of Creation [ה' אלפים צ"ח = 5298 AM — but 5298 − 3760 = 1538, not 1500 — flagged: AM/CE mismatch]. That sage died in the year [?] in the land of his birth, in the province of Prussia [פרייסן = Preussen], which is the year 1543 [1543 = אלף תקמ"ג] by their count [CE], the year 5305 of Creation [5305 = ה' אלפים ש"ה AM — 5305 − 3760 = 1545, near 1543 — flagged: minor mismatch].

[The author's defense — that astronomy originated with Israel:] Now you, O reader — although [from?] all that has been related it would appear, indeed, [that] the science of astronomy [had?] its origin and root [among] the nations [— let it not be so in your eyes!]. Therefore know that the matter is not so: the principal knowledge of this science went forth first from the children of our own people, as the Rav HaMoreh [Rambam] wrote in the *Guide*, Part I [Moreh Nevuchim, Part I], chapter 71 [ch. 71, פ' ע"א]. So too wrote the author of *Derech Emunah* [Sefer Derech Emunah], Section 3 [sha'ar 3], citing the author of *Me'or Einayim*, [chapter?] 2 [Me'or Einayim, ch. 2]; and so too in [Me'or Einayim?] ch. 8 [?]: that the science of astronomy [was] first [among?] Israel — but when the nations ruled over us, it came into their hand. And we learn it from them, [so that] it appears [as if?] they were the first [to possess it] and that it came from them — [for?] [as Chazal said:] "Who could be greater than Moshe?... yet [the science] went forth [from us] and came to be theirs [— turned to the reverse?]" [— a paraphrase] — end of his words.

There never was a sage like him [Moshe], nor after him did one arise [like him]. We have already been exiled from our glory [our splendor] in the science of astronomy, and his books and the books of the rest of the ancient sages on the matters of astronomy we have not seen. So too is it written by the Rambam z"l in [his] *[Mishneh Torah]*, Laws of [Kiddush] HaChodesh, [chapter?] 17, [halacha?] 24 [Hilchos Kiddush HaChodesh 17] [?]: that there were books on the matters of astronomy composed by Moshe Rabbeinu A"H [the Peace-be-upon-him], or by the sages of Israel of the sons of Issachar — but they have not reached us. End of his

[the Rambam's] words there. And it may well be that those books came into the hands of the sages of the nations, and they boast of these matters as though it were they themselves who, by their own wisdom, discovered all this in their own time — even though some of them have revealed [the truth of] this, [as] the author of *Shevilei Emunah* [Sefer Shevilei Emunah] [did] in the eighth pathway [netiv].

[So] you must know that, ever since we were exiled from our land [to dwell?] upon a foreign soil [— the alien land — then?] our affliction was recognized [our distress made plain]: we, the people of HaShem, [went] into exile, scattered and dispersed among the peoples across the four corners of the earth; and breach burst upon breach within us [פרץ על פני פרץ], and we were tossed from nation to nation and from kingdom to kingdom, [one people to another,] amid all the manifold troubles that beset us round about. [In all this our science] was diminished; our holy and established [tradition?] [?] came to an end; and [our knowledge of] the science of astronomy dwindled away from us — until its very memory was all but lost. They [the books / the sages] were no longer to be found, except now and then a single one to a city and two to a province [— Eichah 3, "one of a city and two of a family"]; and the few books that remain in our hands in this time.

the matters of astronomy from the books of the nations: from them they learned, from them they received — as the Rambam and the rest of the [later] authors did. And in truth they acknowledge this [openly]; they declare it [plainly?] [in?] this [matter?], [against?] the words of the ancients [— even though] they gathered and gleaned [it] from their books. The science of astronomy itself is not [thereby diminished] [?]; and from the book of the Almagest [אלמיגוסט"א] and the rest [?] [— degraded —] of [מיאו"ט = ?] [?] [— to render void?] [?], [the science?] that is in their hands [remains intact?].

[Objection answered — is it permissible to learn from gentile books?] **And now,** even though we learn from them, and their books contain good [— upright —] words and novelties on the matters of astronomy, let it not be thought [that there is?] any blemish in this at all [— there is no blemish in this whatever]. For we have already found, in the chapter [— Bertinoro on?] [tractate?] in the Laws of Arugah [— *Hilchos Kil'ayim, the Mishnah of "Arugah", Eruvin*?] [?] [— in *Hilchos Kil'ayim*, ch. "Arugah"], that Chazal themselves received the laws of [grafting and] suckling [the laws of plant-grafting — יניקה] from the Emorites, and they said [the Emorites] were expert in the planting of olives, vines, and figs, and [in knowing]

how to root [them] [?] — [whether] one should water the soil [?], or [know] when the soil tastes [— Rashi there]; see Rashi's commentary there.

They also said, in chapter 2 of [tractate] Megillah [Megillah, ch. 2] [?]: "Whoever speaks a word of wisdom, even among the nations, is called a sage." Chazal also [instructed] us to recite a blessing upon seeing [a gentile sage]: "Blessed [is He] who has given of His wisdom to flesh and blood" — as is brought in the chapter "HaRo'eh" [*Berachos*, perek HaRo'eh], and cited in the Tur, Orach Chaim, siman 227 [Tur, O"Ch 227]. And who is greater for us than Moshe Rabbeinu, who wrote in the Laws of [Kiddush] HaChodesh [Hilchos Kiddush HaChodesh], end of chapter 17 [ch. 17, end]: "And since all these matters [rest] upon clear proofs that have no blemish in them, and a man cannot doubt [them] [— there is no need to be concerned about who their authors were]: whether they were composed by prophets or composed by the sages of the nations [— gentiles], so long as the matter is one whose reasoning has been revealed and whose truth we know by [those] flawless proofs [— we rely upon the man who said it or taught it]." So long as the matter has no blemish, we rely upon it on account of the revealed proof and the [evident?] reason that has become known — end of his words.

[The later authors:] So too, throughout all the world, [there are?] the later authorities, whose books [the gentiles'] we have studied [drunk from?]; we have examined [them], and recorded their words and their names in our composition [as did] the author of *Sefer HaIkkarim* [the Ikkarim] and the author of the *Akeidah* [Akeidas Yitzchak], and [the author of?] *Yesod Olam* [— and others besides him] [?]. [NOTE: *Yesod Olam* attribution remains disputed in this work; flagged per handoff.] Therefore I said: "It is not good that I, [Anochi?], should remain alone [?]" — [it is] not fitting [for me?] [to refrain]. In particular [since] I have found the sages of [the nations of?] our own day, [those] perfected in [this] science, [supported] by the hands of kingship and princes, who spend upon them [upon astronomy] many thousands of gold dinars — as Alfonso [אלעונס], king of Portugal, did, and as in our own time has done this emperor רודאלפו"ם [Rudolf (II)] yad"h [— may his glory be exalted], as explained above.

And now, at this time, I have found two parties of men who speak insolence [arrogant speech], railing against the science [of astronomy] and its students. The first party [are] "wise in their own eyes" [— but HaShem has not granted them a heart to know, to discern, to understand and to be enlightened, to study and learn the science] [— or to seek out others]; and concerning them Shlomo HaMelech A"H said [— Mishlei]: "[the wisdom that] is too far off and exceedingly deep — who can find it out?" [— a paraphrase of Koheles 7:24] — what they did not attain

by reason of [the?] depth of the [profound?] wisdom, of which but a fraction was drawn out [by them], [some of it] they ascribed to false speech, and some of it to the matters of soothsayers [diviners — מעוננים] and [deeds of?] sorcery. For this reason, in scorning this science and those who learn it, the scoffers of the generation call it [by a mocking name?] [?] — because they mock [those who study it] with the derision of their lips [— with mocking speech], saying: "Astronomer! Have you ascended on high [— to the heaven of the stars?], to the breadth of the earth [— to know the laws of the heavens?] — to the heaven [— upon the ladder whose top reaches] [— Yaakov's ladder?]? Did you go up to heaven [— Mishlei 30:4]? Did you knock at the gates of heaven, give a bribe to the gatekeepers [oxen?] [?], [bribe?] the keepers of the gate to admit you [— "you were in the shadow of Sha-dai"?] [?]: 'Tell me what the Almighty has wrought!' Has He revealed His deeds to you?... [— Iyov] [— have you known the ordinances of heaven?]" — [and] many [such gibes].

But the second party are themselves true sages who [grasp?] [— attain?] the truth of [this] science and acknowledge that [in?] all [its] ways [— the intellect is built upon paths of wisdom?]; therefore [these] true sages did not speak insolence against this science nor against its students. Rather, their mouths declared concerning it [its praise], and they said that it is not fitting for a man to lose or to abandon [— and to nullify?] [this science?], saying [— what use is there?] [— rather, on the contrary,] that there is great profit in this science [— and when it is received?] [— for it brings reward both in this world and the world to come]. For is [a ruling?] in [a matter of] this science any less just [— more frequently litigated?] than [a ruling concerning] forbidden-and-permitted [issur ve-heter], or matters of monetary law [dinei mamonos], or the laws of divorce [gittin] or betrothal [kiddushin]? [— surely not!]. Therefore I said [to myself]: to know, to make known, and to make it known [that] they [the scoffers] have strayed from the path [of?] [— the King's highway, derech ha-melech] — for they are many.

And because of the great profit of this science, I resolved to include some of it [these matters] in this book of mine, and not to set apart [— to omit?] the science of nature [physics — חכמת הטבע] [together with it?] from their books [?] — for this is what Chazal forbade in tractate Menachos [Menachos] when they forbade learning *[chochmah]* from the [— the "outside" books?] [— Greek wisdom?]. Now these [scoffers'] words cause the people to think [— darken the people's heart?] [that astronomy is among] matters of mockery, and strange and corrupt opinions; and [the Sages] have already sounded their voice like a ram's horn [shofar] [against them], placing under ban and curse [— נידוי ושמתא] those sects [who study] the "outside books" [— *sefarim chitzonim*] — those who read in the outside

books, who are not of Israel and [are of?] the children of strangers [— and the children of foreigners] — as is brought in the Responsa of the Rashba [She'ut HaRashba]; see there: "Woe to them and to their souls" [— for they have at least degraded?] [?] [— those who turn from the path of truth and the [voice of] reason], and have cast into themselves heresy [minus] toward the gate of apostasy [apikorsus], as [So-and-so] did when he excelled greatly [in error]. [— And greater is the counsel of] [— it is a great counsel] of the sages: that the wisdom [*chochmah*] [of Mishlei?] [— and the profit] is specifically in [the matters of?] this science of astronomy, in order to discern [— and to grasp —] and to render rulings in the laws of [Kiddush] HaChodesh [Hilchos Kiddush HaChodesh].

The first benefit [of this science]: it is already well known that through this science there becomes known to us the magnitude of the might of the Living [God], by whose word the world came to be [— who created and brought the world into being]. As the commentators — Radak and others — wrote on the verse "The heavens declare [the glory of God]" [Tehillim 19:2 — *"HaShamayim mesaprim kevod Kel"*], "and the firmament shows His handiwork" [*u-ma'aseh yadav maggid ha-raki'a*] — and as the author of *Sefer HaIkkarim* expounded at length, in Treatise 3, chapter [3] [Sefer HaIkkarim, Ma'amar 3, ch. 3] [?].

Second [benefit]: the astronomers [— the philosophers?] have already demonstrated, from the two [circular] motions we observe in the heavenly luminaries [— the two motions of the spheres], that there exists a First Mover [a Prime Mover — מניע ראשון]. And our [Sages] already hinted to us that Avraham Avinu A"H, through his wisdom in the configuration of the heavens, came to [attain?] [— the?] knowledge [of?] his Creator — as in the matter of which it is said [the midrash]: he saw a [lit?] castle ablaze [*birah doleket*], and said, "Can it be that this castle has no master [*manhig*]?" [— *Bereishis Rabbah*] [— "is there no Lord to this castle?"]. And even though the principle of our faith is to hold fast and to believe in HaShem and in His Torah without [need of] proofs — [for so] our ancients z"l set [the order of] [our tradition] for us — nonetheless, our Chazal z"l have already admonished us, saying: "Be diligent to learn Torah, so that you may know how [to answer] [the Epikoros]" [— *Pirkei Avos* / *Sifrei*] — "and how sweet and pleasant are the words of Rabbi Eliezer" [?] [— degraded] — [a teaching] that R. Eliezer derived from the Deed of the Patriarch[s] [— *ma'aseh avos*], [and which] R. [Eliezer?] Ashkenazi [?] [— degraded] derived [— in his book?] from the verse: "And you shall know this day, and lay it to your heart, that HaShem, He is God" [Devarim 4:39 — *"ve-yada'ta ha-yom"*]. He did not say "and you shall believe [*ve-he'emanta*] that HaShem is God," but Scripture said "to know HaShem" — and did not say "to believe in HaShem." [This teaches] that after faith

is firmly fixed in one's heart, one must also strive [to know] by his knowledge [— by reasoned knowledge]: not [merely] that one who says "I believe that HaShem exists" — though this thing is good [— it is not reckoned to him as wisdom]; rather he must say "I know that HaShem exists," as the prophet [— concerning whom?] [Yirmiyahu] said upon this: "[Let not the wise man glory in his wisdom...] but in this let him glory: that he understands and knows Me" [— *ki im be-zos yis'hallel ha-mis'hallel haskel ve-yado'a osi*], "for in these things I delight, says HaShem" [Yirmiyahu 9:23] — and [Moshe] [the prophets?] said: "[that I may] know You, that I may find favor in Your eyes" [Shemos 33:13 — *"ve-eda'akha"*].

The third principle [benefit]: it is already known that this science is the foundation [*yesod*] [— a third foundation?] of the science of intercalation [*chochmas ha-ibbur* — the calendar], as the Rambam z"l already testified upon it [in] chapter 11 of the Laws of [Kiddush] HaChodesh [Hilchos Kiddush HaChodesh, ch. 11], z"l: "Let not these ways [of the gentile astronomers] be light [trivial] in your eyes, [merely] because we have no need of them in this time [— for these matters are deep and profound paths] [— the secret of intercalation —]." "...[the secret of intercalation,] which were precious [deep] and profound paths [— that is, the foundation of the calendar]. They are the [great?] secret [— the secret of intercalation]; and the great sages do not withhold [knowledge of] them — and we are not [embarrassed?] [— we do not lack the means to know them], save only for [their being?] [reserved?] for [advanced?] students" — end of his [Rambam's] words. So too wrote the sage R. Yitzchak Israeli [ר"י הישראלי] in his book *Yesod Olam* [Sefer Yesod Olam]: "And the Sanctification of the Month is no small matter [*lo milsa zutarta*]" [Aramaic phrase] — for it is [— like?] [the whole of the Torah?]. [And] indeed [— through it?] all of the Torah, in its entirety, [is fulfilled?] [— there is no [single] mitzvah in all the Torah comparable to it?]: for upon it hang all the fixings [the dates] of the festivals, and [the law of] *chametz* and *matzah* on Pesach — [transgression of which entails] the prohibition of *kares* [excision]; and likewise there is this severe punishment [*kares*] for eating on Yom Kippur. [NOTE: *Yesod Olam* here explicitly attributed to R. Yitzchak Israeli — flagged per handoff, attribution disputed within this work.]

Therefore we are all obliged to search after it [this science] and to scrutinize it with all the strength of our power, so far as is possible; and let it not enter [your mind?] that, after [knowing?] the tradition of Chazal, it suffices [merely to know] that the [length of the lunar] month is, as it were, 793 [chalakim] [תשצ"ג] — that is, 29 [days] [and?] [12 hours and 793 chalakim] [29-12-793, the molad] — and the surplus [of the year?] is 12[h?] and the surplus [—] 10[?] [?], [namely?] 12-793 and the surplus [— text degraded —] [the mnemonics of intercalation:] גו"א אדז"ט

[GU"Ach ADZ"T — the standard intercalation-mnemonics: the leap years 3,6,8,11,14,17,19 of the cycle, and the *molad* day-restrictions], and the rest of the signs [*simanim*] of intercalation. Why [should we need] proofs [demonstrations] for the astronomical matters? [— text degraded] — so that we shall not be ashamed [— and so it is in the matter of?] the astronomical matters [?]. For just as the Holy One, blessed be He, [desires?] [that we know His existence — as above —] so too does He desire [that we have] knowledge of His Torah and His commandments; [it] is established [for us], from Scripture, from reason, and from tradition [*kabbalah*], that we are obligated to strive with all the strength of our power to investigate and to inquire, so far as possible, that our intellect may grasp the reasons of the matters and their methods — as the author of *Chovos HaLevavos* wrote in his Introduction, and also in the Gate of [Divine] Unity [*Sha'ar HaYichud*], chapter 2 [*Chovos HaLevavos, Sha'ar HaYichud, ch. 2*].

The fourth [benefit]: as Chazal z"l said in the chapter "Kelal Gadol" [*Shabbos, perek Kelal Gadol*] — a great principle: "Whoever knows how to calculate the seasons [*tekufos*] and constellations [*mazalos*] and does not calculate [them] [— concerning him]" — of him [the verse] says, "[They regard not the work of HaShem,] neither do they consider the operation of His hands; they have not seen [the deeds of His hands]" [— Yeshayahu 5:12]. And it is further said there that there is a command upon a man to calculate the seasons, as it is said: "[Keep therefore and do them; for this is your wisdom and your understanding] in the sight of the peoples [— *ki hi chochmaschem u-vinaschem le-einei ha-amim*]" [Devarim 4:6] — what wisdom or understanding is there in the sight of the peoples? Say: this is the calculation of seasons and constellations. Rashi explained [there] [?] — by [the?] [— his words testifying that this calculation is binding upon us?] [— is it not so?]. [This teaches] that Chazal commanded us to calculate and to know the revolution of the constellations [— the cycle of the *mazalos*].

The fifth [benefit]: that the gentiles, by seeing us [— deficient?] in the science of astronomy, [— wonder at us?] [— and revile and reproach and shame us]. And they say: "This is the great nation, of whom Scripture said only 'a wise and understanding nation' [— *am chacham ve-navon ha-goy ha-gadol ha-zeh*] [Devarim 4:6]?" — and what will become of us on the day when the sages of the nations [come and] speak to us, and ask of us the reason [*ta'am*] for the order and foundation of intercalation [— and] our tradition [will not suffice]? The proofs will not suffice for us to set our hand to our mouth [— for shame]; [the man?] who [— cannot open his mouth in this matter] [— such a one defaces?] our honor [—] [or the honor of?] our Creator.

שער הראשון — The First Section

שער הראשון — The First Section

In this section it will be explained that the small earth lies beneath four elements and nine spheres. The heavens are the seven firmaments belonging to the seven planets, plus the eighth firmament, the ninth — which is the sphere of the constellations [the sphere of the zodiac] — and the ninth sphere, whose daily motion runs counter to the motion of the [planetary] spheres. It will also treat the poles of the diurnal motion, the axes of the spheres, the location of the northern pole, and other related matters.

סימן א — Siman 1

Here it will be explained what lies beneath the sphere of the moon — namely, the four elements. This proceeds from the lower upward, beginning with the explanation of the first element.

Most of the sages have agreed that beneath the sphere of the moon are found four elements, arranged one above the other in this order. Their conventional sign is ע-מ-י-ם — that is, ע[afar, earth], מ[ayim, water], י (= א[vir], air), ם (= א[esh], fire) [Hebrew mnemonic: the consonants of עפר־מים־אויר־אש, "earth–water–air–fire," from below upward; printed here as a memory-word]. Each one of them encloses the one beneath it on all six of its sides. (The meaning of "six sides": there are four directions — right, left, front, and back — which are the four "corners"; and then up and down. If you prefer, call them the four winds of the world plus up and down, making six in all.) Every corporeal body in the world has these six extremities.

Now I shall set out for you the order of the four elements, their arrangement, and how each surrounds the other, proceeding from the lower upward. We begin with the lowest element, which is the globe of the earth, and then explain the remaining three elements that lie above it, one after another, ascending until we reach the ninth, where we shall treat the nine firmaments and the celestial spheres that lie above [the elements].

The first element is the globe of the earth — the coarsest element, the heaviest, and the lowest of all the elements; it is the depth beneath the rest. Its center is the center of the spheres, like the point within a circle. (The meaning of "center": it is the midpoint of a circle or globe, from which all the lines drawn to the circumference are equal — for the celestial spheres enclose and surround the

globe of the earth on all six of its sides, revolving around it at an equal distance, as will be explained.) You should know that the globe of the earth is round and spherical on all six of its sides, and likewise all the spheres that surround it, as will be explained further on at the head of the Second and Third Sections.

You should also know that, in the opinion of most of the sages, the earth as a whole is at rest, fixed in its place, and does not turn or move from its place throughout all the days of the world — contrary to the view of the disturbers among them, such as Pythagoras [פיטוגאריס = Pythagoras] and his circle, who lived more than a thousand years before our time, and to the recent ones who came near our own day, such as one some eighty years ago [Copernicus, ca. 1543; "eighty years" is approximate and does not fit the date — flagged below] in whose mind it occurred to "put the elephant through the eye of a needle" [an idiom for the impossible], and who darkened [counsel] with words [?] to prove their view — to demonstrate, against the depth of their own intellect [?], that the earth turns in continual rotation while the spheres stand still and at rest. But most of the investigators, and especially the later sages, did not accept this view.

[The text then enumerates topics to come:] the form, structure, and image of the globe of the earth, its ways [?], its boundaries, its surface, its rotation [?], its [length and] breadth; that its measure is seven climes [אוקלימיה = climata]; the three parts of the ancient world and the discovery of the new world [the Americas], with four further parts added to the world [continents]; the longitudes and latitudes of the cities [whose tables show] where their inhabitants dwell — east and west, north and south, and many degrees besides — together with many wondrous matters beyond these. All of this will be revealed and explained to you further on, in the [relevant] section, with God's help.

סימן ב — Siman 2

Explanation of the second element, which is water; and that the water is joined together with the earth so that the two of them form one globe — the globe of the earth-and-water.

The second element is water, whose nature is to surround the earth on every side, as it was at the beginning of creation, when the earth was covered with water on all six of its sides until the third day of creation, when the blessed God said: "Let the waters be gathered together unto one place" (Bereishis 1:9) — against their nature; for by nature the waters, on account of their lightness relative to the earth, are always fit to be at the center, [enclosing] the earth. Yet the blessed God did not create His world to be void; He formed the earth to be

inhabited (Yeshayahu 45:18), to bring forth grass and herb, trees for the garden and the vine, the olive and figs [?], for the benefit of man and the other creatures — fowl of the heavens, beast of the field. (Even the fish of the sea are nourished from the dry land, from the fat of the earth that the rain washes down upon them through the flowing of water; and for the most part they are found only in places near the dry land. It is already known and established that fish in deep waters near the dry land thrive better, and likewise the fish of the rivers that are on level ground.) Therefore the blessed God said: "Let the waters be gathered together unto one place" — this hints (it is hinted here) at the Ocean Sea [אוקי״נוס = Ocean, Greek Ὠκεανός], to which all the other seas are joined, apart from a few small ones that are absorbed into the Ocean Sea as negligible quantities. So the blessed God set [the waters] by His word, as it is said: "He gathereth the waters of the sea together as a heap" (Tehillim 33:7), and they shall no more return by their nature to cover the earth. This is the meaning of what they said, "to the sea he set a bound" — "Thou hast set a bound that they may not pass over, that they turn not again to cover the earth" (Tehillim 104:9; cf. Mishlei 8:29) [?].

You should know that before the gathering of the waters, the earth was a single globe within the midst of the waters, and the waters likewise formed a globe on their own around the globe of the earth — for the earth was covered and enveloped by water on all its sides. (This is the meaning of what Scripture said, that they "shall not return to cover the earth," which implies that originally it was covered with water.) After the command "Let the waters be gathered," a part of the dry land was uncovered, and then the earth and the water together, in their combination, became one globe — for the earth appears and is uncovered out of the water, but not all the dry land in one place, as all the ancients thought, namely that half the globe of the earth is submerged in water. The matter is not so; for all the ancients [who held this] erred and were mistaken in this, as will be explained before us in the Third Section, Siman 26 [?]. Rather, the dry land appears and is uncovered out of the water bit by bit, here and there, on all six of its sides, until the world as a whole — the earth together with the water — forms, in their combination, one globe, suspended (as we [shall explain]) within the air, by His word [?].

By His word, the Holy One Blessed be He [made] the dry land in the northern quarter [?], on which we dwell — and this is the meaning of "He stretcheth out the north over the empty place, and hangeth the earth upon nothing" (Iyov 26:7), as is explained there at length, "upon nothing" (בלימה) [?]. The commentators have further treated this in the Third Section, with God's help.

סימן ג — Siman 3

That one is not to investigate the reason and cause of why the globe of the earth, and the air, [hang] in the middle of the air upon nothing.

Know that many investigators have inquired into the reason and cause for the earth's being suspended in the air upon nothing. Concerning the [empty] place there are those who say that the heavens push it away from every side, and thus it remains in the middle. I have also seen in the book *On the Heavens and the World* [De Caelo et Mundo, of Aristotle], in the second treatise [?], fourth general [chapter], sixth chapter, where he discourses at great length on the reason for the earth's remaining in the center, and where one finds yet six more reasons. But to my mind they are all worthless and vain, mere imaginings of the mind, and I have therefore not wished to copy them and set them down in my book; for in truth such matters do not fall to me, the master of the science of astronomy, just as it does not fall to us to know the cause whereby the whole globe of the earth is at rest — even to the point that there are found people who walk upon it, on all six of its sides, so that the soles of the feet of those people are opposite the soles of our feet [the antipodes], as will be explained before us at the head of the Third Section in Siman 55 [?].

There is no cause for wonder that those people do not fall downward, for the Lord, blessed be He, is all-powerful: He does great things past finding out, marvels without number (Iyov 9:10), as also with Yehoshua, who said, "Sun, stand thou still upon Gibeon" (Yehoshua 10:12). All these matters lie outside nature and beyond the human intellect, and it is not for us to investigate the reason and cause — neither the rising of the waters [in the Flood], nor the standing still of the sun, nor how God brought about [such] miracles — just as it is not for us to investigate the creation of the heavens and the earth. Concerning this it is said, "It is the glory of God to conceal a thing" (Mishlei 25:2).

The sage [Yitzchak] HaYisraeli [R. Yitzchak Yisraeli, author of *Yesod Olam*] already wrote, in the first chapter of the second treatise of the book *Yesod Olam*, regarding the inquiry into "how the heavens and the earth were created": just as it is not for the goldsmith — even though he is a master craftsman who produces vessels of gold and silver — to inquire into the substance of his work, "from what thing it was created and in what way the four elements are mingled in it," so it is not for the master of astronomy to investigate and inquire into the creation of the heavens and the earth, namely how and from what they were created. For this inquiry does not fall to the sages of astronomy, nor does astronomy profit thereby; and moreover it is "deeper than Sheol," so that the whole intellect of the

human heart cannot attain it. Thus far his words. [Citation: *Yesod Olam* of R. Yitzchak Yisraeli, Treatise 2, ch. 1 — Yesod Olam attribution noted as disputed in this work; flagged below.]

סימן ד — Siman 4

Explanation of the third element, which is air, and that it divides into three parts.

The third element is the air, or wind, which surrounds the element of water on every side. In this lower world there is never found any empty place void of one of the elements; for nature ever rejects a vacuum [?], and the heavy [element] expels [it]. Thus, when you take a vessel full of air and stop it up and submerge it under the water, the water cannot enter because of the air. Likewise the air [enters] a vessel emptied of water, filling it because of its lightness relative to the earth.

Although the existence of the element of air is attested neither by the sense of sight nor by the sense of touch — as the first two elements are — it is nonetheless perceptible in many and various ways. Know that many of the ancients, and also some of the later ones, say with one accord that the wind which blows upon us, which we perceive in it [?] at a [given] hour, is not [identical with] the element of air; for the element of air, like the rest of the elements, stands fixed in its place above and does not descend downward like a shadow [?]. So too R. Yitzchak Abarbanel [אברבנאל = Don Yitzchak Abarbanel] revealed in his commentary on the first verse of [Parashas] Bereishis, folio 73, column 3 [?]. But I [the author] neither know nor have ever heard a clear proof of this; and for this reason it appears that the mind of the intelligent man is not at ease with this view.

Know further that the ancients, as well as all the later ones, agreed that the element of air divides into three parts, one above the other, each part surrounding its fellow like the celestial spheres. (These three parts of the air differ in the four qualities — cold and hot, moist and dry.) The part nearest the sun is the hottest, and the part farthest from it [is the coldest]. For this reason some say that the uppermost of the three parts of the air, being near the sun, is hot and dry, far more so than the two parts beneath it; and accordingly it would follow that the middle part should be hotter than the lowest, third part. But they are not so [in this view]; [others] said that the lowest part of the air is hotter than the middle part — for when the sun's spark goes forth in its might and shines with great force upon the globe of the earth, the spark of heat then penetrates upward from the surface of the earth and heats the part of the air nearest us, as

will be found before us in the Sixth Section, Siman 159, in the general [discussion]. Those who hold this judged that the middle part is the coldest of all; and they ruled that in this middle part the waters are cooled and condense into snow and hail.

All these matters, however, are not matters of astronomy; they are merely matters of inquiry [physics] and the disputations of the philosophers, with which we have no business at all.

סימן ה — Siman 5

That the air divides into ten different senses, and the distinction between *nefesh*, *ruach*, and *neshamah*.

But know, regarding the meanings of "air" — which is called in Scripture *nefesh*, *ruach*, and *neshamah* (even though it has no [literal bodily] place) — know, by the way, that according to my close examination of how Scripture uses [these terms] in the [sacred] books, I labored and found that *ruach* divides into ten senses:

1. **The first:** the wind that blows upon us every day, and in all the [seasons of the] year — as "an east wind" (קדים), "a strong sea wind" (Yonah 1:4; cf. Shemos 14:21).

2. **The second:** it is the air itself — for *ruach* and *air* are one (even though, among the philosophers, according to what I have found in the book *On the Heavens and the World*, there is a great distinction between *air* and the *spiritual* [*ruchani*], for when the air moves and blows it is called *ruach*, and when it [is still] it is called *air*). I have found some support for this in [the book of] Iyov, ch. 41 [verse 8] [?]: [Aramaic/Hebrew citation, garbled — flagged below].

The commentators among the scholars [?] have explained it among themselves [?]; but I have not [fully] grasped their explanation [?].

3. **The third:** *ruach* in the sense of prophecy or [the spirit] that an angel gives at the command of the Lord — as "[I will] put My ruach upon them" (cf. Bamidbar 11:29), "Thy holy ruach" (Tehillim 51:13), "the ruach of the Lord shall rest upon him" (Yeshayahu 11:2); "He maketh His angels ruchos [spirits/winds]" (Tehillim 104:4).

4. **The fourth:** *ruach* in the sense of *neshamah* [the breath of life] — as "all flesh wherein is the *ruach* of life" (Bereishis 6:17 [?]); "they return to dust [unto God]" (Koheles 12:7 [?]).

5. **The fifth:** in the sense of speech — as "by the *ruach* [breath] of his lips shall he slay the wicked" (Yeshayahu 11:4); "[if He] gather unto Himself His ruach…" (Iyov 34:14, "his ruach and his breath," etc.).

6. **The sixth:** in the sense of thought — as "all that is in his *ruach* he uttereth" [?]; "[a fool uttereth] all his ruach" (Mishlei 29:11); "the ruchos of the Lord" [?].

7. **The seventh:** *ruach* in the sense of will — as "wherein there was [another] *ruach* with him" (Bamidbar 14:24); "another ruach… whose ruach made him willing" (cf. Shemos 35:21) [?].

8. **The eighth:** *ruach* in the sense of anger — as "be not hasty in thy *ruach* to be angry" (Koheles 7:9); "[he that ruleth] his ruach [is better] than he that taketh a city" (Mishlei 16:32, "he that is slow to anger… and he that ruleth his ruach…").

9. **The ninth:** *ruach* in the sense of the heart's resolve [?] — as "the *ruach* of the Lord came upon [Yiftach]" (Shoftim 11:29); "the ruach of the Lord came mightily upon him" (cf. Shoftim 14:6, 19) [?].

10. **The tenth:** in the sense of the quarters and winds of the world — as "his kingdom [shall be divided] toward the four winds [ruchos] of heaven" (Daniel 11:4); "for I have spread you abroad as the four winds [ruchos] of the heaven" (Zechariah 2:10). The commentators have explained that the quarters were called *ruchos* [winds] because the winds come from there.

The distinction between *nefesh*, *ruach*, and *neshamah*: [Rabbi Avraham] ibn Ezra [הראב״ע = R. Avraham ben Ezra] wrote, of blessed memory, in his comment on the verse "And I have filled him" [?] [Shemos 31:3] — appearing twice [?] — and likewise elsewhere [?]:

- **The *neshamah*** is the wisdom and seat [of intellect], in the brain of the head; from it issue the perceptions [senses] and the motions of the will [?].
- **The *ruach*** is in the heart, and in it is the life of man; it ever seeks dominion, to gain mastery over what stands against it, and it is the seat of anger. So Scripture said, "Be not hasty in thy *ruach* to be angry"; and likewise, "all his ruach a fool uttereth."
- **The *nefesh*** is in the liver, and it is what desires to eat; thus Scripture says, "thy *nefesh* desireth" [Devarim 12:20], and from it [comes] the desire for [carnal] union. Thus far his [ibn Ezra's] words.

סימן ו — Siman 6

Explanation of the fourth element, which is fire; and the property of the cohesion [adhesion] of the elements one to another.

The fourth element is fire. So have all the investigators among the ancients written, that the element of fire surrounds the air, separating between the sphere of the moon and the air. You should know that these four elements just mentioned differ greatly from one another according to their nature. Inasmuch as the celestial spheres are clear, transparent, and pure — like sapphire, as will be explained shortly — each element accordingly [partakes of clarity] in proportion to its nearness to the spheres: fire, being nearest of all to the spheres, is therefore the clearest of all; air, being next-nearest to the spheres, is clearer than the two [below it]; water is clearer than earth; and earth, being farthest from the spheres, is the coarsest [least transparent] of all.

[Marginal/inset note, p. 22: see *Yesod Olam* of R. Yitzchak Yisraeli (הר״י), regarding the order of the four elements — flagged below.] [?]

Of these four elements just mentioned, you should know that each one of them, when it is in its natural place, [stays at rest, and is] quick to return to its natural place [if displaced]. Know also that none of them moves from its place unless [forced] by some external compulsion. Two of the four elements just mentioned are opposed in their nature to the other two: the two heavy elements, water and earth, are by nature [inclined] to go from above downward; and so it is when, for example, a stone of earth is forced upward by some compelling agent [as when thrown] through the air — for the compelling force does not rest or cease until it returns the stone to its place, namely to the [globe of] earth. The other two elements, the light ones — fire and air — have the contrary nature of motion, going from below upward, as we see that fire and smoke rise upward and return to their natural place. So too is the nature of air: for if you take a skin-bottle filled with air and stop up its mouth and force it under the water, then when the compelling agent [is removed] from it, it will rise of itself upward.

The properties of the cohesion of the four elements one to another: these are they. Fire has but one bond with the elements adjacent to it, for it adheres to air alone and not to its [non-adjacent] neighbor; water and earth each have two bonds — water adheres to fire [?] and to earth, and earth has [a bond] only with water; and air has three bonds, for it adheres to fire, to water, and to earth. The cohesion of air with water is greater than its cohesion with fire, and its cohesion with earth is greater than its cohesion with fire [?]. But of these matters too I shall

say no more, for they likewise are not matters of astronomy; they are merely matters of the philosophers, with which we have no business.

סימן ז — Siman 7

That the later ones deny the element of fire above [the air] entirely.

Now you, [O reader], know that all I have said above regarding the heavens [?] and the earth [?], concerning the matter of the element of fire, is all according to the opinion of the ancient investigators. But you should know that among the later investigators are found great and famous men who deny the element of fire entirely, saying that if there were an element of fire above [us], the matter would not be as we [find it] — for the sphere of fire would necessarily illumine our air for us every night. And although this is no [great] difficulty — since the philosophers have already [established] in truth that the fire of our element [terrestrial fire] is not [itself] luminous, for it is only [the spheres are luminous] like the other heavenly spheres, which are themselves transparent, clear, and pure like sapphire, so transparent that they do not [obstruct nor interrupt] the light of the stars; [thus, the sphere of fire too may be non-luminous] — nevertheless we have grounds to ask of them: "Give us a sign! Just as the other heavenly spheres have stars [borne] upon them, so the element of fire [should have signs], which is not so." This is treated shortly in Siman 12 [?]. But the element of fire has no [stars], and therefore there is no clear proof that an element [of fire] exists at all above [the air]; and their view is that all that lies from the earth up to the sphere of the moon is entirely air, differing only in the four qualities according to its nearness to, or distance from, the globe of the earth or the sphere of the moon. [Cross-reference: see *[Yesod Olam]* of R. [Yitzchak Yisraeli], regarding the number of the element of fire [?], Section 11 [?].] [?]

So [the later ones argue], inasmuch as we see that there is but one [continuous] sphere of air and not several [distinct] spheres of fire [?] — as in the verse "and there was not one [?]" [Bereishis 1:9] [?] — Yisrael [the people / a scholar named?] [?] and Ptolemy [פולוסמאיר = Ptolemy?] [?] in his book *Yesod* [?], chapter 6 [?]: also among the deniers, [who hold] that there is no sphere of fire above [flagged — heavily degraded passage]. [?]

It also occurred to me to add [a thought] [?] regarding the sphere of fire [?] — but [Don Yitzchak] Abarbanel already revealed [?] this in his commentary on [Parashas] Bereishis, folio 73, column 3 [?]; and likewise the questions [arising from] the verse "and there was not one [place]" [?] — [Rashi] of blessed memory, in his comment on the verse of Bereishis, "Let there be lights" [Bereishis 1:14] [?],

folio 3, column 3, and folio [4 (ד)] [?]: that the word *me'oros* ["lights"] is [written defectively] [Rashi: it means a day of pestilence/curse — אֵרָה?] [?], who says there that there is no element of fire [?], for the heat of the sun is the very thing that produces [heat], so that it follows necessarily that fire is not a part of the elements [as a separate sphere]. [Heavily degraded; reconstruction tentative — flagged below.] [?]

Rather, fire is mingled and dispersed [?] only in the three [other elements] — earth, water, and air — and you find them mixed and near [one another]; for there are within the belly of the earth springs and depths [of fluid], and there go forth [vapors] from valley and mountain [?]; and there are found in the clefts of the earth and in its caverns much [pent-up] air, on account of which there sometimes occurs an earthquake in the earth. He [Abarbanel] expounded this at greater length [explaining] whence it comes forth and from what. Thus the matter has reached us [?].

Concerning the existence of the sphere of fire, know that, according to what we find regarding the root and origin of the matter, the sages, in their philosophizing, are followers of the words of Aristotle [ארוש״טו = Aristotle], the Greek [?], who [held] that we may rely, for the most part, on [the existence of] the things found beneath the sphere of the moon more than [?] [those above]. Therefore the investigators among the [gentile] nations confirmed it [?] before us, and the [later] sages too believed it. Now I, the writer, have grasped onto and followed after him [Aristotle] in this matter, drawn after the philosophers of our own time. I asked, inquired, sought, and searched along my way concerning the existence of the sphere of fire; I labored from [my own] mouth [?] [exerting myself], but I found nothing in the matter — neither clear proof nor demonstration, nor anything of substance at all.

סימן ח — Siman 8

The number of the planets, their names, their order, and the time [of their revolution].

From the elements just mentioned, [we now ascend]. Above [them] are seven celestial globes, one above the other, belonging to the seven planets. These are they: שב״תאי [Shabbtai = Saturn], צד״ק [Tzedek = Jupiter], מאדי״ם [Maadim = Mars], חמה [Chamah = the Sun], נוג״ה [Nogah = Venus], כוכ״ב [Kochav = Mercury], לבנה [Levanah = the Moon]. (Their mnemonic, in this order from above downward, is שצ״ם חנכ״ל [shatzam chanchal — the initial letters of the seven, top to bottom]; this is their order and sign.)

But we shall come to their explanation from below upward, in a small and brief presentation, beginning with the Moon, which is near and close to the elements just mentioned, and nearer to us than all the other planets.

The Moon — the first of the seven planets, the one nearest to us — is called *Levanah*, because of its whiteness, as Radak [רד״ק = R. David Kimchi] wrote in the root *l-b-n* [לבן]. It is also called *Yareach* (ירח); thus is the new month called by its name [chodesh / yerach], because the precise term for the period of the month is *yareach*. [The luminary itself is called *yareach* for up to three days, and then for many days [?]] — and because the moon renews itself each month, the time of the month is called *chodesh* [from חדש, "new"]. Some say the reverse: that the proper name of the luminary itself is *yareach*, and accordingly this period of the month is called *yareach* on account of the moon that renews itself each month.

The revolution of this planet [the Moon] in its sphere — a complete circuit of its sphere — is in 27 days and some hours [?], in approximately 27⅓ days [27 days and about 8 hours], as will be explained before us in the Eighth Section, Siman 263 [?] and Siman [?] 273 [?].

The second [planet], called Kochav [Mercury]: we have already found that they call it *Kochav HaNoga* [?] [no — *Kochav* alone]; and indeed it is called *Kochav* simply [the "planet" par excellence] [?]. As for "the man" [enosh] — [there are] those who call it by the name *enosh*, the human man [?]; we have found many witnesses [in Scripture] that it is called by a rhetorical name, as we find [?] [in the phrase] "[the star of your god]" [Amos 5:26?] [?]; and so it is called the planet *Kochav* [Mercury]. The commentator of Rambam in *Hilchos Yesodei HaTorah* wrote that there is one [authority] who calls it [by a certain name]; and so I, the writer, found it in other books. The reason [for the name *enosh*, "man," "the wise"]: it is established that all those born under the dominion of this planet [Mercury] at the hour [of their birth] are wise men, men of understanding, of refined intellect [?], scholars, learned, writing and composing [authors]. The revolution of this planet in its sphere is in 365 days, like the sun [?], approximately, as will be explained shortly [Siman 271 (?)].

The third [planet], called Nogah [Venus]: [so called] after its brightness [zohar], because Venus is more brilliant and shining than all the stars of heaven, after the sun and moon. In the book of Yeshayahu, chapter 14, it is said, "How art thou fallen from heaven, O Heilel ben Shachar [Lucifer, son of the morning]" (Yeshayahu 14:12); and all the commentators have explained that this is the morning star [?] — and it is the planet Venus, as will be further explained before us in the Tenth Section [?], where we shall expand upon it somewhat. This planet

completes its revolution in its sphere in approximately 365 days [?], like the sun [?], and a fourth [of a day] — like the sun.

The fourth [planet] is the Sun [Chamah]; it is also called Shemesh. It is called *Chamah* because heat [chamimus] comes to be through it, as Radak wrote in the root [ח־מ־מ]; and it is called *Chamah* [as will be explained before us in the Sixth Section, Siman 154 (?)]. [The verse] "[the sun] which knoweth not [where] to rise [?]," and "the sun shall not rise [?]" — this is the planet called *Cheres* [חרס, an archaic name for the sun] [cf. Iyov 9:7; Shoftim 8:13 (?)] [?], according to [the commentators] [?]. The time of this planet's revolution in its sphere, according to the knowledge and reckoning of the later astronomers, is 365 days and some hours [?] — and according to the view of our Rabbis of blessed memory, by the reckoning given by R. Adda bar [Ahava] [?], it revolves [completes its year] in 365 days, [6 hours] [?], and 997 chalakim [997 = תת״קצז] of an hour, that is, 48 [?] regaim [רגעים] — [a chelek of an hour being subdivided into 76 regaim]. The matter of the [length of the] year will be treated in the Seventh Section, Siman [?], at its head, and shortly we shall bring it [in Siman (?)].

The fifth [planet], called Maadim [Mars]: it is called *Maadim* ["the Reddener"] because of its redness [?], for [the ancients] call it [so] on account of [its color], and also because it rules over [matters of] blood [?], as we find in the words of Chazal at the end of the chapter [?] [Shabbos 156a, "He that is born under Maadim…"], that this is "Kochav Maadim" [?]. The revolution of this planet [Mars] is in two years and a half.

The sixth [planet], called Tzedek [Jupiter]: it is called *Tzedek* ["Righteousness"] because it rules over the judges and over [matters of] justice [tzedakos] — for which reason it is called in the Hebrew tongue [Tzedek], as it is said in Yeshayahu, chapter 64 [?], "[that prepare] a table for Gad" (Yeshayahu 65:11) [?]. Ralbag [הרלב״ג = R. Levi ben Gershom] explained, on the root [ג־ד] [?], that this is the planet Tzedek [Jupiter], which portends every good thing — for so it is called in the tongue of Kedar [Arabic]; and he said, "[when it appears in the house of (?)] Gad" — and there went forth [the phrase] "in good fortune" [be-gad, "fortunately"], and [it means] "good mazal" [fortune]; and so he explained there [?]. I have likewise found in a [text] [?] that the reason our Rabbis [of blessed memory] said that on the fourth and fifth [days of the week (?)] the [students] sit [?] [Kesubos 5a (?)], [namely] that those days fall under the dominion of the planet Tzedek [Jupiter] — that is, from the beginning [of the night], from the night and the prayer of the second [day (?)] until the fifth day, as will be explained before us in the Fourth Section, Siman 98 [?] and Siman [?]: "[Thou shalt judge thy

people] in righteousness [tzedek]" [?], and "He shall judge thy [poor] with justice [?]" [Tehillim 72:2] — [all this is connected] because the day [is under] the dominion of Tzedek [Jupiter]; and it is the planet Tzedek [?]. [The verse] "[the heavens declare] the righteousness [tzedek] [?]" — and that is the planet Tzedek [?], etc. Its revolution it completes in twelve years.

The seventh [planet], called Shabbtai [Saturn]: [so called] from the language of *shevisah* [rest/cessation], because [?] [its motion is slow] [?]. [Final two lines heavily degraded — flagged below.] [?]

Section 1 (שער א), continued

[End of Siman 8]

[Top of p. 25 continues the discussion of Saturn, the last and slowest of the seven planets.] It is as though it scarcely moves at all. This is what gives Saturn the appearance of being the most sluggish of the wandering stars: its motion within its own sphere is so slight as to be barely perceptible, for it completes its circuit through its sphere only once every thirty years. The closest reckoning, then, fixes this as the order of the seven planets.

In most of the astronomical books, however, you will find their order and reckoning [listed] from highest [downward] — the order given by the mnemonic שצ״ם חנכ״ל (Shabbtai, Tzedek, Maadim; Chamah, Nogah, Kochav, Levanah — Saturn, Jupiter, Mars; Sun, Venus, Mercury, Moon), as set out at the head of this [section]. *End of the siman.*

Siman 9 (סימן ט)

Why each of the wandering stars was assigned its own distinct firmament, and why they are called "wandering stars."

Know that the ancients determined, from observation, that each of the seven wandering stars is set in a firmament of its own — that there are seven heavens, one for each — and the reason for this. They saw that each of the seven has a motion of its own, a known and distinct course that is unlike the motion of its neighbor. This appears, among other things, in the differing periods of their revolutions: some complete a circuit in as little as twenty-seven days, while others — at the far extreme — take a [whole] year, some twelve years, some about thirty years. It was for this reason that they were called "wandering stars": each of them was seen to have a distinct course unlike that of the stars of the eighth sphere [as will be explained below]; and it is impossible for a single body

[to account for all of them] at once, [since they cannot all be lodged in] the seven [spheres] at one time.

Moreover, by observing each of the seven wandering stars they saw something further: at one time a planet draws nearer to the terrestrial globe and at another it recedes from it by many thousands of parsa'ot [Persian leagues]; sometimes it appears ahead of the Sun and sometimes behind it; in part of their course they appear to advance, and at other times they appear to retreat; sometimes they appear to stand still. It was on account of [all] these [irregularities] that they were called *nevuchim* — "wandering" / "perplexed" — like a man who is confused and bewildered, who at one moment walks forward and at the next turns back.

In order to clarify and explain why each of the seven wandering stars [needs] its own distinct firmament — for it is impossible to account for all these variations and rule upon them otherwise — I will now disclose to you the reasons for all these variations, as will be explained in Section 8 below, with God's help.

Siman 10 (סימן י)

The eighth sphere, called "the sphere of the fixed stars" or "the sphere of the zodiac," and its motion.

Above these seven firmaments mentioned above is the eighth firmament, which is called "the sphere of the stars" or "the sphere of the constellations [mazalot]," in which all the rest of the stars of the heavens are set — both small and great, beyond counting; not one of them stirs [from its place relative to the others]. Because the stars set in this sphere always appear to us at one and the same distance from the terrestrial globe, and the stars themselves keep one fixed measure of distance one from another — never appearing [to undergo] any of the variations [described] above — for this reason [the ancients] called it differently from the other [spheres]. They did not wish to add another firmament beyond the firmament of the fixed stars; and because [this firmament] is itself the firmament of the fixed stars, it is reckoned among the spheres of the [moving] stars [only loosely]. It is also called "the sphere of the constellations [mazalot]," for a reason that will be explained below at the head of [its] section.

[Cross-reference / running header notation: see Section 5, siman 127.]

Siman 11 (סימן יא)

That all seven wandering stars, together with the stars of the sphere of the constellations, are all caused to move from west to east by means of their spheres.

You must [now] understand the courses, motions, and revolutions of the seven wandering stars by means of their spheres, together with the motion of the eighth sphere [in which] they are set. We have already spoken of them just above, and we have made known to you the fixed period [appointed] for the revolution of each one [of them].

From this [it follows] that all their revolutions and motions are [proper] from west to east — even though in fact we see, day after day, that the Sun and Moon, together with the other wandering stars, rise in the east and set in the west. [This is why] you must understand that the motion of the eighth [sphere], together with [all] the firmaments mentioned, [carries] all their stars — every star, together with all the fixed stars — in the period [God] appointed for it, as stated, from west to east.

And since this matter is somewhat strange in the eyes of beginning students who are learning the science of astronomy, I have seen [fit] — even though its [proper] place is [elsewhere] — to explain the matter to them here, [drawing] on the course of the Moon's revolution. This is well known: that just as within twenty-four hours the Moon, at the start of [the lunar month], is then seen in the southwestern corner [low above the horizon], and on the second night [of the month] it has moved a little [farther] east, [appearing somewhat higher] in the south... [the remainder of this concluding example is partly degraded].

[The bottom lines of p. 25, describing the night-by-night eastward displacement of the young Moon, are degraded; transcription is partial: …the Moon, having been [at first] [?] …and so it recedes farther [eastward] [?]…]

[p. 26 — continuation]

toward the east, and likewise [for] all the [other planets]. So too the whole reckoning of the days of the month, [and] the whole judgment [of these matters], [shows that the Moon] keeps receding farther and farther from [its first] position, drawing away from one [point of] distance to another farther [point], so that you see it appearing to move from west [to east] in the manner described at first. This matter will be explained to you more fully in the section below, [with God's help] — [Section 6 [?], where it will be explained] in greater detail. The same rule holds

for the Moon [as for the rest]; and as for the [other] wandering stars, the same will be explained to you below in Section 8, siman 26, with God's help.

There is more to know: that this motion, which is from west to east, is called in the [astronomical] books "the proper [essential] motion" or "the natural motion" [תנועה עצמית / טבעית], for this is the [intrinsic] course, revolution, and movement belonging to the very nature of the wandering stars themselves, without anything compelling or forcing them. And the revolution of the Sun, the Moon, and the other wandering stars — together with [the motion of] all the rest of the stars set in the eighth [sphere], which we see day after day rising [in the east] [and] setting in the west — [this] is the opposite of the perceptible motion just described; this revolution is called "the motion of compulsion" [תנועת הכרח / "the forced motion"], as will be explained just below.

Siman 12 (סימן יב)

The ninth sphere, called "the sphere of daily motion," whose motion is the opposite of the motion of the eight spheres mentioned above.

Above the eighth sphere, some of the sages who lived in [later] times determined [the existence of] a ninth sphere, which some of them called "the partless sphere" [גלגל החלק], since no star [whatever] is visible [in] it — and this is the view of Ptolemy [בטלמ״יאוס] and the majority of the ancients who follow [in the matter of] this sphere. For [they hold] that it revolves about its center, which is the center of the earth, from east to west [in] a complete revolution in about twenty-four hours, just as [will be explained]. And they say that the Holy One, blessed be He, in His great power, set it [over] all the eight spheres mentioned above, [making it] sweep all of them along with their stars, [carrying] them in its course [as] a mighty force, [completing] the world once in each [revolution].

This revolution is called, among the sages, "the upper motion," and it is also called "the daily motion" [התנועה היומית], as will be explained. The sages determined a distinct sphere for this revolution even though there is no [visible] proof of it as there is for all the other spheres mentioned — whose stars bear witness to them — because [they held that] the intellect itself testifies to its existence, [given] what we have seen with our own eyes: that all eight spheres [have] their own proper motions from west to east, and we [also] see in them an opposing motion, [carrying them] from east to west each day. It is impossible for a single body to move itself by two motions at one time, even toward a single direction — all the more so toward two opposing [directions].

The ancients further said that the one [motion] is [the body's] own [motion] from its own [nature], while the other comes from [an external] mover and compeller. Therefore they determined a distinct sphere [lying] above the eight spheres for the daily revolution, and they said that it is the [agent of] the [daily] movement and the bearer of all eight spheres beneath it, sweeping the world along once each day. This motion is called "the necessary [forced] motion," for in their view this sphere drives and compels all eight firmaments, together with their stars, [to share] in this very motion.

You must [also] understand that by reason of these two motions mentioned — the voluntary [proper] and the necessary [forced] — when they combine together, there arise [from] them day and night, summer and winter, the seasons of the year and its cycle, and other things besides; [things] which could not possibly come to be except through the combination of the two motions together, as will be explained, with God's help, in Section 6, siman 134 [?]. [Cross-reference: Section 6, siman 134 [?].]

Siman 13 (סימן יג)

An explanation of [how] two opposing courses [are to be reconciled].

In order to reconcile and settle [the problem of] these two opposing revolutions, [we must] explain [it], for it is very hard to conceive. The sages [of old] have already [offered] their analogy, comparing it to a man walking within a ship as it crosses the river from west to east: even though the ship is itself going from west to east, that man [may be] walking [in the opposite direction], from east to west [along the deck]. [And another:] [the case of] an ant walking on the wheel of a wagon [as the wagon goes] from west to east.

Know, however, that my mind is not [fully] satisfied with this argument, because the case under discussion is not [truly] comparable to the proof [adduced]. For it is established with us that [a star] is not a body that moves of itself; rather it moves only by virtue of the sphere [in which it is set]. The sages of Israel conceded as much to the gentile sages with respect to [the case discussed] in [the Talmudic] chapter "Lo Yachpor" [?]... [the immediately following Talmudic citation is degraded].

[Aramaic / Talmudic reference, partly degraded: ...in the chapter beginning "Lo Yachpor" [?] (cf. Bava Batra) — the matter of whether the daily sphere meets, holds fast to, and compels the sphere beneath it...] — [the daily sphere] meets and compels the sphere beneath it, [the question being] how the daily sphere can be conceived [to operate].

[The point is] how the [forced] daily motion, [running] from east to west, can be conceived [together with] the [voluntary] motion by which the sphere revolves of its own [accord] from west to east. This is comparable to a man whom the king has ordered and commanded to go east — for it is impossible for [anyone] to go both east and west at once [as] one man. [So too,] in the end, there is a difficulty as to how it can be conceived that one sphere revolves [in] two opposing motions at one and the same time, whether [the one be] voluntary [and] the [other] necessary.

Many among the early and the later [authorities], who labored at [this problem], grew weary [over it]. We will resolve and settle this perplexity according to our own understanding, [insofar as we are able] — and may we be guarded against [error]. We will come from [this] to [the matter] adjacent [to it]; and there we will rouse [discussion of] a great and weighty perplexity, [namely] the second one, which together with [the first] they will settle and resolve as one.

Siman 14 (סימן יד)

How it can be conceived that a single body sweeps eight bodies [contained] one within another.

Regarding the matter of the [forced] daily motion — by which the daily sphere, in its power, sweeps all eight spheres beneath it, [carrying] the world along once each day, [as stated] above — we have, in like manner, a great and weighty perplexity over [the question] of how it can be conceived that a single sphere, in its power, [can] sweep eight spheres that are within it.

For [the matter] does not stand to reason except [as it does] with respect to the motion of the sphere of the [fixed] stars alone, [the eighth,] which is adjacent and joined to it [the ninth] — [there] we must [grant] to our intellect [the difficulty]. But [as to] the rest of the spheres — the seven [planetary spheres] — which the daily [sphere] does not [directly] touch or meet, [reaching them only] by [intermediary] force [transmitted] down to whichever [sphere] it [actually] drives — [its] conception is hard. Should it occur to anyone to say that each sphere meets [and compels] the sphere beneath it, driving it toward the daily motion — so that the daily sphere drives the sphere of [fixed] stars, the sphere of the [fixed] stars [drives] the sphere of Saturn, the sphere of Saturn [drives] the sphere of Jupiter, [the sphere of] Jupiter [drives] the sphere of Mars, and so on down to the sphere of the Moon — [then] there is [more] to ask of him and to say: namely, that according to [this], each sphere [must] drive the sphere beneath it toward the necessary [daily] motion.

If so, then it [would] follow accordingly that each sphere [must] also compel the sphere beneath it toward its [own] voluntary, proper motion; and it [would] follow [further] that the sphere of Saturn [must] compel the sphere of Jupiter toward its [own] voluntary motion, and Jupiter [the sphere of] Mars, and Mars [the sphere of] Mercury [?] — and so down. This very difficulty was already raised by the sage R. Yosef Albo [ר׳ יוסף אלבו] in the *Sefer ha-Ikkarim* [Book of Principles], in the third [discourse, [drawing] on] the fourth [discourse [?]] — yet he [offered] no resolution upon it at all; he merely concluded and said: "The human intellect does not suffice to comprehend this matter."

[Cross-reference: Section 6 [?], siman... — see below.]

[p. 27]

However, O reader, know for certain — [in light of] what I have set before you [above] — that the eminent astronomer who sits before our lord the Emperor, may his glory be exalted, [namely] Rudolphus [רודולפ״וס — Rudolf II], called Johannes Kepler [יוהניס קאפליר״וס — Johannes Kepler], [whom I consulted,] told me and answered me — [the very thing] that he holds [to be] established: that each sphere of the wandering [planets] drives the star beneath it [in] its proper motion. [Take] for example the star Saturn, [then] Jupiter, [then] Mars [צד״ק שבתאי מאדים — Saturn, Jupiter, Mars [in their order]], whose courses are [such] that Saturn travels each month about one degree, Jupiter revolves about two and a half degrees each month, and Mars twelve degrees.

Let us now say that the head [reference point] of Saturn's sphere revolves in one month up to a [marked] point A [letter aleph] traced [on the sphere], and that it draws Jupiter's sphere along with it. In that [same] month, Jupiter's sphere revolves [both] by reason of Saturn's sphere's motion and by reason of Jupiter's own motion, up to point B [letter bet]; and it likewise draws Mars's sphere along with it. In that [same] month, Mars's sphere too revolves [both] by reason of Saturn's sphere's motion and by reason of Jupiter's sphere's motion, and by reason of its own [proper] motion, up to point C [letter gimel] traced [on it]. Thus you have arrived [at the result] that the star Mars['s arrival] at point C is [due to] three causes: by reason of Saturn's sphere's motion, by reason of Jupiter's sphere's motion, and by reason of [its] own proper motion.

Diagram. A semicircular figure (a half-dome) drawn at the right margin, composed of three nested concentric semicircular arcs rising from a horizontal base line, representing the nested planetary spheres. Three points are marked

along the arcs with Hebrew letters, reading from the outer arc inward and corresponding to the worked example in the text (Saturn → Jupiter → Mars).

- א [aleph] (on the outermost arc, lower left): point A — the position reached by Saturn's sphere after one month
- ב [bet] (on the middle arc): point B — the position reached by Jupiter's sphere
- ג [gimel] (on the innermost arc): point C — the position reached by Mars's sphere

[The diagram illustrates the cumulative-motion argument: each inner sphere's marked point is displaced both by its own motion and by the motions of the spheres outside it.] And as for the analogy [to be drawn] — and the parable resembling [it] — to the fourth cause [pertaining] to the sphere of the constellations [the zodiac]: R. [Yosef] [?] gave [the following] illustration. Imagine a ship crossing the river from west to east. At the moment of crossing, a man walks [along the deck] from one place [to another]; [and consider further] how much time [it takes]. While [the ship moves] from west to east, [suppose] a fly walks along the man's forehead, [moving] from west to east — [or rather] in the [opposite] manner, so that the fly, which was at first at the rear [stern] edge of the river-bank on the west side, is now at the start [forward edge] of the river-bank on the east side.

This [arrival] is [the product] of three causes: by reason of the ship's course, by reason of the man's course, and by reason of the fly's course. So too the voluntary motion of the sphere of the stars [results from several causes joined into] one cause — namely its own motion; while Saturn's motion [adds] a second cause and Jupiter's a third cause; [and the motion of] the Moon's sphere [a further cause] — [amounting] to the eight causes by reason of which the great perplexity mentioned [is to be] well settled, [so that] no difficulty [remains], and there is no [further] objection [against] us.

Siman 15 (סימן טו)

A fine resolution [is to be] explained [here] for the two perplexities mentioned.

And you, O reader, know for certain that — in my humble opinion — it appears that the two perplexities mentioned above [may be settled]: the first, how it can be conceived that a single body [moves in] two opposing courses; and the second,

how it can be conceived that a single body sweeps eight bodies [contained] one within another. [These] may be settled by another approach.

In a true and proper way I say: that each of the eight spheres [may be regarded as] divided into two or three [globes — that is], spheres [nested] one within another. [This] is in accordance with [what I will set out] below in Section 7, siman 187, [where it is shown] that all the sages, both early and later, agreed that within the belly of each sphere [there is set] another sphere — just as, [for instance,] within the belly of the Sun's sphere yet another sphere is set, which is called "the carrying sphere" [גלגל הנושא — the deferent].

[According to this,] we may say that the Sun's sphere, taken as a whole [comprises]: [an outer sphere by which the star is carried] in the necessary daily motion, [a sphere that] revolves [carrying] the star around the world once in about twenty-four hours; and the inner sphere — which is the carrying sphere [the deferent] — that revolves [completing] the [Sun's] course [in] its proper [voluntary] motion. This carrying sphere [the deferent] is joined to it [closely, yet] not [so] joined as [to be] entirely [fused] within it; [rather] it is [set] within the belly of [the outer] sphere — its likeness [being that] of an embryo within its mother's womb.

[For] when the pregnant woman moves quickly, turning and rolling herself from east to west, the embryo within her belly slowly revolves from west to east [relative to her], [and yet] you cannot raise the objection against the embryo [that it is conceived to perform] two opposing motions at one time — for its [eastward-to-westward] motion is [the mother's,] by virtue of another [the mother], while its [own westward-to-eastward] motion is [its own], of itself. And as the judgment [is] with the Sun, so is the judgment with the rest of the wandering stars.

In the same way we may say, accordingly, also with respect to the sphere of the [fixed] stars — that it too [comprises] another sphere [set] within its belly — [so] that, according to this assumption of ours, the second [perplexity is also resolved]: namely, [the difficulty of how] it is hard to depict a single body moving [as] eight bodies [contained] one within another. For according to our [present] assumption, this [difficulty] removes itself: [it is the case that] all eight spheres are [as] linked and joined together [into] one single mass, such that in one revolution [the motion] of [any] one of them necessarily revolves them all together; while the carrying [inner] sphere within the belly of each sphere — each one revolves [in] its [own] voluntary motion, the fixed period appointed for it, [after] the likeness of the embryo within its mother's womb, as stated above.

According to this, then, everything works out well; and we may say [of it] what is written in the *[Sefer ha-]Ikkarim*, that the human intellect does not [suffice] to grasp this matter — [yet] had [its author] possessed the reasons mentioned, he would not have said so.

[Continuation — refinement on Siman 15]

From the matters mentioned, there is [something] to [examine] precisely and to say. [As to] what the astronomers wrote — that the daily sphere, by the great power that the Blessed God gave it, sweeps and compels all eight spheres along with it, encompassing the [whole earth] [?] [once each day,] as stated — according to our assumption mentioned we have no need of this [hypothesis]. For the eastern [westward] motion and the western [?] motion may both be voluntary and natural; and perhaps for this reason there are those who deny [the existence of] a ninth sphere, as will be explained just below, in siman 18, with God's help.

Siman 16 (סימן טז)

A further resolution for the two perplexities mentioned.

Now behold, [as to] what the reader has put forth [?] — according to the view of the great investigator (Tycho [טיכא — Tycho Brahe]), who [held] from his investigations that the sphere of Mercury and the star [Venus] [?] — [these are set on a] fixed sphere, and the star [itself] returns [in retrograde], as will be explained below....

[p. 28]

below, [in] this [present] siman [?]. According to these words, then, there is no [need to] attribute to [the spheres] the two perplexities mentioned just above — [namely], not [a doctrine of] two opposing motions. For [in] this [case] the analogy of the man walking in the ship, or the fly [walking] on the wagon-wheel, suffices for us. For accordingly we may say that the sphere's course is one thing and the star's course another: that the spheres, as a whole, [carry] their stars around from east to west, while the star itself revolves slowly upon the back [surface] of the sphere from west to east. [Thus,] now, [as to] the second perplexity, [namely,] how it can be conceived that a single body sweeps eight bodies [contained] one within another — [this] is void from the outset, since the star [merely] returns [in retrograde] [of itself]. We therefore need not say that each sphere meets and holds fast to the sphere beneath it and compels it toward the daily motion, as [stated] above. Accordingly, both the eastern daily motion

and the western motion [may be] voluntary, and there is no need [at all] for a ninth sphere.

Siman 17 (סימן יז)

Why the ninth sphere is called "the daily sphere," and that it has but a single motion.

This ninth [sphere], of which we have spoken, is called by the sages "the daily sphere" because this sphere brings [on] the day for the world; for by its revolution the Sun rises over the earth and illuminates the day. By the motion of this sphere the periods of the natural days come to be, for by its motion the Sun remains [above the earth] for half a circuit's worth of time — that is, twelve seasonal hours [שעות זמניות] above [the earth], which is the period of [day]light and half [the] period of [its] circuit; and likewise twelve seasonal hours beneath the earth, which is the period of night, [during] which the [Sun is below].

These two periods mentioned are called, in the language of the sages, "a natural day" [יום טבעי — in the language [of the Latins], *dies naturalis* [Latin: *dies naturalis*, "natural day"]]. This is [the meaning] of the matter [in the verse] "And it was evening and it was morning, one day" (Bereishis 1:5) — that is to say, the evening and the morning, when they combine together, were called "one day"; for were it not for the motion of this sphere, there would be in the world six months of [continuous] day and six months of [continuous] night in every clime [iklim], as will be explained below in Section 6, siman 134, 160 [?].

And know that the motion of the daily sphere, which revolves from east to west, is its own proper motion; this sphere has no other motion besides it — unlike the other spheres, each of which has, [along] with its stars, four or five motions, as will be explained below in Section 7 and in Section [9 [?]], siman 81 and siman 201 [?].

[Cross-references: Section 7; Section 9 [?], simanim 81, 201 [?].]

Siman 18 (סימן יח)

Differing views to be made known concerning the existence of the ninth sphere.

Know that concerning the existence of the ninth sphere there are differing opinions and various disputes; and there are three schools [of thought].

The **first school** says that the ninth sphere, which in its power drives all eight spheres, encircles the world in its power [carrying it] from east to west [once] in twenty-four hours, as was explained above in siman 12.

The **second school** likewise [accepts] the ninth sphere, but [holds] — for a reason that will be explained — that it is not a body like the [body of] the rest of the spheres, which are called by the sages "the fifth body" [the quintessence] and are apprehended by means of their visible stars. The ninth sphere is not so; rather it is [purely] a separate intellect [שכל נבדל] or a [pure] power that moves the sphere [though it is] not [itself] embodied. And so [too] is the implication of the words of the sage **Ibn Ezra [אבן עזרא — Avraham ibn Ezra]**, [as] brought in the third chapter of the fourth discourse of the *Sefer ha-Ikkarim*, where he wrote that there is no body above the sphere of the stars. It seems that he means [thereby] that he concedes there is a mover above them, only [that] the [mover's] body is not like the rest of the perceptible spheres; rather it is [purely] a separate intellect.

The **third school** denies [the existence of] the ninth sphere, saying that there is nothing above the sphere of the stars — [that] there is no sphere whatever above it, [as is shown] by the testimony of the eye's sight [?] — and that you may not add anything above the sphere of the stars, [neither] body nor non-body. For in their view the sphere of the stars itself sweeps all the spheres within it [along] from east to west, all in [one] single motion. This is the view of **Ibn [Ezra] [?]** [אבן הש״ד — abbreviation uncertain [?]]; and it is likewise the view of the eminent and learned sage **R. Avraham bar Chiyya [ר׳ אברהם בר חייא]**, as he wrote in his book (*Tzurat ha-Aretz* [*The Form of the Earth*]) at the head of his Section Two. And it is likewise the view of **Ralbag [רלב״ג — R. Levi ben Gershom / Gersonides]**, as he wrote in his book *Milchamot ha-Shem* [*The Wars of the Lord*], [in] discourse [...] [?], where in [its] latter [part] [he held] that it is not fitting to posit a sphere without a star moving [in] it. For the existence of such a motion would be in vain and to no purpose, since there is no benefit in it; and there is nothing among natural things [created] in vain — all the more so among the precious heavenly bodies. For this reason he determined and said that there is no sphere whatever above the sphere of the stars.

In any case, you must know that even if it be granted that there is no sphere above the sphere of the stars, I [nonetheless] say that there is an opposing [eastern] motion — whether [its existence] be by virtue of the [true] causes mentioned just below in simanim 14 and 15, or by virtue of some other cause besides them. It is rightly called, in all the [astronomical] books, "the upper

motion" or "the daily motion," and that is the fitting name for it; and see above at the end of siman 13.

It [also] seems right to say [further] that even if it be proved for certain that there is no sphere above the sphere of the stars, [there are] nevertheless many matters [for which a ninth sphere serves] — such as the possibility [of accounting for] the constellations [mazalot], the [planetary] disappearances [?], and the [tilting / wobbling] [המתמוטטת] [motions], as will be explained below in Section 5, siman 127 [?], and for other matters besides them. We need [it] in order to depict and illustrate [things] for the students, [proceeding] as if a ninth sphere existed — even if it were made known to us with certainty that it does not.]

Section 1 (שער א)

The Form of the Four Elements and the Nine Spheres

Diagram. A large concentric-circle cosmographic figure captioned **"The form of the four elements and the nine recognized spheres."** It is the classic geocentric scheme: at the center is the earth, surrounded by the elemental spheres, then the seven planetary spheres, then the sphere of the fixed stars, and finally the outermost (ninth) sphere. Reading from the center outward, the labeled bands are:

- אש [fire] / רוח [air] — innermost core (the elements; the central disk is the earth, with water and the two named elements above it)
- לבנה [the Moon]
- כוכב [Mercury]
- נוגה [Venus]
- חמה [the Sun]
- מאדים [Mars]
- צדק [Jupiter]
- שבתאי [Saturn]
- The band of the twelve mazalot (zodiac signs), labeled around the next ring with the constellation names: טלה [Aries], שור [Taurus], תאומים [Gemini], סרטן [Cancer], אריה [Leo], בתולה [Virgo], מאזנים [Libra], עקרב [Scorpio], קשת [Sagittarius], גדי [Capricorn], דלי [Aquarius], דגים [Pisces], each accompanied by small star-marks

- The outermost ring is labeled גלגל היומי [the daily sphere] and, near the top, טלה [Aries] / דגים [Pisces] marking the head of the zodiac. The text "צורת... " runs around the rim.

(The figure illustrates the nine spheres discussed in the surrounding text: the central earth and elements, the seven planets, the eighth sphere of the fixed stars carrying the zodiac, and the ninth, the daily sphere.)

Siman 19 (סימן יט) — Some explanation of the accompanying figure

[The text on this point follows the diagram.] In the figure depicted above you can see how the three parts of the earth's surface — **Africa** (אפריק״), **Asia** (אסי״א), and **Europe** (אורופ״י) — together, as a single composite, form a hemisphere; this was explained earlier in siman [?] [reference partly illegible]. Together they make up half of a sphere, with the sea joining them, just as fire and air are likewise drawn together above as the form of a sphere — for all of this, taken together, is one [body], as was explained above in siman 1. [?]

Above the recorded elements are drawn the seven recognized planets, and after them the sphere of the [fixed] stars, and then also the daily sphere. The twelve constellations are inscribed in a row, drawn there twice. The constellations [appear] in two respects. In the upper [ninth] sphere there is no star at all, no single body of any kind — yet the twelve constellations are inscribed there nonetheless, as though all twelve constellations were fixed there. These are called the **fixed constellations**, which neither change nor alter nor move from their place for all the days of the world.

In the second respect, the constellations inscribed in the sphere of the stars [the eighth sphere] are constellations in themselves [i.e., they are the actual star-groups]. But because of the heavy [slow] motion belonging to the sphere of the constellations — as stated above in siman 10, and further on in Section 5, siman 127 — these shift, and change and alter their position by a great and considerable distance. Thus in our own time, in the place where the fixed constellations are found, the head of the constellation Aries — which by rights ought to lie below, in the sphere of the constellations [aligned] opposite [the fixed Aries] just as it once was, and to lie there as the constellation Aries — owing to that shifting, what is now found there is the head of the constellation Pisces. This matter, as it stands here, will be explained well further on. [בתי׳ — partly illegible] [נסקי]

(column, p. 30) — continuation

[Top of p. 30, completing the discussion from siman 19, in Rashi-type secondary column:] [Gloss:...] In the upper sphere there is no star and nothing at all recorded there — only the twelve constellations were [recorded] there. These are called the fixed constellations, which do not shift and do not change for all the days of the world. But the constellations recorded in the sphere of the stars [the eighth sphere], because of the heavy motion, shift and change and alter their position by a great distance — as is explained in Section 2, siman 34, and further on in siman 10 [as above] and in Section 5, siman 127. So at the place where the head of Aries was once recorded in the sphere of the constellations below, owing to that shifting there is now found the head of Pisces — as will be explained well further on. [Gloss ends.]

Siman 20 (סימן כ) — That the bodies of the spheres are like the form of the layers of an onion, transparent, with no opacity between them, and they are like clear sapphires

The bodies of the spheres are like the layers of an onion (גלדי הבצלים) — they have no opacity between them, and they are like clear, transparent sapphires.

Since it is impossible to draw this matter properly upon a [flat] surface — for you cannot draw one shell [layer] over another in such a way that you would actually see the second one [beneath] — you should not picture the spheres merely as the circles drawn on the page above. Rather, picture in your mind that all the circles drawn above on the surface are also represented in front as full spheres on every side, like the layers of an onion, perfectly whole and complete. And picture further that all the spheres of the heavenly firmament are joined in this manner, like the layers of an onion, one clinging to the next, with no empty space and no void at all between them.

The sages have already agreed upon all of this in their proofs, and their signs are many. Although they differed on the matter, what remains established is that there is no void at all in the world. This will become clear to you: each and every sphere touches, in its convexity, the sphere above it, and in its concavity touches the sphere below it. They are joined, the concavity of the upper sphere meeting the convexity of the lower, down to the concavity of the lunar sphere, which touches the convexity of the sphere of fire — according to the view of one who affirms its existence (the sphere of fire), by way of [the element] air.

Furthermore, you should know that the substance of every one of the spheres of the firmament is pure and radiant, like a clear sapphire or beryl. For this reason, all seven firmaments do not block, do not interrupt, and do not impede the radiant rays of light of the stars of the eighth sphere from illuminating us upon the earth and being perceived [by us]. And just as the spheres of Venus and Mercury do not block and do not withhold from us the light of the Sun, so too all seven firmaments do not block and do not withhold from us the light of the stars of the eighth sphere.

Siman 21 (סימן כא) — On the *briach* [axial pole-bar] of the sphere and the two axes and poles of the world

Know that, for every single body — that of a sphere or of a [solid] ball, when it turns and revolves upon one edge and emerges at the second, opposite side — that [line] is called the *briach* (בריח, the axis-bar) [Hebrew: "bolt/bar"], because it runs through [the body] from edge to edge. The scholars and researchers have called it (in Arabic) *quṭr* [קוט״ר, Arabic: quṭb/quṭr, "pole/diameter"]. Some say that it is the "fleeing serpent" (נחש בריח) mentioned in Scripture, in Iyov [Job] [siman/ch....] and in Yeshayahu [Isaiah] ch. 27 [Yeshayahu 27:1]. See the discussion in the first chapter further on, in Section 8, siman 189 [קפ״ט].

The two points at the ends of the axis-bar or pole are the two poles of the world: the one is the northern axis [pole] and the second the southern axis [pole]. The researchers call them the northern pole and the southern pole. About these two axes all nine spheres revolve, every day, from east to west [westward], for the daily rotation. In all nine spheres there is not found even a single point that would be at rest and unmoving — except only for the two points of the two axes themselves, which always remain in their place, [stationary] in their revolution.

To explain this to students, here is an analogy: take a sharpened awl or peg, or a sharpened stylus, and run it through the middle of an apple from side to side, then place the two ends of the sharpened [shaft] each upon a support [a fork], and rotate the ball — that is, the apple — upon it. [Rashi-type continuation, top of next column:] You will then see that the two ends of the shaft, at the point [of support], do not move, while everything around them turns and revolves [with the apple]. So too, the two ends [poles] of the axis do not move and do not shift; only they always remain in their place during the revolution. Thus the northern axis and the southern axis alone are the axes of the ninth sphere.

Siman 22 (סימן כב) — That the northern and southern axes mentioned above are themselves alone the axes of the ninth sphere

Know that the two axes or poles we mentioned are the axes of the world; upon them revolves the sphere of the upper motion, which is the daily sphere. In this way all nine firmaments are turned by these two mentioned axes, every single day. But the motions belonging to the inner [individual] spheres — the sphere of the Sun and the Moon and the rest of the spheres of the seven planets, whose proper [individual] motion [proceeds] of themselves from west to east, as above — these have for themselves two other poles, distant from the two poles of the world mentioned, by about 24 degrees, as will be explained further on in Section 2, siman 34. (This will become clear to you from the fact that in eight of the spheres there is not found any point that is at rest and stationary — for even their own two axes are also set in motion, by the cause of the daily sphere, which turns and rotates the entire world in one revolution, around it, every day, as explained above in siman 37 [ל״ז] [?] — and all of this is according to the view of those who affirm a ninth sphere.

But according to the words of those who deny the ninth sphere and say there is no sphere above the sphere of the [fixed] stars at all, it appears we must say that in their view the two axes of the world are within the sphere of the constellations itself. It follows, on this view, that the sphere of the stars has four axes: the two axes of the eight spheres' motions — those that encircle [the heavens], each in its own time, from west to east — and the two axes of the world, [shared] by all of them together, by which they turn the body of the earth once each day.

And if it is difficult for you [to grasp] how a single body could revolve with two opposing motions — we already explained this above in simanim 14 and 15, [resolving it] according to the capacity of our understanding.

Siman 23 (סימן כג) — That even those who deny the spheres' [ninth sphere] may properly call it the daily sphere or the sphere of the upper motion

A small note, to be kept between your eyes: wherever in this book of ours you find mention of "the matter of the upper motion," or "the daily sphere," or "the sphere of the part [the *galgal ha-chelek*]" — let it not trouble you, and do not let it be hard for you, that this conflicts with the view of those who deny the ninth

firmament. For even according to what we have stated above, this can be reconciled in one of two ways.

The first: with respect to the [planets'] essential, proper motions, [a body] is not compelled to be a sphere; rather it [the planet] revolves upon the sphere [as a wheel runs along the ground]. [Rashi-type:] just as a wheel revolves on the surface of the [main] sphere and a star travels along the [main] sphere.

And the second: within the belly [concavity] of every sphere there is set yet another sphere, and all eight spheres are bound and joined together as one body, in a single revolution in which they all turn together as one — as above in simanim 14 and 15. And let it not [trouble you] —

(p. 31) — continuation of Siman 23

— Therefore, whether you suppose there really is a ninth sphere or that there is not, you should accordingly understand: you can explain the matter of the upper motion, or the matter of the daily sphere, or the sphere of the part [*galgal ha-chelek*], either according to the view of those who affirm a ninth sphere, or even according to the view of those who deny it. For we can say that the belly [concavity] of each and every sphere — and the sphere [interior] of the eight firmaments — this innermost one is called the sphere of the upper [daily] motion, the sphere of the part. For the belly of every sphere is the [part] superior to the sphere we set within it; and by the same reasoning, the belly of [the outermost] sphere is called the daily sphere or the daily motion. See above, siman 18.

Siman 24 (סימן כד) — That each star, in its daily course, traces a circle around the axes

From what we have said you may understand a further general principle, [namely] that every star among the stars of the firmament, in its course each day, traces a circle and an arc around the two poles of the world. These circles, or the arcs of these [paths] — they are what are called by the astronomers "the arc-circles" (*megillei ha-mesibah* / the circles of revolution), or "the rolling-arcs of the stars." Of these arcs there is no number [reckoning] for them: some of them are large, some small, some smaller still. For some of the stars trace a large circle and some trace a small circle, according to whether they are near to or far from the axes. For every star that is near the axis, its arc will be smaller than the arc of a star far from it.

For this reason you will not find the faces [planes] of the rolling-arcs equal to one another for any of the stars of the eighth sphere as regards their motion [path], except where two or more stars stand upon a single line [meridian], at one equal distance from the axes — they are all then joined together in a single shared [great] circle.

Siman 25 (סימן כה) — Whether a star is fixed or revolving: it is fixed, and the sphere is what revolves

The early sages, and likewise the later ones, have decreed and stated that all — or most — of the stars of the heavens, whether each one of the seven wandering planets or each one of the other fixed stars, that not one of them has any motion of its own at all. Rather, each one of them is fixed and set in the thickness of the hollow of its sphere. Their [the stars'] revolving, their rising and setting, their inclination toward north or south, and their gradation [in position] — all of this is solely by means of the motions of their spheres, which carry them along like people seated on a ship or fixed upon pegs set into the wheel of a wagon. Thus the star is fixed, and the sphere revolves.

This accords with the words of him who said, "The sphere is fixed and the constellations [planets] revolve" — which is the opinion of the sages of Israel as against the sages of the [other] nations, as cited in [Tractate] Pesachim, chapter "Mi she-haya tamei" [Pesachim, ch. 8] [Babylonian Talmud, Pesachim 94b].

But know this: the great researcher, the wonder of the science of the stars [astronomy], the singular and unique one of his generation, foremost of the sages who sat before our master — His Excellency Tycho Brahe (טיח״א ברא״הי) [?], [in service of] the most serene Emperor Rudolf (תדלפו״ש הקיסר) [Rudolf II], may his glory be exalted (יר״ה) — said to me: their sages did not act well in conceding to the sages of the [other] nations on a false matter, for the law [truth] is in fact with the sages of Israel — that the stars revolve in their essential, proper [motions], not [merely] compelled by the motions of the spheres, but they themselves swim and run through the air like a bird flying aloft. And he wrote much on this, with proofs.

[Tycho's] writings, by his signs and his speculative demonstrations, [show] that some stars revolve [in such a way] — [as] a comet (*kochav megueil*) [?] traced [a path] [?] crossing the disk of the Sun, [or] passing over [it] [?] — with proofs the like of which no one in the world has equaled, all of which he beheld by means of his marvelous instruments. On this account he judged and decreed that a star, too, revolves apart from the motions of its sphere.

And likewise I heard from the mouth of the distinguished sage **Kepler** (קעפליר״ש) that, in truth, since it appears to us that certain stars sometimes shift and circle in various figures [paths] — even returning [retrograde] in single [varied] figures, sometimes toward the north of the path and likewise toward the south — it is impossible to stand upon and settle the crookedness [irregularity] of the stars' courses, unless we say that the stars sometimes swim in the firmament like a bird flying in the air.

And this too I saw fit to inform you of: I found in the words of the sage **Don Yitzchak Abarbanel** (דון יצחק אברבנאל) [R. Isaac Abarbanel], in his commentary on the Torah, in [parashat] Bereishit, on the verse "And God made the two great luminaries" [Bereishit 1:16], that the early philosophers — such as **Plotinus** (פלוטי״נו) [Plotinus] and his school — wrote in their book, which is called among the sages of the nations "the [Book of] Nature" (הטבע״י) [the *Physics*?], that the seven wandering [perplexed] stars [planets] travel through the midst of the air. And a third [authority] held this same view — Plotinus wrote this in his book; [and] **Plotinus** [?], a disciple of a disciple of **Aristotle** (ארסטוטלוש) [Aristotle], and the greatest of their great ones, who composed books in all of philosophy [philosophia], wrote in [his book] [...] that the luminaries are not [embedded] parts of the spheres, and are not fixed in them at all; rather, the stars travel through the air between heaven and earth, and between the spheres — they are at rest [there], yet they [also] travel. End of his words.

And he wrote there further that it is not proper to decide definitively regarding what Chazal said, "the sphere is fixed and the star revolves," that it should be a void [rejected] statement; at the very least the matter was [held to be] so among some of them. And I found great support for this in the words of our Rabbis, of blessed memory, in [Bereishit Rabbah], parashat Bereishit, in the [discussion] "And let them be for luminaries" [Bereishit 1:14] — and these are their words there: R. Shimon ben Yochai said, We do not know whether they [the luminaries] fly aloft in the air or whether they travel along their [fixed] courses; and the matter is very difficult, and it is impossible to fabricate [a firm conclusion] to settle upon it. End of his words.

Siman 26 (סימן כו) — On finding in the eighth firmament the point that lies opposite, [for] depicting the northern axis that is in the ninth sphere

Know, you sons of [transient] life [*chled*, mortal men], that we too dwell and reside toward the northern side of the world, as will be explained at the head of

this Section [near its beginning], and as will become still clearer to you further on in Section 3. [Therefore] the northern axis or pole — which appears to us as elevated above the earth, ever higher [the farther north one goes] — and likewise the southern axis, which is hidden and concealed from us, as will be explained.

And inasmuch as in the knowledge of the elevation [altitude] of the northern axis we have great need — for the knowledge of the host of the heavens, and for the knowledge of all the inhabited regions and the elevation of every place, and you have no other instrument [more useful] for it in the study of the science [of astronomy] than this — because, just as the eye cannot directly see the place of the northern axis itself (for the northern axis is itself nothing visible), [we approach it] by an exceedingly easy method, without calculation or measurement at all.

It is already known to the gentiles, [though] not [known] to most of the Jews, by way of the great star — the large, radiant stars that gleam toward the north and that do not set [for us] who dwell to the north [...] forever. There is the figure formed by the stars of [the constellation] which, in the shape of the stars, [is set out] [...]. The astronomers call it the **Great Bear** (דוב הגדול) [Ursa Major]; the common folk call it the **Wagon** (עגלה) [the Wain]; the Ashkenazim (אשכנז) have in their language [the name] [Yiddish:...] [the name partly illegible — likely "Wagen," the Wagon].

(p. 32) — continuation of Siman 26

[Yiddish:]... "der Wagen" [the wagon] in Ashkenaz [German]. Take from them two of the bright stars — star [labeled] ב and star [labeled] ג, [as] in the figure before us — and picture for yourself in your mind two lines that rise upward [as] in the figure recorded; then the two lines will meet at the second [point]. There [you will find] the small stars, others, that also gleam by day [?]. We have no occasion now to deal with this at all; only work along the two lines until you meet, further up the path, two more stars; mark them in this way, and you will have, near them, two further stars; mark them likewise, and you will have four stars in the shape of a square, like this:

Diagram. A star-map schematic of the constellations **Ursa Major** (דוב הגדול, "the Great Bear" / the Wagon) and **Ursa Minor** (דוב הקטן, "the Little Bear"), with the **pole star** (כוכב המלחים, "the sailors' star") marked. Stars are shown as six-pointed star-marks, connected by lines, with Hebrew-letter point labels.

- צי״ר (position: upper left): "axis [pole]" — marks the celestial north pole

- כוכב המלחים (upper left, near the pole): "the sailors' star" (Polaris)
- דוב הקטן (left-center): "the Little Bear" (Ursa Minor) — the smaller star-group near the pole
- דוב הגדול (lower right): "the Great Bear" (Ursa Major / the Wagon)
- א, ח, ו, ב, ג, ד, ה, ז (point labels): the individual stars of the two constellations, lettered for reference in the prose (ב and ג are named in the text as the two "pointer" stars; ה and ז are the two stars of the Great Bear used to extend a line toward the sailors' star)
- Marginal text around the figure: "the recorded stars in the [star] figure, and sometimes they are empty [unmarked] in their position; the Great Bear above, the axis... and sometimes at its side..." (descriptive labels, partly worn)

Upward and to the left [of the square] there are three additional stars set [in a line]; when they join together with [the others] you will find seven stars all together, in the likeness of a small wagon — like the form of the large wagon [the Great Bear] — as you will see depicted before us. This small wagon they call the **Little Bear** (דוב הקטן) [Ursa Minor]. The astronomers [call it so]; and the star at the tip of this Little Bear is a brilliant, radiant star, and it is called the **sailors' star** (כוכב המלחים) [the Pole Star, Polaris]. For those who go down to the sea in ships have made this star a guide of righteousness [a true marker], because by the position of this star sailors and seamen know toward which of the directions of the world [they sail], and toward which the directions of the world lie — [for the four directions] of which you will need [further explanation in Section...]. By it sailors steer their ship and direct it to the proper quarter, toward the destination they intend, in accordance with their purpose.

This is because the [sailors'] star is so very near the axis that it appears to us almost as though it were the axis itself, and is reckoned as such. But know that, from the pole or the axis, [the sailors' star] is a little distant below it [?] toward [the side of] the Great Bear, [seen] in a clear horizon [...] [a small declination from the true pole].

[Rashi-type / continuation:] And there is a point [near it] which, were it to lie [exactly] at the northern pole, [together] with the outer stars of the Little Bear — if all three were arranged in the shape of a triangle or [forming] the figure of a point — all three would appear [aligned]. And you, the reader, [proceed] as I have set out.

After [finding] the sailors' star a second time, in the manner explained, and once you have made yourself familiar with the place, you will then be able to find its place still more [easily], in any place and in any clime, by this method: take the two last stars of the Great Bear, which are star ה [he] and star ז [zayin]; for the figure [the eye] continues in your mind from star ז upward along a straight line until you meet a single bright, radiant star — and that is the sailors' star [Polaris]. You will see [it] in this figure:

Diagram. A second star-schematic showing the figures of the **Great Bear** (דוב גדול) and the **Little Bear** (דוב קטן), used to demonstrate the "pointer" method of locating the sailors' star (Pole Star).

- דוב גדול (Great Bear / Ursa Major)
- דוב קטן (Little Bear / Ursa Minor)
- כוכב המלחים (the sailors' star, Polaris) — at the tip of the Little Bear
- ציר (the axis / celestial pole)
- Point labels for the individual stars, including כוכבי שתים ("two stars," the pointers) and the stars labeled toward the pole
- Marginal note: that the axis [point] recorded here is not the true axis but [a point] resembling it ("ציר הדומה" — the axis that resembles [the true one]), opposite the outer star of the Great Bear called by [name]

In this figure are depicted the forms of the **Great Bear** and the **Little Bear**. The axis depicted here is not the true axis, but only an axis resembling [it] — opposite the true axis.

You should know that the Little Bear, and likewise the Great Bear, and also the rest [Rashi-type marginal:...] of the [northern stars] — the sailors' star, the Little Bear, the two pointer stars adjacent [to it] — [the sailors' star] does not set, for us who dwell in the north, ever, as will be explained further on in Section [...], siman [...] [Section 2, siman...]. Also know — [marginal: even though the] stars that are in the figure are sometimes empty [unmarked] in their position, the Great Bear is above the axis, and sometimes [below].

[Resuming main text:] I have chosen, in order to explain it, that wherever any one of them stands elevated above the axis, opposite the point of the head [the zenith], as it is in the figure, I will set out for you further on [how] to find the place exactly opposite the point of the axis, and precise as to how high it is above the horizon of the earth, in every time and in every place — both on sea and on dry land.

And further: you should know in your heart, from what we already explained — that the axis of the world is in the upper [ninth] sphere — that accordingly you should know that the point of the axis which I have recorded for you here in the sphere of the stars [the eighth] is not the axis itself, but is only [the point] opposite this outer star of the Great Bear, called [the pointer], between [the body and] the upper axis itself; see further on in Section 11, siman 260 [ר״ס] [?]. The reason I have called it "the resembling axis" (ציר הדומה) is that it [closely] resembles the [true] axis itself. Let this be [a note] for remembrance between your eyes, for you will have need of it further on.

And know further that the [specific] times [positions] mentioned [for the pole] hold true precisely for us only in our own time; but with the passing of many years and long stretches of time, the positions [of the stars] will change — and this [is] by reason of the motion of the sphere of the heavens [the precession], as will be explained further on at the end of Section 5, [in the section] on siman 131 [קל״א].

Siman 27 (סימן כז) — The proofs that the heavens are spherical, and that there is no figure but the spherical figure

[Body heading as printed, p. 32 lower right — but see note: the running siman number here is given as כה/כו in the column rubric and כז at the foot; transcribed as printed.]

The sages, both early and late, have agreed that the heavens, and all the spheres, are all spheres [spherical], and they have given many proofs for it. [The text breaks off at the page boundary:]... and the proof that they found... [continues in next batch].

Section 1 (שער א) — conclusion of Siman 27 and Siman 28

the proof that they found, which the ancients [derived], is that the whole matter of the [stars'] distance in the orb of the earth [yields] distances. Therefore, in our opinion, it follows by necessity from their being equal upon the circle to the center. Were the heavenly orb not spherical — but rather shaped like a triangle, or like an egg, or any other figure — then the lines going out [from the center] would not be equal, and one star would be more distant from us than another. But since their distances are in fact equal, the center must be equidistant from every point.

A further proof: people have observed that the magnitude of the places [of the stars] across the whole world is uniform — that is, all the stars of the eighth sphere are of one [apparent] size and measure. Were the sky [shaped] otherwise, a single star near to the body [of the earth] would appear, from that very place, larger than the one more distant from it. [?]

On the matter of [why] the investigators have given their reasons: a complete thing — that is, the earth that they spoke of [?] — is by nature whole, lacking nothing. Since the sphere is the most complete figure in the world, and nothing can be added to it or subtracted from it, [it follows that] any sphere, at the time it is made into its [proper] shape — if you should later add a little to it or take a little from it, it can no longer contain a straight line, nor will it [remain] a sphere; and from every point upon it, [if you] add or subtract, the straight line will not remain [straight].

A second [proof]: It is already known that all the figures in the world are one of three: either circles, or a triangle, or a square. [?] All the other figures branch off from these three, for the spherical figure has priority. [?] The spherical figure, or the round figure — and this [is the figure] of the [heavenly] ring — [stands] above all the other figures. To surround any other figure, lines are needed, [whereas] one line by itself can encompass [the spherical]; therefore the philosophers held it [as a settled principle]. A third [point]: there is found, by nature, [the sphere] preceding [all] the many. [?]

In every species there is found one [individual] preceding by nature the many — [hence the sphere] is fit to be a third [proof]. The philosophers held it as established that there is no [empty] place outside the world. And it might rise to our minds [to ask the following]:

[Diagram is here in the source — see below.]

that the figure of a triangle [?] — [suppose] we posit a sphere; for example, [the figure of] a triangle [labeled] א, ב, ג [aleph, bet, gimel]. From this it would necessarily follow [of necessity, by demonstration] that there is a place outside the world. And this [is] what everyone [grants] [?]: that it is outside the triangle א, ב, ג, as [shown] in the diagram. Now, behold, the three corners [angles] of the triangle א, ב, ג — when [the figure] truly [rotates] — [the corners] move and revolve upon the inner circle [inscribed circle] of the figure, [these being] the chords. Behold, in their motion they [move] the outer circle, which is outside [the inscribed one]; and in their motion they would leave their place, so they would necessarily require a place outside the world. But [the principle] is that there is

no place outside [the world]. So it is [resolved] for the corners, which [are] no [longer] found [extending] outside. [This is] the law, and both [things hold] true: these are the natures of the figures, according to the philosophers.

✻ A reason that the sages gave: We testify that [there can be] no figures other than spheres or circles, [as] a fitting figure for the spherical heavens and earth, because there is none more fit [than the sphere] to rotate [continuously] about itself, with nothing [keeping it] back from its [completion]. In addition to the reasons already mentioned, [Scripture] gives a fine and apt reason, [in the verse that] "the Singer [the Psalmist]" set near to this [matter]: "*How manifold are Your works*" [etc.] (Tehillim 104:24) — by wisdom He made [them all]. Through the demonstration-line [argument from the line], it will become clear to you, by the true demonstrations, that the heavens are spherical, and the [truth of it] — as will be explained at the head of Section 3, with God's help. [?]

Siman 28 (סימן כ"ח)

Siman 28 — That the figure of the circle is the strongest of all figures. [body heading, p. 33]

The Proof. No figure was found among all the figures [that is] a stronger proof [demonstration] than the figure of the circle. Even though this matter belongs to [the domain of] the books of the [mathematicians] and the geometers, and its proper place is not here in our book, nevertheless, for a reason [I will give], I saw fit to disclose to the ear of the reader [the following]: that the sages already [established] this matter with well-known proofs — and this is the demonstration with [its] proofs. [?]

[Diagram is here in the source — concentric circles and a pyramid/triangle figure. See below.]

Take, for instance, one line, אָ-בָּ [a-b], whose length is 22 cubits, and make from it a circle; it will be — by [the rule of] the [natural] sevenfold [ratio] [?] — [a circle]. [?] The half of its diameter is [found] from [the diameter] together with half its circumference; for the half of its diameter is its [radius]: half its diameter is 3½ cubits, and half its circumference is 11 cubits. And when 3½ is doubled it comes to 7; [multiplied] by 11 it yields 38½. Now if we take the [full] line, ו"ק [?], whose length is 22 cubits, and we make from it a square, then each side will be 5½ cubits, and the area is known from the rule for multiplying the two sides of a square [against each other]: 5½ times 5½, which is [the product], yields 30¼. [?]

So you have here, in the matter [under discussion], that the figure of the circle holds more [area] than the figure of [the square that bounds it] [?] — [the circle holding] 38½ [against the square's] 30¼ — [a difference of about] one and a quarter cubits [?]. This is clear and plain to those who know the science of geometry and [measurement].

Siman 30 (סימן ל')

Siman 30 — That the sphere of the mazalot [zodiac] is divided into 360 parts [degrees] along the length of the world, and likewise along its breadth. [body heading, p. 34]

All the ancient sages, in their [computations], [agreed] [?] — and so too [is the practice]: the line that revolves [about] the center of the sphere of the mazalot, and likewise [the case for] all the other great circles that pass through the center of the earth, each of them — [they divided] into 360 parts [chalakim]. And they called them "degrees" (maʿalot). How [is] this division [made]? It was explained briefly in Section 2 [?]; [and the reason] the astronomers chose to divide it precisely to this number is that it is a number capable of [many] divisions — in half, in thirds, in quarters, and into a tenth, an eighth, a ninth, a twelfth, a fifteenth, an eighteenth, [a twentieth], a thirtieth, a fifth, and others. Moreover, this number [360] is close to the count of the days of the year, since on each and every day the sun, in its volitional [proper] motion, traverses beneath the sphere [an amount] close to one degree of the mazalot, [though] a little less, as will be explained ahead in Section 7, siman 165.

As for the point from which the reckoning of the 360 degrees of the circle of the mazalot begins: the ancient sages agreed to make the beginning of this reckoning at the head [first point] of the constellation Aries (Taleh), as will be explained ahead in Section [?], siman 119 — that is, the point [marked] from [?] which the head of the constellation Aries [begins], [the point] at which begins the line from which the Hebrew [?] astronomers reckon. And [it] goes round, [the count rising through the constellations] [?] — Taurus, Gemini [?] — and encompasses all the windings [of the ecliptic] until it returns to the said point from which the count began, completing the 360 degrees, as will be explained further ahead. Now this is enough; this sum is what is called the length of the firmament [the longitude].

The line that revolves about the center [in this way] runs along the [length] of the earth from north to south; even though it too holds [?] 360 degrees in every place — [yet] know that all the great circles divided north-and-south, each of them divides into four quarters [reaching from the equator to] the [poles]. Every

quarter has ninety degrees, and the degrees of those quarters are all called the breadth [latitude] of the firmament, as will be explained ahead in siman 94 and in siman 95. [?]

It is further fitting for you to know that the astronomers agreed to divide each and every degree of all the degrees of the sphere into sixty parts; and these are called "minutes" or "seconds" [?]. The minutes [?] of the [whole] circle of the mazalot come to 21,600. And each second [?] they further divided into sixty parts, and these parts are called "thirds." And likewise [the thirds] they divided again into sixty "fourths," and the fourths into sixty "fifths," and so on to sixths, sevenths, eighths, ninths, tenths.

[End of Section 1.]

✻ *With the help of the One who forms Israel, we have completed [established] the First Section* ✻ *The First Section is finished* ✻

Section 2 (השער השני)

The Second Section. In it is explained the making of the sphere resembling the celestial sphere; the number of its principal circles; its repair [adjustment] and correction; one [further] instrument [?] will be shown; and the finding of the height [elevation] of the northern pole above the horizon at any place — along with further matters pertaining to it. [section preamble, p. 34]

Siman 31 (סימן ל"א)

Siman 31 — The nature of the sphere resembling the heavens, [and] its diameter and its poles. [body heading, p. 34]

After we explained the order of the four elements [?], [and the order of] the nine [spheres] — [namely] the celestial orbs, one above the other — [all] this with great brevity, above, [it is] now fitting for us to return, to explain and to set in order for the students [the following], so that there may be [clear] before [them] [?] the principal circles of the eighth firmament. For the [purpose of grasping] [?] the form and likeness of the celestial sphere itself — [a sphere built] after the very pattern of [the heavens] — through this sphere itself there may become known to the students its root and foundation, [namely] the science of the stars and the mazalot.

And you should know that the making of the said sphere [globe] [the astronomers] chose [to construct] in two ways. The truth [is]: [some] were

accustomed to make it [the sphere] over [?] [a frame of] hollow strips [bands] [?] of [thin material], which they call [in their language] ספירא (sfira) [Latin: *sphaera*, "sphere"]. And [some made it of] a solid lump [globe] [?] — [a body] hard [and not hollow] [?] [— and this is not a hollow body at all] (I, [the author], say [the following] to the students: this one [solid globe] is better, in my opinion). [The choice between the two:] this [the band-frame] or this [the solid globe], the difference between them is [only] this: that the solid globe [made of one piece], upon which one can draw [depict] for it all the host of the stars of heaven — [whereas] that which [is] [the open band-frame] [?] — [the bands are spaced] [?]. [Heavily degraded passage — see flag.] [?]

because the calculations of the sphere of the fixed mazalot, which are upon it, [must be] reckoned [?] according to [the true mazalot]; and the [true mazalot] visible to our eyes [are reckoned] according to [the visible sphere]. [?] These two [tests/examinations] will be explained to you in siman 110 [?]; therefore it is the practice in such matters [to teach the students by means of the sphere]. And [the masters of the craft] [say/do] [the following]: by means of the celestial sphere they teach the students, [for] it is the [easier] thing [?] to explain and to clarify, because the matters of teaching the small students [beginners] in [their first studies] [?] — it is more fitting [to use the sphere]. [?] So that [the students] should see, [and grasp] for themselves [?], that these are the [principal] [?] circles of the sphere — [the very ones] that are [depicted] [?]. [Heavily degraded — see flag.] [?]

most of the matters of [study] are [taught] [by means of the celestial sphere], [as] in our book here. [?] By the likenesses and the parables [comparisons] [?] [we explain] [?] the [matter of] the fixed mazalot, [so that it may] be the more easily known and [grasped]. [And they are depicted] [?] upon the sphere [in such a way] that when [the students depict] [?] the mazalot truly according to [?] [their proper places], [it will be] as the people [?] [see them]. We have [not] seen [a place] [?] where these [mazalot] are [arranged] [?] in this firmament, [unlike] [?] [what is described] in siman [?] [in the matter of] [?] [the dissolving/wandering] [?] — and [as for the] [hidden ones] [?] [explained] in siman [?]. [Heavily degraded bottom block on p. 34, right column — see flag.] [?]

Section 2 (continued)

[Top of p. 35 continues the discussion of constructing the resembling sphere.]

this whole [matter] from one [thing], on account of habit [familiarity] [?]. [When the student] examines [?] [the sphere] with a careful eye, [he understands] it; and

from here onward [he proceeds]. [In] the explanation of the [sphere], [it is fitting] that we and our [students] [?] [model ourselves] [?] upon the sphere of the people [the common globe]. Therefore, just as [we said] [?]: there is no [real] difference or distinction [to be insisted upon] in [this] matter — [namely] the hollow sphere — in this place [?]. [The point is that] the material of the celestial sphere [?] takes [for itself] a likeness [model] [from] the sphere that [the maker] makes [?]:

✻ A round circle [globe] [?] — not [shaped] like an egg, and not like a [flattened] disk [lentil-circle] — but [perfectly] round, all of it [?], [its] heights [equal] [?] [on all sides] [?], and its six diameters [?] equal [?], and there is found in it neither [protrusion] [horn] nor depression [hollow], neither convexity nor concavity, neither high nor low, neither thick nor thin, neither length nor breadth (except [in the sense] [?] [that will be explained] ahead, in [Section 4 / siman?] [?]). [Degraded — see flag.] [?]

The Sphere [?] — and this [is] what Scripture [calls] [?] [in the verse]: "*[He] [winds you up] [tightly,] [winding,] like a ball [kadur]*" [?] — *kaddur*, [the word] [for] "sphere" [?] (Yeshayahu 22:18). And Rashi (רש"י) [?] [comments] [there]: a [round] thing [?] which they call in [the vernacular] *פלוט"א* (plota / pelote) [Old French: *pelote*, "ball"]; one [throws] [?] it from hand to hand and they catch it. [?] And the Radak (רד"ק) [R. David Kimchi] explained the root [of the word] *kadur* [as] "sphere." That sphere [round thing] is known in the Mishnah, and the [ball] which they call in [the vernacular] *פל"א* (pela) [Old French: *pelle / pelote*, "ball"] — which in [Arabic / the foreign tongue] they call *באל"ן* (balin / balle) [?]. [These are] [Rashi's words, end of citation].

Imagine to yourself the resembling sphere [as having] one true [central] middle-point [center], because all the lines going out from it to its [surface] circles are equal in their [measure]. [?] And this point, in the language of the sages, is called the center of the sphere [the center of the orb]. [And] the line [that] enters from one side of the sphere [passes] [through the center] and goes out [the other side] [?] —

Siman [29? — see anomaly] (סימן...)

[A body rubric "סימן" appears mid-column on p. 35, with no clearly legible numeral — see anomaly note.]

[the line] which the investigators [scholars] call the diameter; and it has [?] two end-points, which are the two principal points [poles] of the sphere — [these] are

the [axis] (the ציר) or the poles of the [one] world [?]: the one is the northern pole, and the other is the southern pole, as has all been explained above, in siman 31.

It is fitting for you [now] to set aside [push off] [the difficulty in] the [thought] that the sphere which we have called "resembling the heavens" — since nothing is visible in it except its [convexity] [?]; that is, the outer [convex] side, [whereas] the celestial sphere [as we actually see it] — the side we see of it is its concavity, which is its inner side. Therefore, when this resembling sphere is properly set up [adjusted] in its circles and its stars [according to its rule], you should set it before you: as if you yourself were sitting [placed] within the middle of the sphere, at the place of its center; and you place your face to the east, with the northern pole to your left and the southern pole to your right. Then you rotate the sphere and place your eye at its concavity [its inner curve], and you will see all its circles, and every star, and the pole-star [the marked star] [?] upon the [globe]. [As you turn it, each star] is [seen] rising [?] [over] the eastern side and ascending toward you, until it reaches the point opposite our zenith [?] (which is the meridian line — the noon-line [?] — as will be explained), [then] descending behind you and setting [going down] beneath the earth, and [returning] to circle [around] [?] [perpetually] — [returning] as at first from the eastern side.

Siman 32 (סימן ל"ב)

Siman 32 — The number of the circles of the sphere, and its form and figure. [body heading, p. 35]

The Circles. The circles [drawn] for the construction of the resembling sphere are ten in number. Six of them are great [circles], equal in their magnitude [precisely], and the center [of each] is the [true] center [of the sphere] — a complete and perfect center, common to each one of them. Each [of these six great circles] divides the sphere into two halves [?], [in such wise] that all the [great] circles [of these ten — those that are great] divide the sphere into two equal halves. [Of the great circles,] some have their thickness [running] from east [to west], and some [run] from north to south; and each one of these six [great] circles divides each [other] at right angles [?]. [The remaining four] of the said ten circles are [small] circles, and the center of the earth is not the center of [these four small circles]. For this reason — namely, that [these four] divide the sphere into unequal parts — they [the masters] called [each] of them, sometimes a [parallel] circle [?], and sometimes [by other names], for a reason that will be explained. [?]

The ten circles of the sphere — I saw fit to set before you, [drawn] from the very beginning of the figure of the construction [the diagram], together with a portion of the circles of the sphere. [?] Since it is not possible to draw a sphere in its three dimensions [?] [upon a flat surface] — know therefore that the drawing [I give] is upon a flat surface. [?] And it is a representation of [only] half a sphere. [It is] like a [bowl] [the bowl] that is [turned] face-down [the concave dish set upon its mouth] [?], [and the things] engraved [and depicted] upon [the eastern face?] [?] [are drawn] upon half [of it]. [The whole figure is half the sphere; and the half-circles] are a representation of half the [arcs] of the [bow / arc-circles]; and imagine to yourself that the [other] half of the sphere, together with [its] half-circles, the arc-circles, [is] sunken and hidden [and concealed] beneath the page [leaf] upon which the sphere is drawn. [?]

And you, the reader who is beginning to learn this science [?] — [I will tell you] how you may [best] set [this] up for yourself, [in] two or three [ways] [?]: [you may make] a hollow sphere [of bands] of strips [woven] according to your [need], and the size [scale] of the drawing [should be] [close to / like] [that] given [here] [?]. Make for yourself, [as a model], a sphere [globe] [?] — [the manner of] which [the craftsman] [Dürer?] [?] [דרעקסליי"ר ... פרש לנ — see flag] [?] explained [?]; or [make] a sphere of [wood] [?] or [of some other] material, and engrave [draw] upon it all the circles of the lines, [just] as [they] are drawn upon the flat surface — and [bend] [?] the lines [around] [the surface] around the sphere. [?]

[Diagram is here in the source — the great circles of the celestial sphere, with cardinal/quadrant labels. See below.]

Section 2 (continued)

[Top of p. 36 continues siman 32 / the construction of the sphere.]

[everything is] in proportion: in a small sphere, [each part] [drawn] according to its smallness, and in a large [sphere] according to its largeness; the same [rule for] the length, and [for] the near-and-far of these lines in [proportion] one to another. And if God has set in your heart the [understanding] [?] to know [this], it will be easy for you to grasp the law [rule] of this sphere and its making — [even] from its diagrams [alone], [without any] teacher or instructor [?]. But [if you rely] upon the [flat] drawing that is on the surface, because the [craft] [?] will be too hard for you, and you will not be able to [complete] [?] what you [need] [?] — then make for yourself a sphere [globe], or a hollow [body], or a solid [body] [?]; [and so] you will [succeed] [?] and gain understanding.

Siman 33 (סימן ל"ג)

Siman 33 — The explanation of the first circle, called the equator [equinoctial — "the equalizer of the day"]. [body heading, p. 36]

The Circle. The first [circle] with which we begin our [explanation] [?] — by its [definition] [?] — is the [great circle] [?]. [It is] the [equator], the circle [drawn] upon the middle [equator-line] of the sphere; and it runs [extends] from west to east, at [an equal] distance [?] [that is], midway between the two [poles], the northern and the southern; and the [axis] passing [through] [?] it [runs] upon its center, [from] this [southern] [?] [end of] the circle [from south to north], that is, from [axis] [pole] to [axis] [pole], which is the [world-axis] [?], and the two end-points of the [axis] are the two [axes] [poles], called the poles of the world, as was explained above in siman 31.

This circle is called in the books, by many names: "the circle of the equalizer" [the equator] [?], "the level circle," "the straight circle," "the equinoctial line." Each of these names has a reason. It is called "the equalizer of the day" [equator] because all who dwell beneath this line have, forever, all the days [of the year] day and night equal. [?] Moreover, when the sun revolves beneath this line, [which happens] twice in the year — when it reaches the head [first point] of Aries, [and the head of] Libra [?] — then the measure of the day and the night [are] equal in all the inhabited world, in all the climes, as will be explained. [?] And [the reason] it is called "the level circle" [the circle of the leveling] is that those who dwell beneath this line see the two [poles] [?] and the orb of the earth appears to them [as] level [upon] the surface [horizon] [?], a level [land] — to the exclusion of those who [are inclined] [tilted] away from it, for whom one of the [poles] is [raised] [?], this [being] [on account of] the sphericity of the earth. And [the reason] it is called "the straight circle" or "the straight line" is that it stands [most] upright [?] in the middle of the sphere, neither inclining to north nor to south.

Moreover, all who dwell beneath this line have the 12 mazalot divided to them equally — and more precisely [?], six to the north side and six to the south side. And further: for all the days of the year, the mazalot rise for them, forever; and more precisely, equally — that the six mazalot which rise for them [in the day] [?], the [other] six mazalot rise for them by night; the time of their revolution above the earth [equals] the time of their revolution beneath the earth, as will all be explained ahead in siman 138, with God's help. And from all the [aforesaid] things [it follows], for the [reason of] each and every [name]: it is called "the equator" [the straight/level circle] [?]. And [as for] the reverse of all these [aforesaid] things [— the inclined dwelling] — [for those] who incline from the

[equator], whether to the north or to the south, [it] will be [otherwise], as will be explained ahead, with God's help.

Siman 34 (סימן ל"ד)

Siman 34 — The explanation of the second circle of the sphere. [body heading, p. 36]

This straight circle [the equator] of which we have just spoken, we [now] divide into 360 parts, which are called degrees (maʿalot); and the [uses] [benefits] of this division will be explained to you ahead. So that this division may be [done] [?] swiftly and easily [?], divide each quarter [?] at the head [first] of this [revolving] circle [?] by means of a [compass / protractor] [?] — [dividing] each quarter into four [?], and each quarter into three parts, [so that] the whole [comes to] 36 [arcs]. [?] [The whole circle will be] [made of] 36 [such arcs]; therefore, in the circles of a small sphere — where, on account of [their] smallness, [there is no room] to mark all 360 degrees — [the practice is] to mark off [?] the revolving line in [units] [?], ten by ten [degrees], up to [?] 10, 20, 30, 40, etc. — yielding the [sum of] thirty-six [arcs], [each of] ten [degrees], in the great [circle] [?].

[Repeating the rule:] each of these 36 [arcs] you then divide into 36 parts [?] [— degrees, so that the total of degrees is reached]; therefore [each] of them holds [?] [its share], so that the sum of the [parts] [degrees] yields, of all of them together, 360 degrees [in] the whole circle. And further, you [may divide] each degree into [60] minutes [?], and [each minute] into 60 seconds, yielding [?] 15 [?], 20 — [the fineness of the division being limited only] by the [compass]; but the sum of all of them is 360 degrees [in] the whole circle. The same law holds for [each of] the five [great] circles [the other great circles] in every section [chapter] [?]; each of them [the great circles] [is divided] into 360 degrees. There is, however, a difference among them [?]: some of them are divided into four quarters [?], and each [great] circle [into] ninety degrees [per quarter], all [coming to] 360 degrees, as will be explained further ahead, with God's help.

Siman 35 (סימן ל"ה)

Siman 35 — The explanation of the second great circle, called "the dividing circle" — the horizon. [body heading, p. 36]

The Proof [Definition]. [This is] the horizon, [also called] the [bounding] circle [?], or the [circle of sight], or the [circle of] the [bow / arc] [?] of the earth [the earth-circuit] [?]. The books of the [astronomers] [the geometers] [?] call it "[the horizon]" (אופק, ofek) — and the word "ofek" is an Arabic word. This circle, too, is

[one] of the six great circles [that are] in the whole sphere. This circle [the horizon] goes and extends along the [curvature] of the eighth sphere [the firmament] [?]; and they [engrave] [draw] its circle [?] in the [lowest place] [the lowest extremity], at the place where, according to the sight of the eye, the [end] of the heavens and the [end] of the earth [appear] joined together there as one. And [in the mind / in thought] this line [is conceived as] continuing [running round]: from the [southeastern] [?] edge, going round through the whole eastern [direction], and likewise through the whole northern direction; and from there to the [northwestern] [?], and to the [southwestern], until it returns to the [southeastern] edge.

The center of this [horizon] circle is [the point] beneath the sole of [your] foot [the nadir-point] [?]. And the point opposite it, above, in the sphere of the mazalot [the zenith], is called *נכ"ח נקודו"ת* [?] (the opposite-point / "nokach nekudot") (which point, too, [is the zenith]) [?] — that is, the [point] of [the zenith] [?] [marked] for the [sight-circle / horizon] [?] of each and every person, in whatever place he is sitting.

And the [Bow] [Arc] [?] — that is, the line of the circle going out from the horizon, [rising] in its [uprightness] [perpendicularity] [?] from [its level], [going] up [?] from us, [along] the curvature [of the sphere] [until it rolls / reaches] [up to] [?] [the point] opposite the zenith [— this being the highest point]. [This] is the [arc] [?] — a fourth [quarter] of [the breadth of] the firmament — and it is called "the circle of altitude" [the height-circle], because from it is taken the altitude [height] of the sun and the moon, and the rest of the stars, in every place and at every time — how many degrees each one of them [stands] above the horizon, as will be explained on this matter ahead, in siman 52.

This straight circle [?] and the [horizon] circle [?] mentioned above [is] called "the dividing circle" [the separator], as [stated] [?], because it [separates] and divides between the stars [— between those] that are [seen] [revealed] above it, and those stars that [are] [hidden] from us [those that set] [?]. And for this very reason, the [sight-circle / horizon] [?] is also called "the circle of sight" [the circle of vision], because our sight [reaches] [extends] only as far as its circle [the horizon]; and all that is [below] it [?] [— beneath this line —] is hidden and concealed from us. As regards the matter of this line: on the eastern side of this line, every day we see the sun emerging [sprouting up], rising [ascending], coming forth; and on the western side we see it setting [going down]. [This is] because the half of the circle of the mazalot in which the sun [stands] above the horizon — [the part the sun traverses] — [some] of the [authorities] call "the bow [arc] of the day"; and the

[other] half, which is below it, they call "the bow [arc] of the night." And as the law [holds for] the [rising and] setting [of the sun], so too is the law for the [rest of the stars] in their [emerging and] their setting [— the moon and the rest of the planets and stars]. [?]

Diagrams

Diagram. A geometric figure illustrating Siman 28 (the circle is the strongest/largest of figures). It comprises two stacked elements in the left column: (1) at top, a set of about ten concentric circles (a bull's-eye of nested rings) representing the circle as the most "complete" figure; (2) below it, a triangular stack of horizontal rules of decreasing length — a stepped pyramid/triangle outline — representing a rectilinear figure for comparison of enclosed area. No interior letter-labels are legible on either element.

- (concentric rings, top): the circle — figure of greatest enclosed area for a given perimeter
- (stepped triangle, bottom): a rectilinear figure (triangle), for area comparison against the circle

Diagram. A triangle with an inscribed circle, illustrating the discussion of the triangle א, ב, ג and the inscribed/circumscribed circle (the "corners that rotate upon the inner circle"). The three vertices are lettered.

- א (top vertex): aleph [A]
- ב (lower-left vertex): bet [B]
- ג (lower-right vertex): gimel [C]
- (circle inscribed within the triangle): the inscribed circle that the rotating corners trace

Diagram. A representation of half the celestial sphere (Siman 32), drawn as a great circle subdivided by the principal great circles into segments, with radial and cardinal labels around and across the disk. The figure shows the equator, the meridian/colure circles, and the great-circle grid, with directional and named-circle labels arranged around the rim and along the dividing lines. Several rim labels are in decorative/curved type and partly degraded.

- אופן ארבע צירים (top arc): "the manner [device] of the four [axes/poles]" [?]
- הזורח / הזריחה (upper-left rim): "the rising [the east]" [?]
- הצפוני (left rim): "the northern" [pole/side]
- המורד / המערב (lower-left rim): "the descending [the west]" [?]

- הדרומי (bottom / lower-right rim): "the southern" [pole/side]
- בחורת הישר (central horizontal band): "the [circle] of the straight [the equator]" [?]
- עגול… (interior radial labels, several): names of the dividing great circles — partly legible: סרטן / עגול… [Cancer?] /... [?]
- (additional interior segment labels, mostly illegible): [?]

Note: more than two labels on this diagram are flagged [?]; this figure is a

Section 2 (שער ב) — continued

[Siman 35, continued — the Horizon (אופק)] The sun rises on the eastern side of the horizon and sets on its western side, as do the moon, the planets, and all the stars. As long as any of the constellations remains above the horizon, that constellation is reckoned as belonging to the sky's visible half.

This eighth sphere is called either "the sphere of the constellations" or "the sphere of the stars." The six constellations above the horizon are the visible half of the sphere for us, and the six constellations below the horizon are the half hidden from us. Yet the half visible to us is not fixed at one moment in one place, nor is the half visible to us identical from place to place [?]. From all that has been said — and from what will yet be explained — you will grasp how many distinctions there are between this circle [the horizon] and the others.

Whereas all the other circles of the globe are shared in common by everyone, the horizon belongs to each person individually : each man has his own horizon, particular to his place, and not the whole world's. We have not transcribed this circle into a single place — its position shifts from place to place. As will be explained shortly, [the horizon] is of such a nature that its quality differs for its inhabitants in every place. None of the world's people has a horizon shared identically with another: in every locale of the earth it changes for those who dwell there, varying degree by degree.

Therefore the horizon is the one circle for which there is no single position fixed between north and south. Each place has its own particular horizon for itself, distinct, and no two men share one — except for two men who stand in two places along the same line east-to-west, with the soles of their feet [directly opposed] [?]; these are the "sailors" [navigators] discussed earlier (as set forth

above in siman 27 [?]). Such individuals are then found among various other distinctions [?]. This is unlike all the other circles, of which we never see more than half.

Moreover, this circle [the horizon] is such that wherever a man sits and rests and dwells, it stays in its place permanently for him and does not revolve about the world as the other circles do.

You must know that the circle we have now been speaking of divides into two kinds: a right (straight) horizon and an oblique horizon — and presently you shall hear their laws.

The right (straight) horizon belongs solely to those who dwell beneath the celestial equator [the line of equal day]. It is the horizon that separates [the visible from the hidden] for them. It lies along the line of the two poles of the world, beneath all who dwell upon it, and they see both poles of the world, the northern and the southern, equally. Their horizon divides the equator's line into two equal parts at equal (right) angles. They have six constellations to the north and six to the south, and all the stars of heaven rise upon their horizon in this manner, and all likewise set beneath it. Not even a single star can be found that is permanently visible or permanently hidden to them; nor is there any difference in the timing of the stars' standing [their rising and setting]. The time a star remains hidden beneath the earth equals the time it remains above the earth, and thus their day and night are always equal. No variation whatever occurs in the cycle of their seeing, ever. The lines of the right [horizon] meet [at the poles], even though one is far from the other by thousands of parsa'ot [?].

[The sun] rises on the eastern side and sets on the western side; so too the sun and the moon, and likewise all the stars of heaven rise for the dwellers [there]. Those to the east see them rise before [those to the west] [?], and no single star is ever permanently hidden from any [of them]; nor does any star set [permanently] for those who dwell beneath it [?].

[Marginal/secondary, left column p. 37 — laws of the right and oblique horizon:] For those who dwell along the right line [the equator], whether to the north side or the south side, several laws apply. [These laws] differ for those dwelling beneath the [right line]:

First: One of [their] poles rises above [the horizon] when the second pole sinks beneath the horizon [?].

Second: Of the stars, some are always visible to them and some always hidden from them.

Third: The time the constellations spend above their horizon equals the time they spend revolving beneath their horizon.

Fourth: Likewise, the time the sun spends revolving above their horizon equals the time it spends [revolving] beneath their horizon. For this reason, the measure of day and night is always equal [there], except for two days of the year, as will be explained in siman 142 [?].

Fifth: Their horizon also divides the right line [the equator] into two equal parts, [but] not at right angles — for the right line [stands] like a tilted wall to its side.

Sixth: For those dwelling beneath the right [line] who are on the north side, the twelve constellations [?] incline somewhat toward the south. For this reason, those who move farther from the right line toward the northern pole — drawing nearer the northern pole [?] — will find all twelve [constellations] inclined for them toward the south.

Seventh: Of the [celestial] globe, the half that is north of the right line — the part of it visible above their horizon — is greater than the part hidden beneath their horizon; and the half of the globe that is south of the right line — the part of it visible above their horizon — is less than the part hidden beneath their horizon. For those dwelling to the south the matter is reversed. You will see all these things sensibly demonstrated by raising one of the poles above their horizon.

[End of marginal laws; resuming main text:]

The manner of the dividing circle, that is, the horizon, of which we have now spoken, cannot be depicted in the figure described above [drawn] flat on the surface, because it is difficult to draw it on a flat surface without folding the front edge [?] — lest the figure confuse you. So now I will explain its construction to you, and how you may make it for yourself afterward out of any material:

Make one ring of wood or brass [?], so that the body of the ring will be a circle. Let its thickness be about half a finger's breadth and its width [the breadth of] a finger — that is, [along] its diameter — and let its inner [hollow] be as wide as the diameter of the globe. Make for this ring three or four [supporting] legs or a base, so that you can stand it upon a tabletop. Its base [?] should be a little longer than half the diameter of the globe. This ring is called "the seat-ring," which is itself the dividing circle or the [plane of the] horizon. The globe rests within this seat-ring such that the two ends of the necessary diameter [the axis], which protrude from

the globe outward, rest upon the seat-ring. In the thickness of the seat-ring let a small notch be cut, one toward the middle of the north and the other opposite it toward the middle of the south.

[A figure of the armillary seat-ring / horizon-mounting apparatus is implied here but is not separately drawn on the page; described in the prose above.]

Then [the apparatus] will yield the right [horizon] for those who dwell beneath the equator. To make the horizon for those who dwell off the equator [the oblique horizon], raise the northern pole above the seat-ring according to the distance of that place [from the equator]. For example: the city of Prague sits at [a latitude such that] the equator [is positioned] toward the pole [?]; you raise its north [pole] and turn [the globe] so that you elevate the northern [pole] by 50 degrees [?] above [the seat-ring].

Above [?] the seat-ring [the elevation will give the latitude], and this matter [?] — the elevation of the seat-ring — will be explained to you more fully later, in siman 45, with the help of Heaven.

This horizon, then, which is the seat-ring itself, you divide into 360 parts or degrees, like any circle. [You may] alternatively divide it another way: divide its rim only into [the degrees of] the equator [?]. Divide each quarter on its own face into the ninety parts that comprise it, [making] all of the four quarters total 360, which will be marked upon the horizon thus. Begin from the middle of the east — which is the [point of] meeting at the place where east is on the horizon [?] — and mark their number up to ninety, by [reckoning] fives: 5, 10, 15, and so on. As has become clear to you regarding the quality of this division, with the explanation of its circle [given] shortly:

The first quarter, [of] the equator, runs from the middle of the east to the middle of the north — which is the place of the northern axis — and there completes ninety parts. The second quarter likewise runs from the middle of the east [?] to the middle of the south [?], completing its ninety [parts], and there the other two quarters end [?]. The first [pair] begins from the middle of the west and completes its ninety parts, [marked] at the middle of the north; and the second at the middle of the south. The benefit of this division will be explained to you later, with God's help.

Siman 36 — Explanation of the Third Circle, called the Circle of the Constellations [recte: the Circle of Mid-day]

This is called "the manner [aspect] of mid-day," and some call the third circle "the southern circle".

The third circle is called "the aspect of mid-day," and some call it "the southern circle." It is drawn [along] the curvature of the firmament from the middle [point] to the middle [?], that is, from north toward the middle of the south, and likewise [a measure] toward the north. It passes over the two axes of the world — namely beneath the poles [?], as above — at [right] angles, and over the point [directly] above [opposite] the zenith [the crown of the head], dividing the equator and also the horizon [?] into two parts each, at equal right angles.

The rule of this aspect [the meridian] is this: when the sun reaches it each and every day, that is the moment of mid-day for all who dwell beneath it. At that instant it reaches all who dwell beneath it [along that meridian], [marking] the time of mid-day — whether the sun be exactly at the zenith point or far from it, near or distant. For you will find the matter [holds] by the aforesaid rule even in the summer solstice [the season of Cancer], when the sun, for those who dwell in the far north, [stands] at its utmost remove and lowest [?].

In any case, when the sun reaches the aforesaid line — which is the line of the middle of the south [the meridian] — even though it be far from the zenith point, it is then at its highest [point] of that day, and every man dwelling beneath it casts a shadow inclined toward the middle of the north. This is the time of the midpoint of the day of all the world's inhabitants [?], in every place where a man dwells beneath it.

You should know, as a general rule, that all places of the world that share [the same meridian] — that is, [those] equal in their longitude, meaning equally distant from the [prime meridian] [?] on the east-west axis [?] — share this midpoint in common, even though their latitudes differ by thousands of parsa'ot [?]. All places equal in their longitude, that is, having no difference [?] in [longitude], lying along one line stretching from north to south — behold, the aspect of their mid-day is one. Whether one [reckons] their distance from the middle of the east [?], or whether [those] who dwell along a right line due east [share it], or whether those who dwell along [some other] line [?] — for each one there is one aspect of mid-day.

[This holds] for itself eternally, and it always comes earlier for the eastern dwellers than for the western, [reckoning] the time of mid-day for that place. For this reason, mid-day always comes earlier for the easterners than for the westerners. So too the sunrise and sunset: just as mid-day comes earlier for the easterners than the westerners in every place. Nor [does it hold] at every time, but only at the season of the equinox of Nisan and Tishrei [?]; for in the rest of the days of the year there is an earlier [arrival] for the northerners than for the southerners [?], in such a way that, in some places, the sun rises for the westerners before it rises for the easterners [?]. These laws will be explained later, in Section 6, simanim 152–153.

From all these aforesaid matters I will now explain to you what we have found regarding the aspect of mid-day [the meridian] and the rest of the aspects [planes/circles] of the globe: two distinctions, which are distinctions in the [circles] themselves, [and] which we have already found in them — and [further distinctions] between the meridian and the rest of the aspects of the globe.

The first distinction: each of the other aspects [circles] of the globe remains [the same] in its quality for every man, both for himself and for the whole world; whereas the meridian is not so, for it [pertains] specifically to a man himself and [those] joined with him in [the same] longitude [?] — not to others.

The second distinction: just as we [said] that the horizon has no motion or sphere [of its own], as was explained, so too the meridian has no motion or sphere whatever. Rather, it is fixed [?], standing upon its base, stable, keeping its watch until the center of the sun comes to dwell beneath it. The making of the meridian [the mid-day aspect] in the apparatus of the globe — know that some astronomers do not make it [as a full] circle, but only [as] a half-circle's arc, dividing it [along] the two ends of the necessary axis so that they can rotate [the globe] from east to west around the whole globe. This is the easiest and best way [?] — that it be more [conveniently] fashioned [as] an aspect [arc] than a complete circle; for in [such] an aspect, half of [what would be] a circle is always the [arc of] mid-day, and the [other] half opposite it is the [arc of] mid-night, as will be explained.

You should know that the astronomers make yet another aspect [device], better [still]; its construction, application, and law will be explained to you later, in siman 8 [?], with God's help.

Siman 37 — Explanation of the Fourth Circle, called the Circle of the Constellations [the Zodiac]

The fourth [circle] is called "the circle of the constellations," and it too is one of the great circles that surround the center of the earth.

[The circle of the constellations] passes over [crosses] the equator and divides it into two equal parts, but not at right angles; for it is drawn at a slant, inclining away from the equator [the line of equal day]. On one of its sides [?] it inclines toward the northern axis — according to the view of Ptolemy [בטולמיא"ש = Ptolemy], by 23 degrees and 51 minutes — and likewise on the other side it inclines toward the southern axis by 23 degrees and 51 minutes. The two points at which these two aforementioned circles — the equator and the circle of the constellations — intersect one another are called the "points of equal [day]" [the equinoctial points]: the one [is] the point of the head of Aries [טלה], and the second [is] the point of the head of Libra [מאזנים].

You must know that this circle, of which we have spoken, the ancient sages saw fit to divide into twelve parts, calling each part a "constellation" [mazal]. And since it has already been made clear that every great encompassing circle that passes over the center of the world is, [according to] the ancients, [divided] into 360 degrees — by which reckoning each constellation receives 30 degrees — and since it has been made clear above that the constellations of the sphere [each measure] thirty degrees...

the [scheme is]: by sixties, [the divisions of each] constellation [?]... [several heavily degraded lines, top of right column, p. 39] [?]

[Degraded passage — the constellation names: the sage [Ptolemy?] [?] named the constellations] Aries [טלה], Taurus [שור], Gemini [תאומים], [Cancer (סרטן), Leo (אריה) [?]],... Aquarius [דלי], Pisces [דגים] [?]... [?]. He named them after [the figures] [?] from the head of Aries onward, as the ancient astronomers established [?]; for what reason [they did so] will [also] be explained later in siman 160 [?], [regarding] the names of the constellations.

[The order is such that,] beginning from the head of Aries, the [reckoning] of the 360 [degrees] of the [zodiac] circle proceeds and goes around, encompassing [the heavens] from west toward east [?], following the curvature of the path of the constellations [the ecliptic], until it returns to that same aforementioned point from which [the sun] departed [?]. The measure [of this] will be explained to you presently.

The first six [constellations] of the circle of the constellations [incline] toward the north [side], [and] these are [?]... and they are called "the northern constellations"; and the second half [inclines] toward the south side, in which are inscribed the six figures of the constellations called "the southern constellations," and these are [Capricorn (גדי) [?],...] [?].

You should know further regarding the constellations that, even though their center is the center of the earth [?], nonetheless, by reason of [the ecliptic's] inclination away from the right line [the equator] toward the north side and toward the south side, as above — for this reason it is necessary [that the matter] of [the constellations'] poles [?] [be as] we discussed above, [namely], that the poles of the constellations [the poles of the ecliptic] are distant from [the poles of the equator] [?]. (We [touched on] this matter in Section 1, siman [?] of [the poles] [?].) [The amount] of the inclination of the line of the constellations from the right line [the equator] is, according to the determination [of Ptolemy], 23 degrees and 51 minutes; and to know [more about] this will be explained later [?]. So too the poles of the constellations [the poles of the ecliptic] are [distant] from the poles of the world by 23 degrees and 51 minutes.

To know [more about] this matter — namely, [that] the poles of the constellations [are likewise distant from those of the world] — as Ptolemy [בטולמיא"ש] makes known, [consider that] for every dweller upon the earth, ever, half of the circle of the constellations is visible to him: the six aforementioned constellations [are] visible above his horizon, [bearing] the names [given], while the other six constellations are sunk [hidden] beneath his horizon — [each] in its [time] [?]. And why are they called "constellations"?... [the figures they resemble] [?].

[Regarding] all the places and all the times of the year, and the [nature] of the figures and quality of the constellations, and the breadth of the circle of the constellations, together with many other great and wondrous matters — all this will be explained to you later, in the section especially devoted to it, [which] is Section 5, with God's help.

Siman 38 — Explanation of the Fifth Circle, called the Aspect of Four Axes [the Colure], or the "Establisher of the Sphere"

The fifth [circle] is called "the establisher of the sphere" [מעמד הגלגל], and likewise [the sixth] is so called, as will be explained shortly.

These two circles, the fifth and the sixth, are [both] among the great circles, for they both lie [extend] over [the globe] along all its sides [?], and [pass through] its

thickness, over the center of the globe, from north to the south and from the south to the north. At the place [where they cross] the two axes of the world, the northern and the southern, the two "establishers" meet [?]. These two [circles] establish [intersect] this one and that, [forming] two east-and-west [crossings] [?], making four right angles, and dividing the globe into four equal parts.

This fifth [circle] is the [colure that] passes over the two axes of the world and over the two axes [poles] of the [ecliptic] [?]; the two poles of the constellations [poles of the ecliptic] are 23 degrees and 51 minutes [distant] from the poles of the world, and [the circle] revolves [as] above. This aspect [colure] passes by way of [?] the head of Aries [טלה] and by way of the head of [Libra] [?]... [as will be explained] in [the appropriate place] [?]. From the aforementioned [matters], the reason it is called the "establisher" [is]: [it establishes the solstitial points] [?].

This [circle] is called by two names: "the establisher," because [it stands over the two axes] [?]; and "the aspect of the summer and winter [solstices]" [?]. And it is called the "aspect of four axes," because it passes over the two axes of the world and over the two axes [poles] of the constellations [ecliptic]. This [latter] name appears more fitting, in order to distinguish between the names of the two circles, the fifth and the sixth, both of which are called "establishers." It is also easier for students to say "the aspect of four axes" and to say "the aspect of the summer- and winter-[solstices]".

Siman 39 — Explanation of the Sixth Circle, called the Establisher of the Equinox

The sixth circle is also called "the establisher of the sphere," because two other "establishers" are found upon it, as will be explained.

This aspect [circle], too, revolves by way of the two axes of the world, the northern and the southern, where the two "establishers" that establish [intersect] this one and that meet, [forming] two east-and-west [crossings], as above. But this sixth aspect does not revolve by way of the two axes of the constellations [poles of the ecliptic]. Rather, it proceeds and revolves by way of the point of the head of Aries [טלה] and by way of the point of the head of Libra [מאזנים] — the two points at which the sun arrives when the days and nights become equal [become of equal length] in all the dwelling-places of all the inhabitants, in every clime, as stated later in siman 139 [?]. For this reason this circle is called "the establisher of the equinox [the establisher of equality]."

[Closing summary — "What the author said"]

Says the author: Behold, we have explained to you here, briefly, the six great circles of the globe — [here is] the gist of the matters :

From the aforementioned matters, three things have been revealed to you. The first: all the great circles are [drawn] upon [crossing] the height [body] of the globe — all of them passing over the very center of the world. The second: that the measure of their diameter and their breadth is [the same] for all of them, exactly equal one to another, in perfect precision. The third: that all those circles intersect [cross] one another into two parts in perfect precision. These three plain matters keep as a reminder before your eyes, for you will need them many times later (see siman 139).

Know also that, among the aforementioned great circles that intersect one another, there are some [that intersect] at right angles — as [does] the right line [the equator] with the two "establishers," and likewise the law with the meridian [the mid-day aspect] together with the right line; and the [oblique horizon] line, [whether] a right horizon [or an] oblique one [?]; and likewise [the law] of the line of the circle of the constellations with the line of the right circle, and the line of the meridian, and so too the line of the right circle. But the line of the horizon with the rest of the [great] circles intersects them mostly at [angles] that are not right [oblique].

And now let us come to the explanation of the four small circles of the globe.

Siman 40 — Explanation of the Seventh Circle, called the Summer Solstitial [Circle], or the Circle of Cancer

The seventh [circle] is called "the circle of Cancer" [סרטן], and is also called "the summer solstitial circle." It is the circle of the standing [solstice] of summer; for when the sun reaches the head of the constellation Cancer [סרטן], it is then near to its utmost [extent] [?], [at] the [summit] of midday at its greatest height [?]. For the sun cannot draw any nearer, [can] go no farther [?]. This is the end [of the cycle], and the days of summer's heat encompass [it] [?]. On that day the sun describes a circle — and this is the outermost [?] and last circle [?] toward the side of the north that the sun describes. [On the day it reaches the head of Cancer] [?] at that time, the day becomes longer for us than [on] any [other] day of the year, and the night becomes shorter for us than [on] any other [day]; the heat too overpowers us more than on any [other] day of the year, because the inclination and distance of the sun's [path] at that time from the right line [the equator] is,

according to Ptolemy [בטולמיא"ש], 23 degrees and 51 minutes. This inclination is called by the astronomers "the great [declination] of the sun." A greater inclination than this of [its] position from the equator [the line of equal day] is not found.

This circle [Cancer] is also called "the reversal circle" [?], because from that point onward the sun begins [its return], [its] face toward the south side, drawing away from the right line and approaching from the right line [the equinoctial line] [?] day by day for us, until the season of winter [?] — that is, until its arrival at the head of the constellation Capricorn [גדי], when it is at its utmost distance from the inhabited [world]; as will be explained shortly among the general [rules] we have mentioned.

It will be explained to you that, for those persons who are far from the equator [the right line] — by more than 24 degrees [?], as we ourselves [reckon], who dwell [in] the northern lands [?]: such as the people of the Land of Israel, and [those of] Egypt [מצרים], Aram [ארם, Syria], Chaldea [כשדים], Spain [ספרד], France [צרפת], Ashkenaz [Germany], Greece [יון], Italy [אטליא], India [?], and many others besides them — for these the sun, [being] without number [?], will never pass over [their] zenith. For all those people of the world, the sun always remains for them toward the south side, since the sun never passes beyond the circle of Cancer toward [the outer parts] of the world. And just as [this is] the law for the dwellers of the north, so [too] is the law for the dwellers of the south who are distant from the equator [the line of equal day] by more than 24 degrees toward the south side: the sun [always] remains for them toward the north side, [for] all the world's [days].

Siman 41 — Explanation of the Eighth Circle, called the Winter Solstitial [Circle], or the Circle of Capricorn

The eighth [circle] is called "the circle of Capricorn" [גדי], and is also called "the winter solstitial circle"; for when the sun reaches the point of the head of Capricorn [גדי], it stands there and ceases to draw any farther from it. For the sun [is then] at its utmost distance from the inhabited [world], being unable to draw any farther; that time is the end of [the season of] winter [?] and the beginning of [the season of] cold [?]. On that day the sun describes a circle of revolution — [by] its daily motion — and this is the outermost and last circle that the sun describes toward the south side in the year. This occurs on the day of the true winter solstice, when the day becomes shortest for us at its utmost [extreme] and the night becomes longest for us of all the nights of the year; and so too the cold

overpowers us at its utmost. There too the sun is distant toward the south side by 23 degrees and 51 minutes.

You should know that this circle is called by the reverse [name from the previous] [?], because [from this point the sun] begins to turn [its] face toward the north side, to draw near to the inhabited [world], drawing nearer to us day by day until the sun returns to the head of the constellation Cancer [סרטן]; and so this matter recurs perpetually, [throughout] all the [days] of the world. [A further note on Capricorn / the sun's southern limit — partly degraded] [?]. I will [explain] to you [more about] this matter in siman 65 and siman 75, with God's help.

Siman 42 — Explanation of the Ninth Circle, called the Northern Circle

The ninth circle is called "the northern circle," and it is [drawn] as a small circle; it is the pole [the circle described by the pole] of the circle of the constellations [the ecliptic]. As has already been [explained], inasmuch as the circle of the constellations inclines from the right line [the equator] by 23 degrees and 51 minutes, and since the axis [pole] of the circle of the constellations [the ecliptic] inclines accordingly — by this same measure, [namely] as the axis of the constellations [the ecliptic] inclines, [so] it is found in the world [?].

Now, when the circle of the constellations [the ecliptic] revolves [together with] the daily sphere, it follows necessarily that the axis [pole] of the constellations [the ecliptic] revolves and describes a complete circle around the axis of the world. This circle is called "the northern circle," because [its] axis [pole] is near the [northern] axis. [It is drawn] in the construction of the globe [as] the most [accurate way], so that there be none like it [?]. And from the general [rules] we have mentioned, it follows necessarily that this circle as a whole is [distant] from the northern axis also by 23 degrees and 51 minutes. Those who dwell beneath this circle are distant, by this reckoning, from the equator [the line of equal day] by 66 degrees and 9 minutes [?]. For every degree [of latitude] the northern axis rises higher for them; and [the pole of the ecliptic] is above their horizon. For those dwelling beneath this circle, the measure of the day will be 24 hours [at the summer solstice], by the [daily] motion, as stated later in Section 6, siman 140 [?].

Siman 43 — Explanation of the Tenth Circle, called the Southern Circle

The tenth [circle] is called "the southern circle," and its inscription [marking] in this [globe] is [made] thus: just as the inscribing [tracing] of the daily sphere [?] by means of the [moving] sphere [?] causes the axis of the [ecliptic] [?] sphere to revolve on the south side — the circle on its [southern] side, revolving in the inhabited world, as has been explained shortly above [regarding] the [tracing] — [so it is] for the southern [pole]. The [tracing] in the tenth circle is itself the very [same as] the ninth, the northern, except that this case [is on the south] and that case [on the north]; [the matter being parallel,] it therefore does not require a separate explanation.

Behold, then, we have inscribed for you the ten circles of the globe, [which are] the most [necessary], [and which] are necessary for the science of the stars and the constellations in the construction of the globe that resembles the heavens. There are [many] other inscriptions and many [other] circles besides them. For the sun [describes] a particular circle on each and every day of the year, [and these] are called "[daily] circles" [גלילי היום] [?], as we [stated] in Section 6, siman 132 [?]. So too [one might] make, in the manner of the rest of the inscribed [circles], [a circle] for every day, establishing them [as a circle] for each day around the sphere of the world. Were all these to be inscribed as circles [upon the globe], [the figure would become confused] [?].

[Marginal/secondary note, left column p. 40 — continuing on the solstitial circles and the equator:]

[Gloss:] Know also that this circle is called by the reverse [name], because [the sun reverses direction]. The sun begins to turn its face toward the north side, to draw near to the inhabited world, drawing nearer to us day by day until the time of summer, [when] the sun returns to the head of the constellation Cancer [סרטן]; and this [cycle] recurs perpetually, [throughout] all the [days] of the world. From the matters we have mentioned it will be explained to you that the difference [in distance] between the utmost remove [of the sun] from the inhabited [world] and [its] nearness to the inhabited [world] is 47 degrees and 42 minutes [recte 42′: the source minutes-glyph is degraded, but 2′ is geometrically impossible — tropic-to-tropic = 2 × 23°51′ = 47°42′].

You should further know [how] to reckon the distance between the two circles, the circle of Cancer [סרטן] and the circle of Capricorn [גדי]; for [the band] that remains [between them] and revolves [is the zone] within which the great

[luminary, the sun, moves]. [This was] the view of all the ancients — [namely], that there could not possibly be found in this [zone any habitation] [?]; they called this [band] a "girdle" [רצועה], [that of] the [tropics] [?]. For [in] some [places, at certain] times the [heat's] strength [?] [makes] the [zone] unfit [for habitation] [?] — three [zones] [?] [?].

Siman 44 — Explanation of the Three Distances [Between] the Circles: the Right Line [Equator], [the Circle of] Cancer, the [Northern Circle], and this [circle] from that

From the general [rules] we have mentioned [regarding] the [circle of the constellations] [?]: the distance by which the axis of the constellations [the ecliptic] is removed from the axis of the world is the same [as] the [distance] by which the entire northern circle [is removed] from [the northern axis] [?]. So too [the distance is] the same [measure] [for] the circle of the constellations [from] the right line [?]. Behold, accordingly, the distance of the circle of Cancer [סרטן] from the equator [the right line] [is as stated]. As will be revealed [and] explained, you will need [for this] a [precise] reckoning [?].

Section 2 (שער ב)

[continuation of Siman 44]

just as the distance between the Tropic of Cancer and the northern circle equals the distance between the equator and the northern pole. Likewise, the distance between the equator and the northern circle — which is the fourth distance, namely from the equator to the [northern] circle, and from there to the northern pole — is ninety degrees, as has already been explained regarding the celestial globe.

The distance mentioned [between the circles] is as follows: the distance from the equator to the Tropic of Cancer is the same as that of the northern pole and axis. The northern axis is 51°23′ [?] — these are the minutes that, subtracted from ninety, leave 47°2′[?] [printed; the geometry would expect 42°? — see note]. The remainder is 43°18′ [?]. Therefore [?], according to its measure, the distance between the Tropic of Cancer and the northern circle is 66°[?] from the equator up to the [northern] circle.

[This passage is heavily degraded in the right column of page 1; the precise figures for the inter-circle distances cannot be read with confidence. Transcribed values flagged]

Thus the distance from the northern pole to the Tropic of Cancer is found of itself, and so too the measures and distances among the three circles — the equator, the Tropic of Cancer, and the southern [circle] — are found by these same measures. The distance between the equator and the southern and northern Capricorn circle is likewise [reckoned] in the same way. Keep these matters in mind, for they recur in many places, and you will have need of them.

Siman 45 (סימן מה) — Explanation and the construction of an artificial meridian-instrument [Method for the meridian by another means], of great usefulness

After we had explained the construction of the ten great circles upon the celestial globe, I saw fit to set forth one further matter: the fashioning and construction of a meridian-instrument [אופן חצי היום] by another method, additional to the foregoing.

In this paragraph I shall teach you how to make for yourself one further device. Make for yourself, from wood, copper, or iron, a circular ring [?] — hollow within in the manner of a finger-ring, hollowed all the way around — which will serve you as a meridian, as will become clear. Let the diameter of this ring be such that the sphere [the globe] can fit within it diagonally [?]. Make the breadth of this encircling ring about a quarter of a fingerbreadth [tziporen], more or less, and its thickness likewise about a quarter of a fingerbreadth, by this measure.

In this ring make two small holes, opposite one another, such that the line drawn through the two holes passes over the curve [?] of the ring. Into these two holes insert the two ends of the projecting axle-pin [הבריח, the rod] that issues from the sphere; place the sphere within the ring at the two axle-points, and the sphere will then revolve within the ring.

After this, take in your hand the ring [?] that is the seat-ring [the horizon-stand], which is the base [?] of the horizon, as was explained in siman 35 [סי' ל"ה]. Make in it two channels [grooves], aligned one opposite the other: one at the midpoint of the northern [side] of the seat-ring, and the second at the midpoint of the southern. Let the breadth of each channel be about a quarter of a fingerbreadth, equal to the thickness of the meridian-ring. Into these channels you will fit it [the meridian-ring], and within these channels two ends of a diameter-axle [?] will stand — entering into this ring, so that the meridian-ring stands [upright]. Set the two holes of the ring level with the horizon [?], and let the meridian-ring stand erect, upright and even, rising vertically in its full height; and let the midpoint of the meridian stand erect. The midpoint of the upper half-arc, above, will face the

point of the zenith [קדקד], and the midpoint of the second [lower] half-arc, below, will face the central point that lies between the feet [the nadir]. You will then have a half-arc of this upper circle — namely the meridian — above; and when the sun reaches it, that is true noon, as in siman 35 [כנ"ל סי' ל"ה].

The two halves [?] of the second [lower] circle [the other half of the ring], below, will be the lower midnight-meridian [אופן חצי לילה], upon which the sun stands at the moment of midnight in every place and at every season, as will be explained to you further on at the end of this section in siman 24 [?] and 25 [?] [printed סי' כ"ד וכ"ה — but this is within Section 2; numeral uncertain].

The meridian which we discussed — about which we also spoke [where] the [degrees] 360 are marked — [is] only a circle, [as is] every great circle [גלגל]. Each quarter, by itself, is divided into the [parts] of degrees and parts [?] of an hour [?]; thus the four quarters together total the marking of 360 [degrees] — ninety degrees to each quarter. This will be the case in the meridian, [for] this half of it, which is the upper meridian. Divide the horizon into two, and there will be two quarters of [?] the meridian above the horizon. Mark each quarter ninety degrees, and begin their numbering at the place of the axle-points [the poles], the northern and the southern, and number them by the ninety degrees up to [?] the midpoint of the height of the meridian — the place where they meet [?] — where the line of the equator meets [?] the line of the meridian. So too shall be the reckoning of the second, lower quarters, which is the midnight-meridian [אופן חצי לילה]; they too begin their numbering at the place of the two axle-points and end at the midpoint of the lower meridian [האופך שלמטה], where the midnight-meridian also meets the line of the equator. (A useful note for the reader [?].)

When the sphere is set [resting] within the meridian, and the meridian-ring set within the seat-ring in such fashion, then in every respect [?] the sphere will have two motions [?]. The first is the motion in which the sphere itself turns within the meridian-ring of the day-half [the meridian] from west to east. The second is that the sphere — since within the channels of the seat-ring [it sits within] the daily meridian-ring — you can rock and move from north to south. This second motion serves only to raise the axle, by which the sphere [is set] as an instrument, according to the height of the axle [the pole] straight overhead, to [match] the horizon at the place you stand. By these two motions of the seat-ring [you may set the sphere], while the horizon — being the dividing horizon [אופק המפריש], or the horizon-instrument, as was written above in siman 35 [סי' ל"ה] — remains in its position without any other motion, as is fitting.

When you have completed the making of the meridian as I have shown, and you wish to know the disposition of the celestial circles — that there is no place going around [the heavens] from any one of them [?] — [you do so thus]: at whatever place in the world you may be, you raise the axle [the pole] of the sphere according to the height of the axle of that place, [as] will be told. Then you will see their disposition, and you will see in the turning of the sphere something resembling the actual motions of the [celestial] sphere — that very wonder of the heavens. By this means the matter becomes known to you through those who relate it [the authorities], and then by your own contemplation, by the method that will be explained at the end of this section.

Since in the city of Prague the height of the axle [pole] is a little more than 50° above the horizon, you must therefore raise and turn the meridian together with the axle, [setting it] upward so that the [pole] reaches the degree marked [as] the fiftieth on the meridian-ring [?] — [the one] that [corresponds] to the horizon. By means of this operation upon the revolving sphere — if there are marked upon it the figures of the zodiac signs and the stars — you will see all their dispositions in their places. The stars of the heavens [in this region] do not rise and ascend from the eastern side of the horizon up to the highest degree, [namely] up to the line of the meridian, and from there descend downward, where they set on the western side; [rather] every day of the year, and every day, also in each and every hour of the twenty-four hours of the day, you will see — as it were, by eye — in the revolving sphere their motion resembling that of the actual stars in the [real] sphere.

[By this means you may] know, for each and every star, [its] nearness and farness from the celestial [bodies] [?] — how many degrees its disposition is removed from the axle [pole], or from the equator, or its height above the horizon; and how many hours each star remains above the horizon, and how many hours below the earth; and which are the stars that remain forever above the earth for us and never set for us, together with many other matters such as these — all of which will be explained in the [following] discussions, with God's help.

Siman 46 (סימן מו)

[The square ribbon/band heading-line is set in a larger display type:] **To make upon the resembling-sphere [the artificial globe] a girdle [רצועה] — a ribbon [קשת] divided[?]…** [heading partly degraded]

[Body, on page 2, running header "כא" / "שער ב" (folio 21):]

the artificial sphere [כדור התרגום / "the resembling-sphere"] that I have made [?]. Of these five [?] [items] I have written [?]: in the quarter-arc inscribed [?] upon the sphere [there is] engraved a marked girdle [רצועה], a quarter [-arc] of ninety degrees [printed תשעים מעלות]. This girdle [ribbon] joins to one [single] axle upon the [meridian-]instrument, at the place of the meridian, opposite the points [marked] at the [intersection] points on the instrument, on the horizon. [The ribbon turns] upon an axle that moves around the whole face of the surface [שטח] of the half of the sphere.

The usefulness of this device, it appears, is that by it we are able to know and to find — at the very first glance and inspection of the sphere — also the point of the zenith [קדקד], and to know and measure by it each distance marked upon the sphere: how great are the distances, whether from the equator, or from the horizon, or from the zenith-points [?], whether from the head-points [the cardinal points] — the whole [reckonable] at the head [first glance] without any [need of] calculation or any reckoning at all.

Siman 47 (סימן מז) — that the meridian-line [קו חצי היום] and the horizon-line [קו האופק] are common to two persons removed from one another by these distances [?]

Know that when Reuven and Shimon are at the utmost distance from one another, such that the horizon-line of the one is the meridian-line [?] of the other — [no:] the horizon-line of the one will be [common], and likewise the meridian-line of both will be [common] to the two of them. This is the case of Reuven dwelling at the eastern extremity and Shimon dwelling at the western extremity [?]; and so too in every place of the world where two persons stand opposite one another, with the diameter of the earth between them [?], their feet directed [sole to sole] one against the other. Behold, the horizon-line is common to both of them, and likewise the meridian-line — the noon-line — is also [common]: this very line, in its meridian, when it tells Reuven the moment of noon, this same line tells Shimon the moment of midnight; and when it tells Reuven [the moment of] noon, it tells Shimon midnight; and conversely, when Reuven [has] midnight, [Shimon has] noon. So it goes by this alternation forever: the horizon-line, too, is common to both [as a single] horizon-instrument. They are [stationed] upon the surface of the earth [?], one opposite the other, [each at] the level of the Equator [?].

[Both share the lines, but] only the [upper] portion that is above the firmament for the one is below the earth for the other; [the two] share the same horizon. So

this [horizon] that is below for the one is itself the [horizon] above for the other; the eastern [horizon] of the one is itself the western horizon of the other. The moment of [the sun's] rising for the one is the moment of its setting for the other; the moment of noon for the one is the moment of midnight for the other; the day-time of the one is the night-time of the other. [So it continues] forever, for the one — from the beginning of his day until its end — it is, of itself, the night for the other; for the eve of Shabbos [ליל שבת] of the one, at its [eastern] extremity, is, on the western extremity [?], the whole daytime of Shabbos itself; and the eve of Shabbos [?]... and so on. [The whole] daytime of [Shabbos] for the one is, at the western extremity, the eve of Shabbos for the other; the whole sixth day [Friday] for the one is, at the eastern extremity, [for the other]... (on the condition that you call the whole day of the world [?] beginning at the eastern extremity — these are the six [days]) — [as] will be explained more fully at the end of Section 6 [שער ו']. From the totality of the matters mentioned it will become clear [?].

So when Reuven dwells at the eastern extremity and Shimon at the western extremity, with the thickness [diameter] of the earth and its foundation between them, beneath the earth — it is found that the meridian-line common to Reuven and Shimon is the horizon-line common to Levi and Yehuda [?]; and conversely, the horizon common to those two [Reuven and Shimon] is the meridian common to Reuven [Levi?] and Yehuda. And [the meridian] common to Reuven and Shimon, and the horizon of Reuven [Levi?] and Shimon [Yehuda?] — the meridian common to Levi and Yehuda is [common to] Reuven and Shimon. Set these matters in your memory, for further on you will have need of them.

[The Reuven/Shimon/Levi/Yehuda cross-assignments in this siman are degraded and internally tangled in the print; the exact pairing of "horizon" vs. "meridian" to each pair is uncertain]

Siman 48 (סימן מח) — On the distance of a man, dwelling [at some place], from the equator toward his north [?]

The distance, or the height of the axle [pole] above his horizon, [is] thus: [for] one who dwells [?] far [from the equator]... [heading and first line in the Rashi-type sub-line are degraded]

[Body:] In every place [a man dwells], [the measure by which] he is distant or elevated toward the north [from the equator] is, forever, [equal to] the height of the northern pole [?]. The northern pole, [seen] above his horizon — that is to say, the distance of [his] zenith [?] from the equator [קו הישר], which belongs to the world — when one of these [quantities] is known to you, then the other becomes

known to you. The matter [is grasped] without need of any calculation at all, and the reason for it in [the case of] these various measures [is] as their proportion [stands].

For a man stands upon [a point of] the equator [?] [where] the poles appear to him at the surface of the earth, or [where] all his sight [?] [reaches]. By the same [measure of] degrees that a man moves away from the equator toward the north, [by] that very [amount] he will rise [in latitude]; and by every [number of] degrees he will be revealed [?] to himself upon the northern pole. [Thus] his horizon and his zenith [?], and the zodiac [גלגל המזלות] as it [appears] over the earth [?], [are determined] — as will be explained further, [with] additional explanation, at the head of Section 3 [שער ג'], God willing.

Siman 49 (סימן מט) — that all the stars near the northern pole never set for us forever

From the principles we have mentioned you will understand also [a matter] that follows by way of inference [?]: that all the stars near [?] the northern pole — [those] within [an arc equal to] the height of the pole above the horizon [or] from the zenith [-point] [from the equator, קו הישר] — remain always above [the horizon] for us and never set for us; and [those] within that [same] portion [near the southern pole]… [degraded].

[And conversely, by the southern extremity:] all the stars near the southern pole [?] — within [an arc equal to] the ray [reaching] from our zenith [?] from the equator, or within [the measure of] the height of the [southern] pole above [the horizon] — are hidden from us always and we never see them by day [?]. All these matters you will perceive tangibly [?] in the instrument [the globe], when you raise it according to the height [of the pole] and turn it [?], the axle [pole] being in its place — as will be explained.

And [as for] the stars that are farther [from the axle] than the [measure of] the ray from the equator [?]: then, according to the height of the axle [pole] above our horizon [?], behold the star far from the axle and near the equator — [Rabbi] Yosef [?] [or: "and also R.... adds" — name uncertain] — the duration of its remaining above the horizon, and the duration of its remaining below the horizon [?] [varies]: [the star] far from the axle and near the equator, [behaves] thus toward the south, and the matter is reversed [in the opposite hemisphere].

Siman 50 (סימן נ) — To find the line of the south-midpoint [קו אמצע הדרום, the meridian-line], and to discern by sense the four seasons [תקופות] of the year

Since the knowledge of the south-midpoint line [the meridian] — that is, knowing the meridian-line [קו חצות היום] and the time of noon [?] in every place and at every time — is one [of the great matters], we have a great need [?]…

[Rashi-type sub-line:] …of the great [need] for masters of practical computation and for masters of theory [?]; great matters depend upon it, hanging from it as from a foundation-stone [?]…

[Body:] …and for the early scholars [?] and the [practitioners]; the foundations and the chief [principles] of [astronomical] practice — to instruct beginners [?]. To find this thing [the meridian], and the times of noon, in [your] places [?], [do as follows]:

Take for yourself a board [דף, a flat plate], and smooth its whole face [שטחן]. Set the board level [ישר], so that its surface lies exactly horizontal [שוה לאופקך], without any tilt or inclination [?] — fixed firm and steady, so that it does not budge, move, or tilt. Upon it draw a circle with a compass [מחוגה], and take a small thin gnomon [?] [a small upright peg], straight in its construction, set upright [?] around the central point [of the circle], whose height shall be less than half the radius [?] of the circle. Fix it upright at the center of the circle at the [central] point, [with] its top thin and fine [?], and fasten it firmly above [?]…

[This long passage on constructing a horizontal sundial-board for finding the meridian and the four seasons spans pages 2–3. Continued on page 3:]

and you must take care [?] that the eye [observes] [?]… [degraded] …each moment, the whole [shadow] goes and shortens, [and as] the shadow becomes shorter [?] up to noon [?], the shadow at first [?] [reaches] [a point] upon the line of the circle. Watch it carefully until its tip reaches a point upon the line of the circle, [and] mark that place where the shadow-tip falls [as] one point. [Up until that moment] the shadow keeps shortening, [and] from then on, after noon, the shadow [?] keeps lengthening again. The shadow [-tip] returns and [reaches the circle once more]; watch it until [its tip] again touches a second point on the line of the circle [?], at one [equal length], and mark [this as] the second point. Draw a line from the first point — call it line א — to the second point: this is line ב [?]; and the line [joining] them [?] [is] line א–ב. The distance between the two points [marked] on the circle — this is the arc [קשת] of this circle [?] — divide arc א–ב in

two equal halves, and the line [the perpendicular bisector] [?] through its middle reaching point ג, draw and inscribe it, and let it pass through them. When the shadow of the gnomon [העמוד] reaches it — to fall upon [this line] — [that is] the meridian-line [קו חצי היום]: each and every day of the year, the moment the shadow of the gnomon falls upon it, that is for you the moment of noon. [Thus you have] the meridian-line for every day, [and you may know] the length of [the] world [longitude] [?] by way of siman 36 [סימן ל"ו].

The exacting [practitioners] [?] in their work, in order that there be no deficiency or error found [?] upon the said board, [draw] three or four circles, concentric one within another [?], each one [tested] against the others, as was explained.

By means of this board you also have [the means] to discern [?] the days of the seasonal turning-points [ימי תקופות השנה — the equinoxes and solstices]. There are two ways [to do this]: the first, an easy way [?] to discern the days of the [solstitial] turning-points; and the second, [the way] to discern all the days [of the year — including] Tishrei and Tevet [the autumnal equinox and winter solstice], [and the rest of] the seasonal turning-points of the year, [as follows]:

When you draw a diagonal line [קו אלכסון] from the midpoint of the west [מערב] to the midpoint of… [from the midpoint, across] to the west [?], passing over the center, [drawing] a chord [?] in the circle on both sides of the diagonal [?] — and this diagonal will be parallel to a line [?] in the figure [the diagram], standing perpendicular [נצב] to line א [?] — line ז–ג [?]. And another [line], such that the line passes over the midpoint of [its] east and over the midpoint of [its] west [?], [will give] the days of the true equinoxes of Tishrei and Nisan [ניסן ותשרי]. Inscribe [?] [the point] opposite point ז and… [opposite] point ח [?]. By this method you will be able to discern the days of the two equinoxes, of Nisan and Tishrei.

[Concerning] all four seasonal turning-points of the year — know that the shadow [צל] of the said gnomon changes in its length day by day. From the day of the Tammuz turning-point [תקופת תמוז, the summer solstice], when the shadow is at its utmost shortness [?] — [for] from that point on the shadow goes and lengthens, until the day of the Tevet turning-point [תקופת טבת, the winter solstice], when the shadow is at the utmost length of its day [?], shortest of the year [in the sun's altitude] [?] — [and] from the day of the Tevet turning-point on, [the shadow] goes and shortens until the day of the Tammuz turning-point in which it is at its utmost [shortness] [?]. As for the turning-points of Nisan and Tishrei [the equinoxes], the shadow is intermediate in its length between the two extremes — the [two] extremes of [the] Tammuz and Tevet [solstices].

If a man keeps watch over [?] this shadow at the noon-moment of his day, throughout the [whole] year, around the times of the four seasonal turning-points — [observing] the four [extreme measures], namely [the moment of] utmost length of [shadow], the utmost shortness of [shadow], and the two intermediate measures — a man is able to know [?] the times of the four seasonal turning-points truly. Yet for [achieving] precision in the hours, [the determination of] their exact times has other ways and calculations, and their apportionment [?], which have their own [place] — and this is not their place here.

Siman 51 (סימן נא) — To construct the instrument called the [quadrant?] [מתקין כלי הנקרא…], a quadrangular instrument [כלי מרובע], called in the Latin tongue [בלשון לטין] קוואדראנ״ט [Latin: quadrans, "quadrant"]

[Author's prefatory remark, Rashi-type:] **[The author's note:] Before [proceeding], the writer says** [אמר הכותב]: at the conclusion of this Section 2, I saw fit to instruct and to give understanding [להורות ולהשכיל] in the measurement of the height [altitude] of the sun, the moon, and the other stars by means of an instrument — [the one] called the quadrant [כלי הרובע], [by which] one may know, in every place, how many degrees and minutes [is] the height of any star above the horizon. And likewise [one may] know the height of the northern axle [pole] — how many degrees and minutes it is above the horizon, in every place and at every time. We have already published [?] a separate pamphlet [קונטריס] on this matter; and in truth, its proper place is not here, but [I have placed it here] only because I did not wish to deprive [?] the students and to detain [?] the other learned [readers] of the [later] sections that we have set aside for the matter of measuring the heights of the stars and the zodiac, and likewise for the measurement of the thickness [angle?] of the northern axle [pole] [near] the end of the book. The proper section is Section 11 [שער הי"א] — it is the eleventh of our sections, [the one] in which, with God's help, we shall expand the explanation [?]… [together] with the Third Section [שער השלישי], by combining [it with] the Tenth Section [שער העשירי] that lies before us [?]. For in truth there is great need for the measurements mentioned, since many matters truly depend upon them. Therefore we saw fit to disclose to the students, here too, also a portion of [this] matter of measurement — [though] only this brief note. And now [hear] the explanation [?].

[Body:] Hear, then, one of the ways of measurement [?]:

Make for yourself, from a board [דף] or from another [piece of] wood, [one] whose form [shall be] as the one before us — that the surface be a quarter-circle [רביעי העגול], whose figure [is] as marked [in the diagram] before us: [the points] being point א, and the corner [-point] [?] of this instrument — which is point א — they call the center [מרכז] of the instrument, for a reason that will be explained at the head of Section [?] — [and] on the left side of the instrument we mark א–ה, and they call [it] arc [?]… [points] א–ג. This arc [the quadrant rim] you divide into ninety parts. (The division, by a swift and easy method for the students — [as] has already been explained — [is]: at the top mark [it]… [degraded] divide it first into three [parts], and divide each of those parts again into three, and each part [will be] nine parts [9], so that each [primary] division [will hold] eighteen parts [?]… [no:] each [will be] divided again into five parts [?]. Below them, on the arc of the instrument, [mark them] by the manner [15 ,10 ,5] ו ט"י, ה, etc., and the gaps [?] [between]… and so forth.) Between [each marked] siman [-mark] and siman, divide each one of them into ten parts [?]… [no:] each into [smaller] minutes — and the total of all of them will be ninety [parts], which are called degrees [מעלות]. [When] each one of them is duly arranged, [its] figure properly set, you will see — for this is [the device] divided [?]… [printed שבעמוד / "that is on the column"?] — [namely] this arc, upon which the numbers of the degrees [are] marked, is called the degree-arc [קשת המעלות / קשת המספרי]. Where you find the numbers of the degrees, then draw a line [קו] from the center [ממרכז]…

[the line drawn] from the center is the line of the instrument's diagonal-edge [the radius], which is [line] א–ד [?] in the figure — and this line is called the plumb-line [קו המשקל, "the weight-line"], for upon it a [plumb-]weight [משקל] of lead [מעופרת] hangs, [serving] to take [readings] [?]; and below [it], join also [?] the [plumb-]thread [חוט], hanging straight downward [for taking the measurement].

Furthermore, join [?], on the edge and side-rim of the instrument's margin — on the side that is [edge] א–ג in the figure — two small thin tabs [מתיכות, sighting-vanes], of copper [נחושת] or [the like], like little finger-nails [ציפורין], each about half a fingernail or [the breadth of one] fingernail. In each of them make a small hole [נקב, sighting-pinhole], such that the two holes are aligned upon the straight line [קו הישר] — [the line] running on the side [edge] from א to ג of the instrument [על צד אל"ף ל… גימ"ל]. Let the two holes be set upon the side-edge of the instrument exactly [?], slightly [raised] above [?] the [edge of] the instrument [?], a very little; only [the two tabs themselves] shall be of equal height, even, and the two holes [aligned]. This [pair of sights] is called — [as] we have discussed — the sighting-line [?] [קו ההבטה]. From now on, this [instrument] will be properly

corrected [?] for our purpose, [made fit] for sighting [?] — hear, [now], the measurement.

Siman 52 (סימן נב) — To find the height [altitude] of the sun, and likewise the height of every other star — how many degrees it is above the horizon

Know that the astronomers [התוכניים] reckon, for every place and every position where the sun is, [the moment] when you find that the sun rises from the eastern side of the horizon [and] reaches the meridian-line [קו חצי היום] [— that is the sun's height — (the sun's height)]; and likewise from the moment that the sun [moves] from the meridian-line, [going down] toward the western side, until [the moment that] it sets [where it descends] beneath the horizon. So too, for the place where you find the sun's height — [how] high [it stands] above the horizon, whether from the eastern horizon or from the western horizon — they reckon it. And just as the rule [is] for the sun, so [is] the rule for every other star.

To find the height of the sun, or of any other star: take the said instrument [the quadrant] in your hand, on the side of the instrument that is the side where the two [sights] are joined [the edge א–ג], [and] raise [it]; set [it] so that line א–ג [the sighting-edge] will be… [aligned with] the body of the firmament [?], and the edge of the instrument [pointed] toward [the body to be measured] [?]. Hold the instrument [tilted slightly] [?]… Close one of your two eyes [?] and sight with the second eye through the side-rim [שולי הכלי] of the instrument by way of point ג, from point [?]… and [raise and] lower point ח, which is the center [מרכז] of the instrument [?], up and down, until you see — at one [glance] — through the two sight-holes [the line of sight passing] to the center of the moon, or of any other star you wish to know. When this has become known to you in this manner, then at that instant, look [and] see below how many degrees the plumb-line [קו המשקל] cuts off — and that is the number of degrees of the height [altitude], [the value] you wished to know.

And in measuring the sun, since a man cannot look directly toward the rays [of the sun] by way of the sight-holes — because of the sparkling [glare] — therefore, in measuring the sun's height, you do not need to look with the pupil of your eye toward the sun [itself]; rather, raise and lower the center of the instrument until [you bring the sun's image to a point] [?]. By [observing] the [shadow of] the two sight-holes, you will see below how many degrees the plumb-line cuts off — and that is the number of [degrees of] the sun's height above the horizon.

And you, knowing reader, know that all that I have set out concerning [?] these matters — the matters [described] for [the purpose] of measurement — is correct, sound, and simple, [meant] for the young students, without any condition [or qualification]. The laws and conditions [the principal rules] of this measurement, with its great usefulness, will be explained to you further on in Section 11 [שער הי"א], where you will find the preparation and operation of this instrument [the quadrant] and the [astrolabe] [?], more fully explained and made plain [?], with God's help.

Siman 53 (סימן נג) — To find how high the northern axle [pole] is above your horizon, and the location of its point in the eighth firmament [ברקיע השמיני]

When you wish to know how high the northern pole is above your horizon, in every place: take for yourself, on a clear night [?] [ליל… degraded], one of the stars that never set beneath your horizon — namely the [circumpolar] stars near the northern axle [pole], [those] elevated above your horizon, as [explained] above in siman 49 [סי' מ"ט]. Observe one of the stars, [waiting] until it is [at the moment] of its rising on the eastern side of the meridian-line [קו חצי היום]; and as that star revolves, by the daily motion, around through the west, until it reaches the meridian-line [קו חצי היום] (which I have already shown nearby in siman 50 [?] [printed נ']) — [for] then the star is at the utmost of its height [from the horizon]. Then measure, or take a reading [תקדוד], with the quarter-instrument [the quadrant], how many degrees its height is above your horizon, and keep [the count of] the degrees found in your measurement [?].

After twelve hours [?], when the star revolves [again] and returns by the same way to the meridian-line a second time, [for] then it is at the utmost of its low point [its lowest culmination]. Likewise measure how many degrees its height is above your horizon, and write down the number found a second time. Then take the mean [הממוצע] between the number of degrees of the first reading and the number of degrees of the second reading: [that mean] is the number of degrees of the axle [pole]'s height above [the horizon] [גובה ציר ממעל].

Let me give the example: when the star, at the meridian-line, [is at] the utmost of its height — [say] you found its height above your horizon [to be] 70° — and it returns to the meridian-line a second time, [where] it is at the utmost of its low point, [and there] you found its height above your horizon to be 30°: then the mean between the two numbers is the height [of the pole], 50° [printed 70°→30°→ mean 50°; arithmetic: (70+30)/2 = 50, correct]. When this has become known to

you in this fashion, [you have found] the [height], upon the meridian-line, of some axle-point [a point of the axle] from the [axle of] the eighth firmament [גלגל השמיני], which resembles [corresponds to] the axle of the true [world] — [the axle] of the ninth firmament [גלגל התשיעי]. [And] to find [this], there are yet three further [methods], by straight [trigonometric] ways, [as] you will find in [Section] 11 [שערי"א]… the axle [pole]… [text continues into next batch].

Diagram. A circle with the four cardinal directions labeled around the rim — מזרח ("East") at top, מערב ("West") at bottom, and the side labels degraded (the Hebrew words at left/right are the remaining cardinal points, partly illegible). Inside the circle are drawn two perpendicular diameters (a vertical and a horizontal axis) plus the two diagonals, dividing the disk into eight sectors; interior labels mark the points where the lines meet. This is the horizontal sundial / meridian-board described in siman 50: a flat disk on which the noon (meridian) line and the equinox/solstice diagonals are constructed from the moving shadow of a central gnomon.

- מזרח (top of rim): "East"
- מערב (bottom of rim): "West"
- (left rim, degraded): cardinal-point label [?]
- (right rim, degraded): cardinal-point label [?]
- א, ב, ג, ד, ה, ו, ז, ח (interior, around center): point-labels of the construction (the shadow-points and the lines drawn through them)

[Several interior letter-labels are faint; reading of individual point assignments is uncertain]

Diagram. A quarter-circle (90° sector) — the quadrant [כלי מרובע / quadrans] described in siman 51. The two straight edges meet at the right-angle corner (the center, point א/ח), and the curved rim (the degree-arc, קשת המעלות) is graduated. Along the top straight edge are drawn the two small sighting-vanes (tabs with pinholes) shown as little raised squares. From the corner-center, the plumb-line (קו המשקל) hangs down across the sector to the arc. The arc is graduated and labeled with numbers; a series of Hebrew numerals runs along the curved scale.

- (top edge, two small raised squares): the two sighting-vanes [ציפורין] with their pinholes
- (corner): א / ח — the center [מרכז] of the instrument, point from which the plumb-line descends
- (along the curved rim): graduation numbers of the degree-arc — Hebrew numerals marking degrees (e.g. י [10], כ [20], ל [30], …, up to צ [90]) [?]

- (line across the sector): קו המשקל — the plumb-line / weight-line [?]

[The individual graduation numerals on the arc are small and partly degraded; exact values along the scale are uncertain]

Section 2 (שער ב) — conclusion

סימן נ"ד (Siman 54) — To find the moment and time of midnight throughout every night of the year

We have already explained earlier how to find the moment of midday and the time of midday for any given day, and we likewise need to find the moment of midnight, for which we now have a great need. Therefore you must know that the moment of midnight is the time at which the Sun reaches the point of the meridian below the Earth, opposite the meridian above. Determine the degree of the zodiacal sign in which the Sun stands during the day, and note the sign that lies directly opposite it (its "watch" / nokhach).

Here is an example. Suppose we found that the Sun's center stands at the tenth degree of Scorpio (עקרב). The degree directly opposite — by which midnight is found — is the tenth degree of Taurus (שור). When the Sun's center reaches the meridian below the Earth, that is, when the tenth degree of Taurus, which lies opposite the Sun, arrives at the lower meridian, that is the time of midnight. [In the worked figure: when the tenth degree of Scorpio is at the upper meridian at midday, the tenth degree of Taurus opposite it is at the lower meridian — midnight.]

[Rashi script / second column:] There is another way to find the time of midnight, since the time of midnight is, by way of the motion of all the fixed stars, [determined] by observing the moment a star rises above the horizon until it reaches the meridian — this is one-fifth [?] of [the path to] the meridian — and from its setting below the horizon until midday; the time is the same for both. Therefore watch one of the stars as the night begins, when [the stars] rise above the horizon, and note the moment that it reaches the meridian; that is the time of midnight.

This reckoning, however, must be done strictly according to the calculation of the equal (equinoctial) hours, not the temporal (seasonal) hours — whose nature will be explained further on, in the fourth chapter of Section 4 [?], regarding the equal hours. And this reckoning holds precisely only on the two days of the equinoxes, in Nisan and Tishrei, when day and night are equal, and not otherwise.

"He is One, and there is no second" (Iyov [Job]); "He grants me all good"; "and along paths of righteousness He leads me." Here ends Section 2.

THE THIRD SECTION (השער השלישי)

Herein is explained: the sphericity of the Earth, its measure and how many parasangs it spans; the seven climes (אוקלימים / klimata) and the three parts of the inhabited world; the existence of the New World — beyond which a fourth part of the world is added — and the form and figure of the Earth in all its features, regions, and routes, comprehended in its entirety on every one of its six extremities; the boundaries of the four directions (winds) of the world, where they begin and where they end, together with an explanation of the third and second [intermediate] directions, each of which is called by its own name; and a table for many places and lands of the inhabited world, and of the length of the days: how much each of them is in the world's longitude, and by how much — along with many other matters.

The author says: Since [the Earth] is the first element, the lowest and least of the four elements [?]— which we have already taken up at the start of this our book — it would therefore have been fitting to begin our book at the head, with an account of the foundations and supports of the Earth, with all its kingdoms and families [?], and to ascend [from there] to the heavens, rather than [the reverse]. [The text here is partly degraded; the author appears to apologize for his order of treatment.] After my account of the years that have passed [?], and to inform my students [?], by way of a brief remark, of the positions of the orbs of the heavens and the stars — which has not [yet] been clarified — and since the Earth's sphericity has not [yet] been made known to us, nor how many degrees or parasangs is its measure, nor how many degrees in the world's longitude its lands and places and the cities of its inhabitants sit, nor how many degrees in the world's latitude between north and south — without first knowing this short introduction from the science of astronomy [it cannot be grasped].

סימן נ"ה (Siman 55) — That the astronomers ruled the Earth's form to be spherical

The astronomers ruled that the form of the Earth is spherical, and they did not take account of the great mountains and the deep valleys found in the world. The reason is that their magnitude is of no consequence on this matter, given the great size and mass of the Earth's globe: it is as though you were to thrust or pierce, with a needle, a small hole into a smooth apple — those needle-pricks do

not negate the sphericity of the apple. [So too the mountains do not negate the Earth's roundness.]

According to the view of those scholars who held that the Earth is flat and not spherical, they brought a proof from what we observe — that the Sun, at its rising, is not [seen as] less than half of it on the horizon, and likewise at its setting, no less than half of it. [They argued] that the Sun descends from the Earth's globe along a straight line; for if the Earth were spherical, it would be proper that the form of half a sun be seen as an arc, by way of the influence of one sphere upon another — just as we see, when the Sun shines upon the Moon, that the Moon is marked [with the Sun's light] at the time of its eclipse, [appearing] as an arc.

The astronomers refuted this proof. What we see in the form of the Moon — that the Sun, too, [appears] as an arc upon the Moon... [text degraded: the reason we are able to see both the Moon and the Sun... the resolution of this difficulty...]

the reason that we are able to see the Sun [and] the Moon [as full disks rather than arcs] is that the Earth, [being so small relative to the Sun], does not [interpose so as to make the Sun appear arc-shaped]. The Sun's [body is so many times larger]: [the Sun] is one-and-some-fraction [?] times [the size of the Earth]. We are not able to perceive the Earth's roundness by our observation in the world; only [the Sun] appears to our eyes [as a disk]. As for the Earth opposite our eyes, it appears to us as though it were flat and not spherical. Therefore the Earth divides [?]... it is [in fact] spherical, even though, opposite our eyes, it appears straight [flat]. This is proven nearby [in what follows] by intellectual demonstration, and through the eye [as well]: were we able to perceive, with the eye's observation, the full extent of these matters, the Earth would be perceived as [perfectly] spherical and round — as will be explained, with the proofs that have come [down to us], etc.

So you should know that the Earth's sphericity rests upon the matters we explained above at the head of Section 1, and as will be explained for you more fully further on: that the Earth, in conjunction with the water, the two of them together, form a single globe. The Earth is revealed within the water [?] on all its six extremities; the foundation [the four elements] spreads out over the entire surface of the globe, [extending] around it — such that even on the surface of the Earth's globe directly opposite the soles of our feet [i.e. the antipodes], there too is found and reached [habitable land], and people who walk upon it, and there are great and mighty cities and many lands full of human beings. [And do not be astonished at this,] even though most of the people who deny the Earth's

sphericity refuse [to accept] this — [namely] that there could be found, walking about the globe of the world on its far side, [people whose feet point opposite ours]. It seems [impossible to them] that Reuven and Shimon could stand on opposite sides of it, this one above and that one below, and that each of them would stand upright in full stature, his head above and his feet below — and yet [to each] the other [seems] hung [head-down], his feet [pointing] above [?]. [They suppose] that one of them would surely fall off, and [argue] that even on half the globe of the world — if Levi stood at the Earth's navel [the center], Reuven at the eastern extremity and Shimon at the western extremity, all of them upright in full stature — Reuven and Shimon would surely fall off.

Nevertheless, know that the Earth's sphericity is proven by clear proofs and by demonstration that admits no doubt, and by sense-experience. This is what we observe: that everything that rises [into view] in the north is hidden from us as we go south, and so too in reverse [going north hides the southern stars]. When a person stands on the equator, he sees both poles even with his horizon; and as he moves away from the equator and ascends [in latitude] toward the north, the northern pole rises for him: for every fifteen parasangs in our lands, the northern pole rises one degree, until — at every fifteen parasangs, up to [the requisite number of] parasangs — he reaches the [region of the] north pole, where the pole is then directly above the crown of his head, as will be explained. From this it is further proven, as will be shown — and this is a complete proof of the Earth's sphericity, and also of the sphericity of the sphere of the fixed stars.

This proof bears upon the [Earth's] roundness between north and south.

The demonstration of the roundness between east and west, and the proof — [drawn] from lunar eclipses [is] clear to us. For every eclipse of the Moon occurs at one and the same instant, simultaneously, for all places of the world and for all inhabitants of the inhabited earth. When two men in two different places investigated a single eclipse — for instance, Reuven standing at the eastern extremity and Shimon standing at the Earth's navel (which is the midpoint between the eastern extremity and the western extremity) — the eclipse [was timed by] Reuven at midnight [and] by Shimon at the beginning of the night.

Even though the eclipse [occurred] for both of them, and for all the world, at one instant that I named, the [observed local time differs] because of the Earth's sphericity: the eclipse preceded [in local time] for Shimon by six [hours] and some [minutes]. For when it was the beginning of the night for those who dwell at the eastern extremity, [standing] upon the Earth at that hour and instant, it would be midnight for the dwellers of [Shimon's location]. So too [the Sun]

precedes for the eastern dwellers in its rising, and likewise in its setting, relative to the western dwellers. Were the Earth flat, then the eclipse would occur at all places of the inhabited earth at one instant, and there would be no [difference between] east [and west]; were that so, why should the eclipse precede [in local time] for the easterner — i.e., its time of day is earlier for him — before the westerner? Since [in fact] the easterner [observes it] before the westerner, this is by reason of the Earth's sphericity. Thus the Earth's sphericity has been explained for you, by the proofs of demonstration, on all its sides.

So you should know that there is no [absolute] precedence [priority of position] for us [on the globe], and the mouths of those who deny [it] are stopped — [those] whose feet are toward the soles of our feet [the antipodeans] — to say that we sit on the upper part of the globe and they sit below us [on the lower part]. For every place at which a man stands — there he is "above," upon the Earth, and that place is to him the height of the globe [the top]. In this respect all places of the world are equal: there is no basis to assign a verdict of "precedence" [primacy] to any one man over his fellow, to say that he alone walks upright while all others walk on their sides. Rather, all of them walk upright, and so do all others.

סימן נ"ו (Siman 56) — That many men circled and went around the entire globe of the world, and returned and came back to the place from which they set out

Furthermore, on [the matter] of the Earth's sphericity, I saw fit to set down here the account of an event that occurred in the year 5281 [?] of the Creation — that is, the year 1521 [?] CE — [the year] תרכ"א [?] by [the Christian] count [the numerals here are degraded; see report]. There was a man, one of [a certain nation] [?], named [?] Magellan [פירדינ"אנדו / Ferdinand], a great sage, a commander of the army of the king of Spain (ספ"רד / Sefarad). With ships [?], by the science of geography (גיאוגרפיא"ה) — that is, the knowledge of the position[s] [and] surveying of the globe of the world, which is also called [?] — he descended into the sea in Spain and went around the entire western side of the southern part [of the world] [?]. From there he turned his face to the east and sailed onward to the lands of India (אינ"דיאה — that is, the land of הודו). There the men of [a certain] nation [?] attacked him, and he himself was killed there; but his subordinate (his lieutenant) escaped in his ship with four hundred men, he and his wife, and the wind carried them onward until they arrived at the far eastern extremity — at the place where the soles of our feet [point] opposite the soles of the feet of the people of the land from which he set out. There they did not turn their faces westward back [the way they had come], but only [continued], to see

whether one could encircle the entire globe of the Earth. Therefore he continued to sail onward in his ship toward the east, and arrived at the New World (its location will be explained further on, in Siman 73 [?]), and circled it, leaving it on his left, his face always toward the east, and he never turned the rudder [?] back toward the place of his departure. [Finally] he turned his face back to the great city of Seville (סיביליא"ה) in Spain, [the place] of his setting out, and made for himself, as a sign upon his banner, the figure of a globe, upon which was written (as though the globe were speaking to him): "You [were] the first to encircle me." Also Ptolemy [?] (פטולמיוס [?] — "the bearer of the light of the eyes" [?]), [a great] sage, mentioned this matter [?].

A deed like this deed [?] one man of England (אנגליט"רא) performed by himself, named [?] Francis (פרנ"ציסקי / Francis [Drake?]), in the year 5337 [?] of the Creation — that is, the year 1577 [?] CE.

סימן נ"ז (Siman 57) — That the Earth stands within the midst of the celestial circle, in the middle of the zodiacal orb [?] within the circle

The Earth stands within the midst of the celestial circle, [equidistant] from the two poles of the [zodiac]. This is [shown by the fact] that the zodiacal degrees [seen at] the meridian — and [each degree's] watch — are not more on one side than another. The Earth also stands [at] the center of the zodiacal orb, and its center [the Earth's] is the center of the ninth orb [as well], for it has already been explained above [in Section 1, siman ~?] that the center of the zodiacal orb itself is also the center of the ninth orb.

For all six great circles of the [celestial] globe pass over the [Earth's] center. Therefore you should know that the Earth inclines no more toward [any one] of the extremities than another: not east, not west, not north, not south, not up, not down. The demonstration of this is that a man, at every place of the world where he stands, sees [exactly] half of the zodiacal orb, in precise equality. Were the Earth inclined toward [any one] of the extremities, then the man standing upon it there would not see [exactly] half of the heavens; the part of heaven that stood above him [?] he would see, and more than half [or less]. This is very strong evidence that the Earth is within the precise middle of the zodiacal orb — exactly [at] the breadth [center] of the zodiacal orb.

סימן נ"ח (Siman 58) — That the Earth, by reason of its smallness, has no [perceptible] proportion or measure, as our eyes sense, against the breadth of the zodiacal orb

From the principle they laid down — that the entire globe of the Earth is reckoned as almost nothing, nor as having any proportion at all, against the magnitude of the breadth of the orb of the [fixed] stars — and from this it follows [?] that the Earth's globe is reckoned merely as a point [?]. For if the Earth's globe had any proportion of magnitude against [the size of] the zodiacal orb, [i.e.] if it were as one part among the parts surrounding [it], then all the inhabitants and dwellers of the inhabited earth could not [each] see, at every place of the world, the whole [extent of the] half-heaven — that is, six whole zodiacal signs. For it is recognized by sense-experience that every inhabited place of the inhabited earth never sees less than half of the zodiacal circle.

[The reasoning is illustrated] as shown in the standing diagram: the outer circle [stands] as a sign for the zodiacal circle, and the inner circle [stands] for the globe of the Earth. The line dividing the zodiacal circle into two equal parts [is the line ב-ג]; the observer stands at point ד [dalet], where the [diameter] line ב-ג [passes]. He does not see [less than] half the circle. [It would be wrong to say] that the observer [standing] on the top of point ד sees less than half the circle, [for if] he stood at point ד on the Earth's surface, below the line ב-ג [?]... [the text discusses how, even when one stands on a mountain, the difference is negligible.] As one who stands on a mountain — the higher the mountain, [the more] he sees [of what lies] below the mountain and below it [the horizon dips] — yet even so, it is possible that even for fifteen parasangs [of elevation] only one degree [of additional view] would be sensed [as additional] degrees of the orb. And since we are always at [a place equivalent to] the center [of the orb], wherever we are, it necessarily follows that six complete zodiacal signs [are visible], and that our horizon is a [great] circle. Our view from the height of the Earth resembles exactly [the view] as if we were standing within the very middle of the zodiacal orb, at the Earth's center — [as if] the line going out from us, from the Earth's center upward, [were drawn] from the [center] point upward... [down to] point ד, which is the thickness [radius] of the Earth's globe, [a magnitude that,] even though it amounts to a line of a thousand parasangs, is nevertheless — as far as our observation goes — not to be reckoned as anything. From this it follows that the whole globe of the Earth is to be reckoned only as a point within the great circle [of the heavens].

The magnitude of the breadth and depth of the zodiacal orb [is so great] that the length of the diameter going out from its center for us, [measured] from the Earth, would be — by comparison — to the eighth orb [the orb of the fixed stars] no larger to us than a grain of mustard or a hair's breadth. For the investigators find that the body of [each] of the fixed stars is many times larger than the body of the Earth, even though to us it appears [only] as the breadth of a coin or a small rock.

[Rashi script / commentary:] Many of the scholars sought out and investigated the magnitude of the breadth of the eighth orb. To this day, despite their great effort, its breadth and its circuit have not become known to them by precise scrutiny and accuracy. R. Yisraeli [Isaac Israeli, author of *Yesod Olam*] wrote, in Chapter 4 [?], in the name of two [other] sages, that some astronomers found that the length of the world's diameter [?] is greater than [had been] supposed — that it is thirty thousand [?] parasangs in a day [?]. If this be true, then its circuit would be a circle of 24,000 [?] thousand [parasangs] sixteen thousand times over [?]... — that is, [a number running to] sixty thousand thousand [?] [parasangs] per day; its number in *milin* [Roman miles] is 481 thousand times [?] eight thousand and sixty [?] thousand [?]. [The numerals in this passage are heavily degraded and internally inconsistent — see Numerical impossibles.] It follows that each star of the first [eighth] orb, standing upon [or near] the straight line [the meridian] or close to it, would therefore revolve, with the diurnal orb's revolution, each and every hour [a distance of] twenty thousand thousand and seventy-five thousand [?] *milin* — even though, by the eye's sight, it appears to us as a single hour [?]. In truth this calculation is correct [?], and it is easy [to verify] for those versed in the sciences of mathematics, of [astronomical] computation, and of measures. Others went still further and wrote [figures] more than twice [as large], reckoning beyond the past number [?]; but I have not found [anyone] to bring [conclusive proof] [?], according to its [true] reckoning.

סימן נ"ט (Siman 59) — That all the lines of the celestial circles, which are all above [in the heavens], are all marked [correspondingly] upon the globe of the Earth below

Since the Earth's sphericity [shares] one measure [of center] with the midst of the center of the ninth orb (as above), as well as with the midst of the center of the zodiacal orb (as before), it follows from this that all the circles of the heavens above are engraved [as it were] in the intellect, in their likeness, [also] as circles upon the globe of the Earth below. Thus: the circle that is the equator — which is

in the middle of the heavens between the two poles, [as] one line [equidistant] and dividing [the sphere]...

the [equator] is called by another name, "the line of the equinox" (קו השוה / equinoctial line) — that [line] above the Earth, which [stands] opposite it [below], is itself likewise the straight circle or the circle of the equator. So too the rest of the Earth's circles that lie opposite the celestial circles — such as the zodiacal circle, and the tropic of Cancer (סרטן), and the northern and southern circles — each one is called by the name of the [circle] above that lies directly opposite it.

The benefit of [reaching] this point is so that there may be revealed to us, by reason of its [each place's] position, the [data] of all the inhabitants of the inhabited earth: under which circle or sign they dwell; the boundary [region] of every district and place of all the inhabitants of the inhabited world — how much it is in the world's longitude and how much in its latitude. From this is made known to us the nature of each land and district as to [matters of] precedence and warmth [climate], [and] as to the length and shortness of [its] days; [and] as to the precedence and lateness of the rising of the Sun for the dwellers of each [place] — and many other matters besides.

סימן ס' (Siman 60) — That the globe of the Earth is also divided into 360 degrees of longitude, and likewise [of] latitude; and at which place this reckoning begins

According to what we explained nearby — that all the celestial circles above are marked upon the globe of the Earth below — you must now know that, just as the astronomers divided the great circles [those] passing over the Earth's center, each of them into 360 degrees, as above in Siman 57 [?], so too every encircling line that surrounds the Earth's globe and passes over the [Earth's] center likewise rises to 360 degrees, and these in turn [divide] into [their] minutes (dakin / arc-minutes), each degree into 60 [?]. Therefore [consider] the [great] line, in thought [drawn] upon the surface of the Earth's globe's center below, running from west to east — this is what is called "the world's longitude," as will be explained — divided into 360 degrees.

We must now consider which is the point or place that has the standing [right] of priority, to make it the starting point — from which we begin the count of the 360 degrees of the world's longitude. Therefore you must know, even though the Earth's sphericity, in its own nature, has no [intrinsic] beginning or end by which a beginning and an end might be measured — that is, [the astronomers had] to choose for themselves some known point and place upon it, on which to establish

[the matter], to set it as the head from which to begin the reckoning. (And for this reason, all the parts of the circle that surrounds the Earth's globe are equal.) Nevertheless, since the early astronomers found that the measure of the inhabited world's longitude, from the shore of the western ocean (אוקיינוס / Okeanos) up to the shore [of the eastern ocean — at the eastern extremity of habitation], is 180 degrees — which is half the Earth's globe, as will be explained nearby — it follows that there are here two [endpoints]: the [western] extremity and the eastern extremity of habitation, which have the standing [right] of priority over the other places of the world.

As for these two known places that have the standing [for priority], the early astronomers agreed to begin this reckoning from the shore of the western ocean. For most of the lands near it [the western shore] are more inhabited than [those at] the eastern extremity; and the early astronomers themselves also dwelt nearer to it than to the shores of the eastern ocean. Therefore [the prime meridian] is the line going out from the north pole and passing over the face of [a certain land] [?], and drawn onward and southward [?]... over the face of the land [?], [passing over] the Seven Islands — these are the islands called the Fortunate Isles (פורטונאט"י / *Insulae Fortunatae*, the Canary Islands [קאנ"ריאה / Canaria]) — [and continuing] over [?]... southward to Africa, by way of [?]... onward, [up to] the southern [pole] (which, in their place, will be explained for you further on in this Section). By this line, which is drawn in thought across the world's latitude from [the north] pole to [the south] pole, I name its appellation "the boundary line" or the dividing line, for it is the boundary, beginning, and end. The middle of this boundary line begins at [the meridian of] the dry-land extremity on the western side, [from which] the straight line of the world's longitude goes out, upon which the 360 degrees are inscribed. From there — that is, from the boundary line, the head [zero] of the count of the 360 degrees — the line of longitude goes out and is drawn, proceeding from the western extremity eastward, until the extremity of habitation on the shore of the eastern ocean, which is 180 degrees (half the Earth's globe), all of it dry land. And this line is then drawn onward from the eastern extremity westward — [the part that lies] beneath the Earth, beyond our reach — until it returns to the place from which it began to go out, [adding] also 180 degrees, so that their sum is 360 degrees.

However, you should know that some of the scholars who delved deeply and investigated, with the science of measurement, attained [a knowledge of] the boundary that the early ones [had] established as above, and they drew, in their reckoning, [a meridian] line from [one] boundary to a [revised] boundary [?]: they moved the first boundary [westward], inward into the western ocean, by ten

degrees, according to the divisions of the equator from which they begin the count of the 360 degrees — and this is by a sound reasoning, as will be explained further on at the head of [its proper] Section, God willing.

סימן ס"א (Siman 61) — Whence it was known to the early ones, who arranged a [prime] line for the longitude; that the dry land is, in [the breadth] of half its globe — for the Earth is spherical — 180 degrees

We have already explained nearby that the dry land's longitude, from the shore of the western ocean up to the shore of the eastern ocean, is 180 degrees, which is half the Earth's globe. You will ask and say: whence and how was this reckoning known to the early ones — that there should be neither less nor more than this? Therefore you must know that the early astronomers [verified] this reckoning. The astronomers chose for themselves messengers and trustworthy men — men and wise persons who knew how to make [astronomical] observations at [the proper] times — and they sent some of them to the eastern extremity and some to the western extremity, even to the shore [?]. They charged them all to watch and observe carefully, each in his place, the time of the onset of an eclipse of the Moon on such-and-such a day [?]. The western observers watched and saw that the Moon began to enter eclipse at the beginning of that night — say, at the beginning of the night of the Sabbath, for example — while the easterners watched and saw, in their place, that at the end of the night of the Sabbath, which is toward morning, the Moon began to enter its eclipse. When [the reports] were confirmed, the investigators set [the matter] up [as established] for the two parties [?], and for the whole [matter]. At one instant... [the calculation] found that between the watch [observation] of the westerners and that of the easterners there was a difference of [a certain interval] [?] of twelve [?] *milin* [or hours?]. By this it became clear to them [?]... that the inhabited [land]....

Section 3 (שער ג)

(Continuation of siman 61, from the prior batch — the determination that the inhabited dry land spans 180° of longitude, and the conversion of degrees to terrestrial parasangs.)

[continuation of the lunar-eclipse argument] … from this it follows that the inhabited world stretches across 180° of longitude, which is half of the celestial sphere, since the [terrestrial] sphere corresponds [to it]. For the discontinuity [of inhabited land] here matches what stands opposite it [in the heavens]; thus what is the beginning of night for one place is the beginning of day for another, as was explained above in Section 2, siman 46 [?].

Siman 62 (סימן ס״ב)

How many parasangs on the Earth's globe are reckoned against one degree of the 360 degrees of the celestial sphere above.

Following what we explained above — that the [thickness of the] terrestrial globe, by comparison with the great expanse of the [celestial] sphere above it, is reckoned as virtually nothing — it follows that the body of the Earth's globe is as nothing relative to the breadth of the sphere. For [even] many thousands upon thousands of parasangs would not suffice, according to the astronomers, to amount to even a single degree of the 360 degrees of the sphere [of the fixed stars], as was explained above in siman 54 [?]. Yet know, nonetheless, that they were not mistaken in this regarding the breadth of the zodiacal sphere; and even had their knowledge of its measure been off by a thousand-thousand times more, that great [error] would still escape them — neither its absence nor its presence [would be detectable]. The astronomers did not labor to investigate and find how many parasangs on the Earth are reckoned against one degree of the 360 of the *zodiacal* sphere. Rather, they took up [the matter of] how many parasangs below are reckoned against one degree of the [daily-rotating] sphere [of the heavens], and the truth of the matter — corresponding to what is above — they sought out and found: that to each [degree] of the rising degrees of the sphere above there correspond 15 parasangs below on the Earth's globe, which are 60 [Italian] *mil* [Italian miles]. This became known to them through investigation, and likewise [it was confirmed] in this land of ours.

And likewise, when they made precise inquiry, they found that for every [degree] a person travels from south toward north in the world, the northern celestial pole rises for him by one degree — for every 15 parasangs [traveled], the northern pole rises one degree, and the 360 degrees of the sphere [are thus matched]. This one finds by traveling from north to south: [traveling] southward, [for] every 15 parasangs the northern pole sinks and descends for him by one degree. They also found, between east and west [?], that the line of the equator [behaves] in just the same way: corresponding to each of the 360 degrees of the sphere above, [one travels] 15 parasangs of our land, until one completes the whole [circuit of the] terrestrial globe. From the general principle it is established that the diameter [?] of the Earth's globe — that is, from the western edge to the eastern edge, namely from the [western] boundary to the [eastern] boundary of the zodiacal [grid] [?] — [is reckoned] in degrees, as is the [span] from north to south between the [two] poles [?]. So too the breadth of the latitude-portion is reckoned in parasangs, just as is the length [in] parasangs; apart from this they found such-and-such

parasangs, as will be explained further on within this Section, in simanim 62, 63, and 64.

And know, regarding what we said — that each of the 360 degrees of the sphere [corresponds to] 15 parasangs of our land above [in measure] — that this is the precise reckoning above [along the great circles], where all the lines [meridians] that converge on the globe and on its center are correct, in [the case of] all six great circles of the globe, as explained above in Section 2, siman 39 [?]. For all the latitude-lines of the globe that are drawn from the southern [pole] to the northern [pole], being all drawn upon the center of the Earth — for each of them, [a degree] is reckoned as 15 parasangs above [matching] 15 parasangs below. So too the equator-line, which runs to the northern side [as] a [great] circle, is so reckoned: that 15 parasangs correspond to one degree, since it passes over [the center]. For it [too] passes over the center of the globe, like the rest of the [great-circle] lines.

But the lines that are drawn [parallel] across the length of the world toward east and west — the parallels of latitude [?] — to neither of these two sides [poles] does any single one [of them] run [through the center], because they are not [great circles] passing [through the center]. None of the longitude-lines [parallels] drawn from west to east [passes through the center], only the equator-line itself, and no other. Therefore — even though, for the purpose of reckoning the longitudes of countries, the whole length is counted, every single [degree of] longitude, as 180° of [the full] degrees — yet the smaller degrees [the parallels closer to the poles], in such a manner that they too [should be reckoned], are *not* counted at 15 parasangs per degree, because all the longitude-lines, the closer they are to the axis [pole], the more they diminish. You will see this matter clearly by the following illustration: just as the circle of Cancer [the Tropic of Cancer] is a smaller circle than the equator, and the northern circle [Arctic Circle] is yet smaller than the circle of Cancer — so too, [though] the circle of Cancer and the northern circle are likewise each divided into 360 degree-portions, those portions are smaller than the [degree-]portions of the equatorial circle.

Siman 63 (סימן ס״ג)

The measure of the line [circumference] that encircles the Earth's globe, and in how many days and years a person needs [to traverse it] going around the globe.

From the general principle that we have mentioned, it has become known and established for us the measure of the line that encircles the entire globe of the

Earth. This [is computed] thus: when we reckon each degree at 15 parasangs above, then for all 360 degrees of the sphere above — being 360 times 15 parasangs below — the numbers add up to 5,400 [German] parasangs (*Aschkenazit* [German measure]). And if we reckon by the natural [pace] of the men of our land — a person's middling daily journey being 5 parasangs — then the time of [making] the circuit around the encircling line, from edge to edge of this [globe], would be 1,080 days, which are three years and 15 days. This accords with the sayings of Chazal, whose import is that the measure of the Earth['s circumference] is a journey of 500 years — for in matters of astronomy and the measure of the Earth, [there are] the words of the Sages on the one hand and the words of the astronomers on the other [?], of which more will be said separately at the conclusion of the book, b'ezras Hashem [with God's help].

Know also that, according to the author of *HaDe'ah* [?], we find in [tractate] *Bava... Metzia* [?] that the measure of the Earth's globe is close to the figure mentioned [here], for there was one who said: "*Shita alfei parsei havi alma*" [Aramaic: "the world is six thousand parasangs"] [Talmud, Bava... — reference uncertain] [?]. Rava said this; and although he was challenged on it from four *matnita* [Aramaic: baraitot/teachings], the text remained as a difficulty there [?]; nonetheless we knew and saw that Rava's tradition is correct, and it is very [valuable] for [refining] the reckoning, which the Rambam ז״ל also anticipated [?] in chapter 5 [?] of the *Hilchot* [Laws of...] [Mishneh Torah, Hilchot Kiddush HaChodesh] [?]; and in his introduction to *Seder Zera'im* you will find that his view inclines also to the opinion of Ptolemy [תלמיאוס] [Claudius Ptolemy], that the Earth's globe has a circumference of 24,000 *mil*, which is six thousand parasangs precisely [?]. See also, regarding Rava's tradition, the *Sefer Me'or Einayim* [of R. Azariah de' Rossi], chapter 28 [?], folio... [?], where it remains a difficulty requiring study [צ״ע], ז״ל.

Siman 64 (סימן ס״ד)

Refutation of the view of certain of the ancients, that they said that half [of the Earth] — namely the Earth's globe — is submerged in water.

Already at the head of Section 1 [?], at the very beginning, we explained our judgment that the lower world, in its entirety — the dry land together with the Ocean Sea (*Okyanos*) joined to the rest of the seas and dry land — is spherical [?]; and that the dry land and the seas together, on all six sides, are [arranged as] a globe [?]...

[The view] that half the Earth's globe is submerged [in water] — and that only half [emerges] — [some] understood from what the verse says (according to the interpretation [?] of Rashi ז״ל and Radak), namely "for He founded it upon the seas" (Tehillim 24:2). And so too the view of the great expert [?] [is] as you will find [it]; and likewise R. [Avraham bar] Chiya [Abraham bar Hiyya], author of *Tzurat HaAretz* [The Form of the Earth], mentions them [these views]. And likewise you will find with the expert [?] R. [Yitzchak] Israeli [Isaac Israeli] in his book *Yesod Olam* [The Foundation of the World] [attribution to Israeli is disputed in this work — flag], and likewise in [other] books, [where] the many generations [of scholars] who relied upon this opinion [are recorded], and many structures were built upon it, as will be explained further on at the end of part 1, essay 1 [?], in chapter 6 [?], siman... [?]. Also from the words of the *HaMidrash* [?] [— see that] his view was so, as the author of *Me'or Einayim* [Me'or Einayim, ch. 41 (?)] examined regarding him; and likewise [the view of] the author of *Shvilei Emunah* [?] [R. Meir Aldabi, *Shvilei Emunah*]. And know that all these ancients [held this], and among the moderns [too] there were found those who erred in this — inadvertent or willful [?].

To the moderns it became known, more than a hundred years ago to this day, by means of ships — the emissaries [explorers] of France, Spain, and Portugal who descended into the sea — what had not [previously] been known, [whether] by sight or in speculation: that on every one of the four [or six?] sides of the globe of the world they found inhabited [lands], some of dry land and some [otherwise], [both] in the upper part [of the globe], according to us, and in the lower part [of it] — that is, the part directly under the soles of our feet, which is the New World, called *...nichba* [?] [the recently-discovered / "hidden" land?]. There [in that place] there is broad dry land — a great part, close [in size] to a third of the world — in which we [now] live [?], and flocks and herds dwell, and [it has] human inhabitants, as will be explained b'ezras Hashem. And although we have found in the fifth chapter of *Pirkei R. Eliezer* [Pirkei de-Rabbi Eliezer, ch. 5] [?] that they said there that the Earth floats [?] upon the deep, like a ship floating in the heart of the sea — and likewise in the chapter "All the Images" [Talmud, *Avodah Zarah*, ch. 3, "Kol HaTzelamim"] and in *Bamidbar Rabbah* they said that the world is [round] like a globe and the sea like a basin [?] — [these] and similar sayings of others, many, which appear from the words [of Chazal] ז״ל to mean that their view was that half the globe of the world is submerged in water, like the opinion of the Chacham [Ibn] Ezra [Avraham ibn Ezra], Radak [?], and R. Eliezer [?] and R. Chiya and R. [Yitzchak] Israeli mentioned above —

[is contradicted by experience]: behold, the famous, manifest, experiential test (*nisayon*) belies, before the eyes [of all], those who deny [the plain reading] — that "for He founded it upon the seas," its interpretation [is] "upon the seas" as in "[He founded it] upon the rivers" (Tehillim 24:2), [i.e., not literally half-submerged]. And concerning the words of Chazal ז״ל [in] all [these places] there is not so much [reason] to wonder, for in matters of astronomy and the measure of the Earth, in many places their words ז״ל are sealed and obscure, and many [things] they stated by way of parable and riddle. And at the conclusion of this our book, [in] a small note [appendix], it will be made plain — for the great investigators have already expatiated at length, hesitating to speak [critically] about words found in [the sayings of] Chazal ז״ל that [seem to] run counter to the astronomy manifest to our eyes — so as to reconcile them somewhat to our eyes, [showing] that they [the Sages] do not dispute the famous [established truth].

Siman 65 (סימן ס״ה)

Whether the Earth stands upon the water, or the water stands upon the Earth.

Since it has [now] been made clear that all the seas together with the dry land are [arranged as] a globe, joined into one body — therefore there is room here to be perplexed, that is, to ask: does the Earth stand upon the water, or does the water stand upon the Earth? Now at first inspection it would appear that the Earth [stands] upon the water and that the Earth is the principal thing, because all the [bodies of] water are seen clearly against [i.e., set within] the globe of the Earth, [being] a minority of a minority by comparison with the globe of the Earth — so much so that, even if all the waters were loosened and lifted [from their places]..., [the Earth would scarcely be diminished] [?]. [The waters] are as something placed, in every place, as if [merely overlying] the Earth's surface, [collected] in some of its low-lying spots.

By this [reasoning], given that the thickness of the Earth — by which I mean from its center up to its surface [?] — on the nearer [reckoning] is some nine hundred [?] parasangs, then accordingly the water could not amount even to one part in a thousand against the thickness of the Earth's globe. Take for yourself a fitting analogy: the substance of an apple, whose thinness of peel measures [?] something like one [part] in fifty of its [diameter] [?]; and *a fortiori* — and all the more so — for the great globe [of the Earth], for the larger the globe, the more its peel [crust] diminishes in proportion to its substance [the rind grows relatively thinner as the globe grows larger]. All these matters are easy for those versed in the science of measurement [geometry], and there is no need here to expand on

their explanation, for it is not fitting to intermingle the [present] matters with the matters mentioned.

From the foregoing matters, it would appear at the outset of inquiry that the Earth is for the most part the principal [thing], and the waters [merely] a minority appended to it — so it would seem fitting to the heart [reasonable] to say that the waters stand upon the Earth.

Yet upon [further] reflective inspection, the inclination of the heart would [also] appear [otherwise], and we may say [the opposite]: that the Earth stands upon them [the waters]. For were we [to suppose] the globe of the Earth as a whole, throughout its interior, [to be solid] — [if] there were not found even one part in a thousand of water against the [solid] measure of the Earth's globe — [then it would be otherwise]; but according to what appears to us, the very opposite is the case: that the interior of the Earth's globe is [otherwise]. For this reason no [perfectly] level [solid] surface is found anywhere on Earth, so that wherever you break open the ground a few hand-breadths or a hundred *amot* [cubits], you do not fail to find water there. For then waters press, issue, and well up from beneath the ground; and we see every day how places break open in mountains and valleys, and waters issue and flow from there, and rivers come into being that previously had never existed. From all this it appears, and it is near to belief and reasonable [to hold], that the globe of the Earth is filled with water within, and that water is the principal thing, and that the Earth stands upon the water (it is possible…). To this [intent] the Psalmist directed [his words]: "to Him who spread out the Earth above the waters" (Tehillim 136:6).

In support of my words I found, in the *Sefer Ma'aseh Hashem* of the Chacham R. Eliezer Ashkenazi, in chapter 3 [?] of his book, on the verse "And God said: Let there be a firmament" (Bereishit 1:6) [?], that he wrote that before God decreed "Let there be a firmament," the Earth was a [single] continuous mass, such that had a man dug down to the center, no water would have been there; but when the Creator decreed "Let there be a firmament within the waters," then [it came about] that "if you dig, you find water" — in such a manner that the [decree] "Let there be a firmament" returned [applied] to the aforesaid Earth, that there should be within it a firmament amid the waters. (End of his words.) And in my opinion, "He who spreads out the Earth" is itself called "heaven" [?] — to this [the verse] said "and God called the firmament heaven"; and it is also possible to say [this resolves] what is found in the words of Chazal ז״ל when they say "upon what does the Earth stand? — upon the water," [so] that the words of Chazal ז״ל agree

with what we have explained. Thus it appears to me. Now let me hear what my colleague [?] will say.

Siman 66 (סימן ס״ו)

Refutation of the view of the ancients, who said — adjoining what they said in siman 65 [?] — that there is in [the region] near the equator no [human] habitation, on account of the great heat, and likewise near the northern pole there is no habitation, on account of [its] climes.

Know that the ancients — Ptolemy [תלמיאוס] [Claudius Ptolemy], head of the astrologers [?] [the astronomers/Chaldeans], and those who followed in his footsteps — judged that from the equator-line, on both its sides, to north and south, according to the whole breadth of the band of the zodiac (which [band] is the surface lying between [the Tropics of] Cancer and Capricorn, as will be explained, b'ezras Hashem, at the head of [the topic of?] the surface lying between the two circles [tropics], whose latitude is close to 47 degrees [?], as was explained) — that it is not possible…

[that men can dwell there] — that there is no habitation that can endure [there]. Yet there was one who said there [?] [the opposite]; and [there were also] those who, on the contrary, [held] that around the equator-line itself [there is habitation], because there [the heat] is moderate [?] — for that is the matter of their judgment [?]; [but] in [the band of] the [whole] zodiac, by the same reasoning, all would be scorched. So according to their view [the ancients held that habitation is impossible] — namely, that all that lies near the zodiac, up to ten degrees [from the equator on either side], would be entirely scorched [?]; and likewise [it is so] at the season of the summer solstice (*Tekufat Tammuz*). So too the ancients [held] that from the northern circle [Arctic Circle] onward, up to the pole, there is no habitation on account of the great cold [?]. According to this, the inhabited [zone] known to the ancients would be only a portion of a quarter of the globe at most: from the equator-line up [to] the northern circle [Arctic Circle], which is 43 degrees — being, by the reckoning of 15 parasangs against one degree, some [645] parasangs [?]. It is concerning this breadth alone that the inquiry of the ancients revolves.

And they divided the said breadth into seven portions [climes], calling each portion and section a *clime* (*iklim*) [Arabic: إقليم (iqlīm) / Greek: κλίμα (klima), "clime, latitude-band"]. In our holy tongue [Hebrew] it is called *nof* (district/region), from the language of the three districts (*sheloshet ha-nafot*) [?]

mentioned in Yehoshua [?]: as it is written, "the three regions [districts]" (Yehoshua 17:11), [where] *nof* signifies "land" [region] [?].

These seven climes [are arranged] such that each one of them runs along the length [of the world], from the western edge to the eastern edge, according to the length of the upper portion [of the globe] — which is here 180 degrees, as you will see more clearly by the illustration:

Diagram. A large circle representing half of the encircling globe (the inhabited upper hemisphere), labeled with the four letters א ב ג ד [alef, bet, gimel, dalet] at its four cardinal points, and divided internally by a series of roughly horizontal lines [the boundaries of the seven climes] running across its width. The circle is captioned in the surrounding text as "the circle אבג״ד [alef-bet-gimel-dalet], which is the form [representing] half the encircling globe of the Earth's habitation."

- ב (top): [bet] — northern point / top of the hemisphere
- א (right): [alef] — eastern edge [?] (the edge of the East, the island called *Gini'ah* [?] — see siman 68)
- ד (bottom): [dalet] — southern point / bottom
- ג [?] (left): [gimel] — western edge [?]
- (Internal horizontal lines): the dividing boundaries of the seven climes, drawn across the width of the hemisphere; the band nearest the equator (center) is the widest, those toward the pole narrower.

Explanation of the figure (continuing the text): The circle אבג״ד is the form [representing] half the encircling globe of the Earth's habitation, [drawn] over against [i.e., projected onto] the points [?]. [The line] passing through the middle [?] — set upon the Earth, the standing pillar [axis] — is the line of the equator at the [central] equinoctial points [?]; line א-ג [alef–gimel] is the equator-line, and line ה-ו [he–vav] is the circle [Tropic] of Cancer [?]; and [it is] the [region] within which the seven climes are situated [?]. Line ז-ח [zayin–chet] [marks another boundary], and the length of [each clime] is reckoned from the western edge — line ה-ו [he–vav] up to line ז-ח [zayin–chet] — running from the western edge [?]; the length of the line of the equator [?] is 180 degrees, even though it is shorter [in absolute terms] [?]. The closer a clime lies to the northern pole, the more it is shortened, so that you will see in the figure that line ז-ח [zayin–chet] is shorter than line ה-ו [he–vav] [?]. [This serves] for the knowledge and locating of all the places of the Earth — how many degrees of [the world's] length each lies along, and how much its breadth [latitude] is. Each one of the climes — whether it be

long or short — and each one of them [extends] 180 degrees along its length, as will be explained further within siman 69 [?]; and the [total] breadth of the seven climes together, as has already been explained, is precisely 63 degrees [?].

The ancients wrote down some of the names of the countries in each and every clime, and also the length of the longest day in each one. But for us there is no need of this in our book, for it suffices us to know the measure of the length-portion and the breadth-portion of the globe, as the full purpose of our words has been explained. The boundary [reached by] the first ancients for [the limit of] the habitation was [marked] thus, and the rest [of the globe] they reckoned as wilderness and waste, and uninhabited regions, into which neither the foot of man nor of beast had passed — on the southern side because of the great heat, and on the northern side because of the great cold.

Yet the [later] scholars who came after them, especially in the days of the moderns, in these [last] hundred-odd years to this day, [it] became known to us [through them] that the inhabited world already [extends] over most of the face of the earth, and the boundary of the habitation [stretches] under the whole breadth of the bands of the zodiac. [Explorers] set out from their ships, [sailing] year after year — *Aschkenazit* [German-style], from France, Spain, and Portugal — and were able to reach *Andia* [India] [and] *Kalkut* [Calicut], places where the perfume-spices [grow], which lie toward the eastern side, [whose lands] are the strongest [hottest?] in those routes; and circling [around] the part of Africa that juts out [as a cape] into the midst of the sea, they rounded it like a bent palm. Before reaching their [destination's] place, and before swinging round to their land and roving back, they had to pass under the whole breadth of the bands of the zodiac — four times, going [out], and twice [more] on their return — [in the course of] which their route brought the sun to stand overhead [?] four times [?]. There they found inhabited [lands] and great and mighty islands, as you will see [in] the matter of their route further on, in the maps of the world. Likewise from the said countries [men] travel just so, year by year [?], from the west to the New World, going to the part [region] of *Pir'u* [Peru], where for the most part that land lies under the whole breadth of the bands of the zodiac, as will be explained further on in siman 70 [?]. Also there was revealed to us *Rivu'a* [?] [a fourth landmass — *Quarta Pars* / *terra quarta* — the "fourth part" of the world] [?], countries [?] that lie beyond the northern circle [Arctic Circle], up to fifteen degrees [?] near the northern pole — such that you should know that the moderns crossed the line [boundary] that the first [ancients] had set as their [outermost] limit.

Siman 67 (סימן ס״ז)

The reason the ancients divided the habitation into seven climes.

Know that the reason the ancients divided up the habitation into seven climes, by the nature of the climes [?], [was] for the purpose of their aim — namely, to know each and every country and city, and through it [to know] in which clime each city lies [?]; and also to know the measure of the longest day of each and every clime. But I do not know [?] why they specifically fixed the number of climes at seven — whether [it was] because *Iklim* itself [the word] is found [used elsewhere], or [for some other reason] — and there is [for our purposes] no concern in this; only the matter [is] in our hands [as inherited tradition]. Also [there are] regions [?] that are children of [i.e., subdivisions of] the climes [?], or districts [?] — [these are] the countries [?]…

the countries and cities, [and] also the measure of the days, in every place and locale [?], by a different reckoning [?], as [discussed] in siman 64 [?] — concerning which I will not expand here, for I have explained it [?] further on in the explanation of the seven climes; nor have I troubled [to assign] them to the markers [coordinates] of the countries, for it suffices us [to know] the measure of the longitude-line and the latitude-line of the globe of the world, [so that] from them [we may] know how to locate [places on] the globe of the world, as will be explained — and the entire astronomy [needed] as well.

And there is for you [reason] to know that the [later] scholars, the moderns, divided up the whole habitation — the said seven climes — into three large portions [?]; and the moderns from [a certain point onward] [?] found [new lands] and added to them. Indeed [they did so]: time after time addition was [made] upon addition, until in our times [the explorers] found [so much] that they divided the globe of the world into eight portions. And these are their names: the said seven climes [the Old World] they divided into three portions, which are (1) *Asya* [Asia], (2) *Afrika* [Africa], and (3) *Aropi* [Europe]; and the New World they divided into two portions, which are (4) *Piru* [Peru] [?] [the southern New World] and (5) *Yukatan* [?] [or *Mexico*?] [the recently-found great portion]. [These make five.] Then they found a further great portion, and over and above the [first] six they added and appended to it a [portion] called *Gini'ah* [?] [*Nova Guinea* / New Guinea?] [— making (6)]; [together with] (7) the northern world and (8) the southern world, [the count] reaches eight. And now I will explain to you their particulars.

Siman 68 (סימן ס״ח)

The model [structure] of the forms [figures] of the globe of the Earth with the seas — all eight portions [of] the dry land mentioned above [taken] together as a whole.

Says the author: Before I come to explain in detail each portion of the eight portions of the world — so that the matter not be [too] obscure for the students, who [study] without a teacher [?] — I saw fit [first] to draw, at the head [outset], the whole model and form of the globe of the Earth with the seas, [and of] the dry land mentioned above, in a general way. Since it is impossible to draw a globe properly upon a [flat] surface, therefore the investigators differed in their opinions and drew it [the globe] in various ways. As I have before me [several] forms of the globe of the world drawn on six different manners [projections], in order to make it easier for the students I have selected from among them the easiest and best drawing, by which we fulfill the obligation of [representing] them all, and through which it is easy to explain it to the students: to draw it [the globe] upon a [flat] surface as two circles. Picture it to yourself as if we took an apple or a globe and split it from top to bottom — that is, from the northern axis to the southern axis, by way of the eastern edge and the western edge — into two portions, each of them 180 degrees of [the full] 360 [?]; and imagine to yourself that we then pressed down [flattened] the two raised heights [hemispheres] of the globe or apple, until it became as it were a surface without height, as you will see in the figure. Nevertheless you will draw [each half] as a [convex] figure: each one of the two circles is like a basin or like half a globe bulging outward, in such a manner that, when the two circles are joined together and the encircling line of one is laid upon [matched to] the [encircling line] of the other, it will appear to your eye like two basins set one upon the other — one portion will be on top and the second portion below. So that you should know that the first circle [represents] the eastern edge — the [eastern] island called *Gini'ah* [?] [New Guinea?] — and that the second circle [represents] the western edge, [each] in the forms as they are; for, according to what appears, [were it not for] the great distance between the two said places, on this [layout] the two said places [would coincide?] [?]. When the two circles are [drawn] one upon the other, the two said places will be near to one another.

[Rashi-script / smaller secondary text on p. 52, left column]

[On the construction of tables (Lochot / lat. *tabulae*).]

[Rashi script:] **The making of the tables.** ... This is the making of the tables (*Lochot*), drawn according to the astronomers' [methods] [Latin: *tabulae*]; ... in the [common] tongue [it is called] *Mapa-mundi* [Latin/Italian: *mappa mundi*, "map of the world"] ... The making of the tables [maps] — I did not find it [done] [?] except by [the method] of *Plat...* [?] ... (and whoever wishes to study a map of the world that the author wrote [should] look within *Karet HaLand* [?] [Dutch: *kaart van het land*, "map of the land"?], a thing readily available) [?].

Siman 69 (סימן ס״ט)

Explanation of the two illustrations [tables/maps], and an exposition of part of [the] eighth circle [?].

The two tables [diagrams]. [As to] the two tables [maps] that we have set down [drawn] in this place, [you should know] that one is set above and the second below them [?]; and they will be required [to be combined] so as to form [the picture of] one globe, as will be explained. And indeed we have already explained above, in chapter [siman] 59 [?], that all the [great] circles of the heaven that are marked above [are] marked correspondingly upon the back [surface] of the Earth below [?]. Therefore I saw fit to mark out for you, upon this surface — which stands for [represents] the globe of the world — six circles, of which the most that are needed [are these]: five of them are drawn [running] toward the east [longitudinally], and the sixth is drawn from north to south. And although they are drawn as straight lines [on the flat figure], you should know that each of them [really] represents an arc or [a portion of] a circle [great circle], [seen as] half a circle.

Now first I will explain to you the middle line of the figure, line מ-א [mem–alef] [?], the line corresponding [analogous] to the straight [equinoctial] line above in the firmament, as will be explained above [?] in siman 59 [?]. This line goes out [begins] from the western edge — from *Sefatayim* [?] — of the Ocean (*Okyanos*) Sea, as was explained above in siman 60 [?], and proceeds and extends to the eastern edge; and from there it circles round upon a hidden circle [the back of the globe], which is reckoned [as] half of the lower globe [hemisphere], until it returns to the very point from which it began. This encircling line will be divided and marked off [graduated] from ten [degrees] to ten [degrees] in portions [?], up to the completion of 360 degrees, and it is called the longitude-line.

I explained above, in siman 60 [?], that there are [in addition] four [other] [great] circles, which are likewise [reckoned] from [those running] from west to east [?]: two of them found toward the northern pole — namely the circle [Tropic] of

Cancer and the northern circle [Arctic Circle]; and the [other] two found toward the southern pole — namely the circle [Tropic] of Capricorn and the southern circle [Antarctic Circle] — each one of them opposite its counterpart [the one] above it, as [explained] above in siman 59 [?]. And [there is] the complete encircling [meridian] circle, which in the figure circles round from north to south and from south to north, [passing] in the north [through] one place and over against [it] [in the south] — [one] of the two upholding axes upon which the height [poles] of the globe [rest], and upon its center, and upon the two axes of the world, the northern and the southern, as [explained] above in Section 2, simanim 38 and 39 [?]. This circle alone appears in the figure entirely flat [as a straight line], which is not the case with the other circles. This complete circle is divided into four quadrants, and in each quadrant are marked the ninety degrees of the sphere, by the method that was explained to you above in siman 35 [?], [pertaining] to these lines called the latitude-lines, by which it is reckoned and [their value] estimated in each and every place [?] — [namely] that it [the meridian], lying between north and south, is reckoned for [measures] the latitude of the world.

And now, when [all this] is marked upon the globe, and the places [?] of the countries and cities [are entered], then you will easily be able to see, in [this] illustration, without any reckoning or much inquiry, the longitudinal positions of the countries — that is, how much each and every one of them lies along the world's length toward the west [from the prime meridian] — and how much it lies along the world's breadth between the equator and the northern axis. For example, [take] Jerusalem: you will find it [lies] along the world's breadth, [measured] from the equator-line, [at] the northern axis [latitude] of 33 degrees [?].

Section 3 (שער ג), continued

[Conclusion of preceding discussion on globe-projection]

and further, the degrees toward the inside [represent] the world's west, and [their] length [?]. This matter will be better clarified in its place, where I treat the depiction of the globe. For the diagram I drew for the student, to instruct him, is small — it is merely a notice [a schematic], not the globe itself: I drew it only to show the parts of the world, but it cannot contain most of the world's countries because of its smallness. It cannot even contain [all] the parts of the celestial sphere — but only [serves so] that, should the Creator grant me strength, I may

bring to light yet another, larger plate (as I have done), from which the diligent reader will learn what I have at hand. [?]

There remain still many cities and settlements upon the terrestrial globe to be known; and every line that may fall upon the aforementioned diagram is not [drawn] properly to scale, for not every distance of the diagram's lines is [equal] in every place from the point of the axis. So too, all the lines of latitude in the diagram are shorter than [those] of an actual globe. Therefore, know, dear reader, that should it occur to you to wish to alter the form of this plate's surface and make a mark upon the globe according to the [true] method, you can do so, fulfilling the matter [as] I showed you above easily, for it is more similar to an actual globe.

I saw fit, in order to complete the work, to inform the reader that some of the astronomers [Rashi script: the wise men, the astronomers] have depicted the world's globe in another manner, beyond what we have already explained. This is what they said: It is as though we cut the globe into two from the northern axis [pole], passing [a line] opposite [it through] the center of the globe to the southern axis. In this manner you will find the two axes [poles] on the two sides of the aforementioned plate: the one axis at the top of the plate, and the other at the bottom, as at the beginning [?].

In this first manner, the early sages used [only] half of the aforementioned spherical surface, because in it the three parts of the world known to them are seen — which is from the western edge to the eastern edge, [comprising] 180 degrees as stated. They needed no more, since in their view all the rest was submerged in water. But in the second consideration — of which we now speak — the sage divides his work in another manner. This is how it is done: imagine that we cut the aforementioned [globe] into two at its middle, along the equator. Accordingly, the northern axis [pole] will be in the middle of the upper plate, at the center of the circle, and likewise the southern axis [pole] will be in the second plate below the earth. With this depiction, which Ptolemy devised, the sages employed both [halves] equally [?].

So you now know the depiction of the globe by the first method and consideration, [drawn] over [a single] hemisphere; and you know the depiction of the two hemispheres by the second method and consideration. Yet recognize that even this latter diagram, though it be truer — being more similar to an actual globe — bears a resemblance [to the sphere only] because of the equator-line and the circle of [the tropic of] Cancer [?] and the northern circle [the Arctic circle], and the rest of the latitude-circles, the ninety circles [the meridians?]. Each of

these is seen in its full circumference, just like the lines that encircle an actual globe. Moreover, every one of them, in returning, runs at an equal distance from the northern axis [pole], as do the circles of an actual globe. So too is the sphericity of the earth — whose length [extent] is seen in this diagram from edge to edge of the settled world [?]. And [yet] [?] it is not [perfectly] round, for [?]…

[The remaining parts] preserve the [proportions] [?]; the lines [are] shorter than [those of] an actual globe [?]. For it is impossible to depict the whole globe perfectly upon a flat surface [as] it ought to be.

Siman 70 (סימן ע') — A depiction of the terrestrial globe in another manner

[Body heading p. 53: "סימן ע' — צִיור כדור הארץ באופן אחר, והוא יותר דומה לבירור השעורים … לשלשה". *Editor's note: on p. 53 the compositor set siman 71 above siman 70 (reversed order), so the first pass read 71 and skipped 70. Restored here in correct sequence; the worn lower-corner closing lines remain `[?]` (see `.md`).*]

The author says: I have already set before the students a depiction of the inhabited world according to its parts in the manner described above; now I wish to set it out in another fashion, one that conforms more closely to the actual determination of the measurements. [?] For when you wish to picture the sphere of the Earth and the disposition of the inhabited portion upon it, you should imagine the whole globe divided so that the inhabited part occupies its known share, while the remainder is sea and the regions not settled by men. [?]

Picture, then, a round body representing the globe of the Earth, and upon it mark out the inhabited zone. Divide it into its parts as the ancients divided it — and the division by threes [the three parts: Asia, Africa, and Europe, treated in the adjoining siman] is the one that accords best with the reckoning of the measures, each part receiving its due portion of the whole. [?] By this means the student may grasp how the settled land is apportioned, and how each region stands in relation to the others upon the body of the globe. [?]

[The closing lines elaborate that this second mode of depiction — a solid globe with the inhabited band marked upon it, divided into the three parts — renders the proportions more faithfully than the flat scheme given earlier, and refer the reader to the accompanying figure; portions in the worn lower-outer corner are not legible word-for-word and are summarized here.] [?]

Siman 71 (סימן ע"א)

That the early ones divided the settled world into three parts, namely: Asia, Africa, and Europe.

Know that the early ones already divided the dwellers of the north [the inhabited world] in general into the seven climes [Rashi script gloss?: the climes], by [scholarly] reckoning; and there is good reason to divide it into three unequal parts. The largest part of them in size is called Asia; the second part, smaller than it, is called Africa; and the third part, the smallest of them, is now called Europe.

I shall now explain to you the boundaries and borders [of each], with [the question of] where they begin and where [they end] — settling everything with clear, well-known markers. In the aforementioned figure [the map] you will see palpably all the markers I shall mention. I shall begin with the part in which we dwell.

The first part is called Europe, upon which we live. It is named for a certain woman [?] named Europa [or: Asropi — Europa], who was [the daughter of?] [?] a king of Phoenicia [פיניצ"אן — Phoenicia], and who reigned and ruled over every side, so that she named this entire part — which was under her rule — after herself, Europe (Eropi or Aropi). [The name has held] until this very day. [?]

As for the location, the borders, and the boundaries of this part: its location is found on the northern and western side of the settled world. It is surrounded and bordered by seas on three sides — from the west, from the north, and [partly] from the south. How so? On the southern side, this part reaches the Great Sea, called in their language *Mar Mediterraneo* [Italian/Latin: *Mare Mediterraneo*, glossed as: the sea in the middle of the world], which is the sea that issues forth from the [strait?] on one side, [by] Spain [שפר"ד — Spain], and continues, passing the entire face of [the lands of?] Spain, France [צרפ"ת], Naples [נאפו"לש], Italy [איטלי"א], and all of Greece [יון], reaching as far as the Holy Land. The length of this sea is about six hundred parasangs, and its width [varies], sometimes more, sometimes less by about two hundred parasangs. This Great Sea separates the part [called] Europe from the part [called] Africa.

The islands found within this Great Sea are very many — exceedingly many — and the scholars of the earth's lands have already agreed that all the islands of this sea, [insofar as they lie north of it,] are reckoned and marked as belonging to the part Europe. This is the southern boundary of Europe, from its [western] edge to its [eastern] edge. On the northern side, this part extends ever higher up to the

northern circle [the Arctic circle], where the [northern] edge of the part is. On the western side, the boundary begins [where] the Western Ocean [is], called *Mar Atlantico [?]* [the Atlantic Ocean / Western Ocean]. Along both these boundaries, the northern and the western, the scholars [reckon] for them all the islands of the northern and western sea[s]. On the east, their boundary [runs] as far as the two rivers: the first is the river called *Idel* [איד"על — the Volga], which runs from south to the north and empties into the northern sea, [and these are] called [?] *Sibiku* [?]; the second is called the *Tanais* [טאני"ס — the Don], running from north to south [?], from the river-course of the *Idel* [?], and empties into the Sea of [Azov, by] the Ocean. [?]

A partial list of the countries in this part of Europe: these are the lands of Ashkenaz [Germany], Spain [ספ"רד], Portugal [פורטג"אל], Italy [איטלי"א], Poland [פאלאקי"א], Lithuania [ליט"א], Muscovy [מאסק"ווי], Lapland [ליפלאנ"ד], Bohemia [ביהמיא"ה], Hungary [אונגריא"ה], Turkey [טורקי"אה] (in part [?]), Denmark [דוניא"ה — Dania?], and the whole land of Constantinople [קונשטאנטינ"א] and Romania [רומאני"א], [Thrace] [טאראצ"יאה], [Greece] [הייני"ראצ"י], and [also] [?] the great island of Scotland [סקוצי"אה], England [אנגלטיר"א]; and from among the islands [are]: Iceland [איש"לנד], Denmark [דעני"מרק] [?], [the] Swedish [שווידי] islands [?]; [also] the islands of Corsica [קורסי"קה] and Sardinia [סירי"דיניא], which are the great islands of [the southern sea?] [?], Sicily [ציצילי"א], Candia [קאנדי"צה — Crete], and yet many more cities, islands, and the like — which, being many [?], [would be too many to list]. [?]

[The width of this part]: as for the [extent and] measure of this part, beyond those [already named], know that the line running from west to east in this part, from edge to edge — its width goes diminishing [as one proceeds] until reaching the part's edge. [?] From the great city of [Lisbon — ליזינ"אן] [?] which is at the western edge, [the part of] Portugal [פורטגא"ל] sits upon the shore of the Western Ocean, [extending] some five hundred [?] parasangs [in length]; and so too [is the measure of] Ashkenaz [Germany]. As for the measure of the line running in this part from south to north, [it runs] up to Iceland [איסלנ"ד] and the island of Sicily [ציצילי"אה] [?].

This part of Europe was settled many days after the part [of] Asia and the part of Africa, as will be explained [presently?]; though it is the smallest of the three [?]. Know that it is not [yet] fully [settled/known]: in it is found only a little inhabited land — except for Muscovy alone [?] — and to its [borders?]. There are no places in it where one finds [people] within a day's or [several] days' journey [uninhabited]; for [in those northern reaches] all of [outer] Europe is not

inhabited [?]. But the great and mighty cities [?] — its inhabitants need not travel [far] in this regard. Travelers alone [?] [wander], going from nation to nation and kingdom to kingdom, [one with another] in tranquility and security. The scholars [say] that the part Europe exceeds Africa in population. Now, in our time, this part is called the part of the Christians, since their religion has spread throughout this whole part, from edge to edge — [from the part near?] Constantinople [and beyond?] [?].

The second part is called Africa [אפרי"קא]; and they also say that it too is called Asia [?] — but this is not [correct]. [Rashi script: as it is named — namely Asia [אסיא"ה] — but this is not so] [?]. The Africa mentioned in the Talmud constantly [Talmud, various places — e.g. Berachos, Sanhedrin] and in other places, beyond [these] — what is written there with an *aleph* [as in אפריקא] and with a *yod* [?] — it is not possible that the two are one. For [the] Africa that Chazal [our Sages] proved [to be] on the eastern side of Eretz Yisrael [?] [— as appears from the words of Chazal there —] is but a single country [a city/province], and it is not [our Africa]. [?] But the Africa of which we speak here — all the early ones, and the later ones, reckoned it to be the third [region] of the [seven?] climes [?], and this part is much larger than Europe — close to double; yet it is somewhat smaller than the part Asia. The borders and boundaries of this part are marked [thus]: it is surrounded by seas on four [of] the world's [directions], [namely the] north [?]. It extends from the north and runs along [?], distancing itself over the whole face of the shore of the Great Sea, from its [one] edge to the other edge — from the right [west] of Spain [ספ"רד] as far as the Holy Land. For all the length of that Great Sea — which is the boundary of the part Europe on the south, as stated — that same Great Sea is the boundary marked for the part Africa on its northern side, as stated. And on the west, the boundary is the Western Ocean. On the south, its boundary [runs] — this part going on and stretching there as far as within the Southern Ocean. On the east, this part broadens out toward the tongue [gulf] of the Sea of Sin [China — the Indian Ocean / Red Sea region?] [?], such that this part is surrounded by sea on all four of its sides — except on the northeast side, where there is found a small tract not surrounded by the sea, but rather joined to the part Asia. This is the distance — the strip [of land] [?] [the isthmus] — which is the [neck of] land from the tongue [head] of the Sea of Suf [the Red Sea] to the shore of the Great Sea, the distance being, by [what] is heard, about [?] eight parasangs of our country. [?]

This part somewhat resembles a triangle, for [its] measure [?] goes on narrowing: on the north side somewhat broad, and on the south side, by the [Southern]

Ocean, it then has no width at all but only a few miles — such that this whole part resembles a triangle or a wedge.

The names of the [great] cities and the large and mighty kingdoms, [renowned and held to be] within this part, are many beyond number, and [I shall mention] a portion of their particulars. They are: Egypt [מצרי"ם], Cush [Ethiopia — כו"ש], Barbary [ברבריא"ה], the [lands?] of the [Antiopia — אנטיופ"יא] [Ethiopia?] [?], Lamboot [?] [מלבו"ת], Numidia [?] [עמי"דאה], Sheba [שב"א], and yet others besides them.

The third part is Asia [אסי"אה]. Its boundary and border, on the west side, begins from the end of the Great Sea — which is at the shore of the Holy Land — and from the tongue of the Sea of Suf [the Red Sea], and likewise from the two rivers Idel [Volga] and Tanais [Don] mentioned above, all of which border it on the west. It [thus] stretches and extends, [bordered] on its western side [?], spreading throughout this part on all six directions of the world. From every side [it extends] to the [farthest] corner: on the east, to its edge — which is the end of all the settled world, that is, as far as the shore of the Eastern Ocean; on the south, as far as the shore of the Southern Ocean; and to the north, as far as the northern circle [the Arctic circle]. This part is greater in size — twice double — than the two parts already mentioned, Europe and Africa. This part was first settled after the Flood, on the Mountains of Ararat [אר"רט] (according to the opinion of the Targum of Onkelos and the opinion of [Yonatan — Targum Yonatan] [?], for [the verse] reads קרדו [Kardu]) — and we have already explained that the dwelling-places of [Noah's] ark were on the Mountains of Kardu [קרדו] [?], which, in my opinion, are in the countries of Armenia [ארמניאה], according to our calculation of the earth's boundaries. In this part the whole earth was of one language, until they built the Tower [of Babel]; and in this part dwelt our forefathers Abraham, Isaac, and Jacob. In this part our holy Torah was given; in this part our Holy Temple was built. By way of general principle, most of the deeds of Creation [Maaseh Bereishis], the deeds of the Patriarchs, and the deeds [recounted in] the Torah, the Prophets — all of them were [in] the part Asia. Only the doings concerning Egypt were in the part Africa. From the part Europe we find no deeds in any of the Holy Scriptures — only that the prophecies mention the worshippers [the inhabitants] of France [צרפ"ת] and Spain [ספר"ד], as in their saying "and the exile of Jerusalem which is in Sefarad" [Ovadiah 1:20], and "the captives… in Tzarfat" — [namely] the country of France [פראנ"ציא] and the countries of Spain [השפ"ניא], as Rashi and Radak explained there [Rashi and Radak on Ovadiah 1:20].

In this part are found great deserts, long and wide, which it would be impossible to measure. From this [fact] [it follows] that the names of the countries and the [provinces] [?] and the great and mighty [realms] found in this part have no number. I shall mention only a portion of them — the largest among them: Armenia [ארמניא"ס], Mesopotamia [ארסנה"ריס — Aram Naharaim?] [?], Chaldea [כשד"יס], Persia [פר"ס], India [אינדי"אה / חנד"ו], and here [?] [Cathay?], the Great Dog [הכלב הגדול — i.e. "Great China"?] [?], China [חינא], Japan [יאפ"ין] — all of them vast and mighty realms, and many others besides.

Siman 72 (סימן ע"ב)

That Noah's sons, Shem, Ham, and Yefes, divided among themselves the three parts of the world.

The scholars [versed] in this science have written that the three [parts] we have been discussing — the parts of the world — were divided by Noah among his three sons, Shem, Ham, and Yefes [Japheth]. His sons themselves apportioned to one another, each one [taking] his part: the part Asia fell to Shem, the part Africa fell to Ham, and the part Europe to Yefes. In my opinion, that which they said is correct, and there is a great hint and support for their words; for when you study the genealogies of Noah's sons [Bereishis 10], you will find — from the plain sense of the verses — that [the matter] will be explained, as is seen [there]. [?]

[Continuation, Siman 72 — page top, second column]

For [thus] it is written: "the sons of Yefes" [Bereishis 10:2] — [these settled] Europe; as it is said, "the sons of Yefes: Gomer and Magog and Madai and Yavan and Tuval and Meshech and Tiras" [Bereishis 10:2], and "the sons of Gomer: Ashkenaz and Rifath and Togarmah" [Bereishis 10:3] — all these names are the names of countries of [Europe]; for each one called his land or his city after his own [name]. And you find this in the *Sefer Yosippon* [Sefer Yosippon], and likewise Don [Isaac] Abarbanel [explained it] in his commentary on the portion [?], as Isaac Abarbanel [explained] in [his comment on] the verse "and these are the sons" [Bereishis 10] [?]. These names are the names of the countries [provinces] that are in this part [Europe], for the [descendants] [?]: [the sons of] Yosippon's [son] Tuval [?] and Magog — from there issued the inhabitants of the islands [of the sea?] [?]. And likewise Gomer [?] [— this is Spain]. [?] [Yosippon] wrote [that] Tuval [are] the Italians [?], and Yavan [are the Greeks — יוונים]; and Tiras [the author of] *Yuchasin* [Sefer Yuchasin] wrote [is] Thrace [/ תורקיה מרציא"ה — Thracia / Murcia?] [?]; and Tiras [תירו"ש] is Ashkenaz [Germany] — meaning [in German:] *Deutsch* [דייטש — "Deutsch," i.e. German], the Cushites

[כושים] who [dwell] apart, called *Tziprin* [ציפרין] [?]; Togarmah [תוגרמה] is Turkey [טורקיא"ן] [?]; *Dodanim* [דודני"ם, Bereishis 10:4] [are] the *Danei* [?] [Danes? Trojans?] [?] — all of whom are in the part Europe.

As for the sons of Ham [— to whom] fell, by their lot, the part Africa [אפריקא], as it is said: "Cush and Mitzrayim [Egypt] and Put and Canaan" [Bereishis 10:6], and so on — all of them are the names of countries that were named after them [these sons], [and which are] in the part Africa today. They need no explanation, for they are all well known [?].

And to the sons of Shem fell, by their lot, [the part] Asia [אס"יא], as it is said: "the sons of Shem: Elam and Asshur," and Aram [Bereishis 10:22] — all of which are the names of countries that [are] in the part Asia. They need no explanation or interpretation: for Elam is Persia [פרס], as it is said in Daniel "in Shushan the capital, which is in the province of Elam" [Daniel 8:2]; and likewise Asshur [Assyria], for [from there came] the great city of Nineveh, called [today by the name of] Tushi [?] [תושי / Mosul?] [?] — which from of old was the foremost and the capital of the kings of Assyria, as the prophet says in [the book of] Kings [Melachim], [II Melachim] chapter 19 [II Melachim 19] [?]; [and] also Aram [Aramea]: there are five lands [named] Aram — Aram Naharaim [Mesopotamia], Aram Tzova [Aram Zobah], Aram Maacah [מעכ"ה], Aram of Damascus [דמ"שק], [and] Aram Beth Rechov [Beth-Rehob] — all of which were presumably named after Aram, son of Shem son of Noah [Bereishis 10:23]. [These are] the marked, [renowned, and] well-known countries in the part Asia.

Siman 73 (סימן ע"ג)

On the discovery of a new world, called America [אמוריק"ו — America], in the year 5252 of the [Creation] [5252 = ה' אלף רנ"ב AM].

[Hebrew: 5252 = (2ב + 50נ + 200ר) + 5000 = ה' אלף רנ"ב AM; 5252 – 3760 = 1492 CE.]

Says the writer [the author]: Since the matter before us is one that is new among us, and is wondrous [in the eyes of] the readers and hearers as well, I have seen fit to expand the discussion of it a little more than the book's purpose requires. For I have said: even though it is not [strictly] a man's [proper] desire and wish to know what is above in the heavens [— what kind the heavens are —] all the more so is it fitting for him to know what is below upon the surface of the terrestrial globe upon which he dwells. Added to this [is the fact] that the [very] existence of the heavens, the [discovery] of the parts and location of the world's globe — these

are [achieved] by [HaKadosh Baruch Hu] [?] through many great stratagems [feats of reasoning], [coming] from great wisdom; and [the early ones] labored and went deep into the inquiries of the heart, as a portion of [their] ways will be explained to you further on — by which the existence [of these things] was [found] through the science of astronomy [תכונה].

Now, to speak of the discovery of a new world: Know, [reader, this novelty]. Know that the scholars of our time [calculated], from the year five thousand one hundred [and some?] [?] of the Creation and onward — [meaning] from the year 5126 [?] and onward — [they reckoned] [?]: by [a calculation] [?] [they discovered], beneath the [feet] [?] of the lower [hemisphere?] [?], [a land] of broad expanse, larger than the two parts Europe and Africa [together]. They called that whole land [by] the name *Nova [Mundi]* [נא"ה — Latin: *Mundus Novus*, "new world"]; [its meaning is "new world"] [— know it] [?]. [The early ones did not know this] [?], for the early scholars [held?] [?] that those near to it [could not?] [?] [reach] the New Land [?] — [for which reason it could not be established for them?] [?] — since half the globe is submerged [in water] [?], as we informed you above (in siman [?]). [This is why] [?] this new [land] was not made known to them [?]. [?]

[Several lines here are degraded and partly conjectural] [?]

The first one [Hebrew script unclear] who [found] this new world [?] was a [wise] and learned man [?], an [Italian?] philosopher named *Christoph[orus] Colon[us]* [קריס"טוף קאלו"ן — Christopher Columbus], [who set out] together with Ferdinand [ורדינגו"ס — Ferdinand], king of Spain [ספר"ד], and with [the king's] wife [Queen Isabella], Queen Isabella [?]. [This is how it came about:] In accordance with what is agreed among the philosophers as an established premise — that the wind issues forth [from?] and [travels?] over the [face] of the earth [?]; and [that] after [the lands] beneath [?] the perpetual settled regions, the winds [blow] [?] — [namely the lands] beyond [the country of] Portugal [פורטג"אל], [where] the Ocean [Okyanos] [is] — it followed [reasoned Columbus] that [by going] from the west toward the west, dry land would necessarily be found there. So Ferdinand [?] sent him — Columbus — and his men [?], who went down to the sea. The sea was [stormy] [?] upon them, and a [violent] east wind [?] bore them along — going and [tossing] — by a [route?] [toward] the southwest, and they kept going and journeying for some days, until — within a few days [?] — they came to a New World [a new land], and saw the great magnitude [?]. But [?] they took it to be only [one] island [?], a [bare] tract [?] [— for it was new]. This

was in the year, by their reckoning, 1492 [תצ"ב לף], which is the year 5252 of the Creation [ה' אלפים רנ"ב ליצירה].

[Hebrew: תצ"ב לף — abbreviation of ת"ק אלף [?]; read as 1492 CE = 5252 AM per context; the figure "492 = "תצ"ב, with the millennium "1" implied (אלף). — 5252 − 1492 = 3760 CE — consistent. The author next gives a second date.]

[More on] these matters [?]: in the year [by their reckoning] 1498 [אלף תצ"ח] — which [in our reckoning is] the year 5258 [רנ"ח] [?] — Ferdinand [?], king of Spain, again sent to the aforementioned lands a third man, a man of understanding and knowledge, a man of war from his youth, named *Amerigo* [אמיר"יקו], whose [family name was] [Vespucci — רע"נצי פול?] [?] — [Amerigo Vespucci]. He had already gone down [to sea] with the aforementioned Columbus [קלו"מבי], [and now he came] with large ships and with him men of valor, men [skilled] in their warfare [?]. He went down now [a second time] to the sea, and they came to the New World, and Amerigo [אמיריק"ו] traveled with [his] men into the interior of that land, a journey of many days, and there performed great and awesome deeds. He gained fame and renown throughout all the kingdoms of Europe — for which reason that whole land was called after the name of Amerigo [America], to this very day. For even though Columbus preceded him, as stated above, he did not perform [such] marked deeds as Amerigo did. This part is the fourth part of the terrestrial globe.

[Hebrew dates: 5252 AM = 1492 CE (Columbus); 5258 AM [= ה' אלף רנ"ח 5000+258] = 1498 CE (Amerigo) — but note the printed Hebrew "רע"נצי פול" appears to garble the surname Vespucci; flagged.]

(Resumed:) After all the aforementioned matters, in the year 5278 [תק"ח אלף — read 5278 per context] [?] — which to the Christians is [the year 1518] — Charles [V] [חארלו"ס — Carolus / Charles] [king of Spain] sent great ships with [men] to the aforementioned land of America, and there captured a large portion of that land. He named that country *Nova Hispania* [נו"בא השפני"א — Latin: *Nueva España*, "New Spain"]. The middle of that land sits, in the world's breadth [latitude], beneath the circle of [the tropic of] Cancer, close to the equator — at [some] 24 degrees [latitude] [?]; and in the world's length [longitude], 280 degrees [ר"פ] from the western edge of the world [?]. It spreads out and [extends so far that] [no one] can measure [or contain it], according to what is heard [reported] and what is written. According to the reckoning of [their] surveys [geometry], that country is as though it were a hundred [parasangs] by a hundred parasangs, approximately [?]. This country is a settled land [?], good and broad, and there is

found there much gold among the sand [?] upon the shore of [?]… [Also] fine pearls were found there in abundance.

In all the aforementioned matters, [Francis I] [פתציש"קו — Franciscus / Francis], king of France [צרפ"ת], also sent his ship[s] with men of valor against that same land, and they too captured there a large portion of that land. He named it *Nova Francia* [נו"בא פראנ"צי — Latin: *Nouvelle France* / *Nova Francia*, "New France"]. The middle of this country sits, in the world's breadth [latitude], at about 50 degrees [נ' מעלות] from the equator, and in [its] longitude 250 degrees [ר"ן]. It too is a broad land; and according to what is written, both its length and its breadth are reckoned as though it were a hundred by a hundred parasangs.

Siman 74 (סימן ע"ד)

The fifth part of the terrestrial globe is also in the [New] World; the great new [land] called *Peru* [פיר"ו].

[Rashi-script gloss / heading line:] …the New World, of which we spoke [comprises] two parts [?]: [one is] the part to the north and [one] to the south of the equator [?]; the part south of the equator [?]…

[The text resumes:] *Peru* [פיר"ו] — concerning which the scholars of [the earth's] regions [geographers] say that most of its countries are drawn out [along the zones] called *Tropici* [Rashi script: זוֹנא — Latin: *zona*, "zone/belt"], in [Latin?] *Tropica* [טורי"דא — *zona torrida*, "the torrid zone"]; [as we explained] above in siman 66 [?], where we explained the matter of the [torrid] belt [equatorial zone]. The early ones judged that beneath the whole region of the [torrid] belt — for about ten degrees on either side of it — no [human] generations would be found, since most of [it] [?] is [the place of] the [tropical] heat [?] and the [moisture] [?] of the earth, [as they said,] that there grows there neither grass nor [anything green] nor anything else, for it is all dry and parched from the heat. [Yet] every [foreign] reckoning [?] [is contradicted by] the thousands and myriads [of people] who are in that country: they saw it, from edge to edge, a settled land, full of people — a populous land [?] — and full of all good [things]. And because there is great wonder at this — how it is possible to subsist and to endure under [such] great heat, [given that] the [breath of life] [?] departs [from man] [?] under it [?] — therefore know [the reason]: HaKadosh Baruch Hu, in His kindness, established for the countries that lie beneath the belt of the [zodiac signs / the equator] [?] a [counterbalancing arrangement?] [?], so that it should be [habitable] for settlement [?]; [and reason itself perceives that] for those who dwell there [?], because the rays of the sun [strike] directly opposite [the points of] their heads —

[perpendicularly] [?] — [there are] gathered for them [?] rains [?] and moisture [?]; and the air of that land is cool and moist by its nature [?]. At the times of midday [?], the heavens [there] [grow overcast with clouds?], in such a manner [?] [that the clouds] [shield them?] from the heat of the sun [?]. [Several lines here are partly degraded — flagged.] [?]

[Rashi-script note / aside:] And indeed, know [the matter] of their [customs] [?]; and they [say] that the people [there] [?] [behave] in a manner [like] our own regions [?], if [it be] as stated above [?], [namely] that [they hear?] year by year from [?] our countries [?]…

[Resumed main text:] Many fall sick and grow faint on account of the great heat, [and] their heat [?]; many die there. Know, moreover, that in the countries of Peru there are found many rivers, and springs of water cold like ours in these countries; and there grow grasses, fruits, and all kinds of grain. They flourish more [there] than in these our countries [?]. The inhabitants of that land are not black like the Cushites [Africans] and like the dwellers in Africa; even those of them who [dwell] in the more southern parts, and who also dwell beneath the belt of the zodiac signs [the equatorial zone] or near to it, [are not so] — for the part Peru does not have such [intense] heat as the dwellers in Africa have [in their part], [though Peru lies] within this [same zone].

Within this part [Peru] there is found a certain land called *Pisilia* [?] [פיסליא"ה / Brazil — Brasília?] [?], a broad land, whose middle [lies] beneath the tenth degree [10°] south of the [equator], [a journey of] about [a] tenth [?] [toward the south?]; and in the world's longitude, [at] about 340 degrees [ש"מ], 11 degrees [?]. It is a blessed land, full of all good [things]; and there is great wealth of silver and gold there, particularly gold, which is found in the sand of the rivers. No rain falls there, but it is rather like the land of Egypt [?]: they have no fixed season for sowing or for reaping, but they sow and reap throughout all the days of the year.

Siman 75 (סימן ע"ה)

That the countries of Peru are [in] Ophir [אופי"ר], whither King Solomon, peace be upon him, sent his ships.

The wise men [versed in] the inquiry of the earth [geographers] have written that the land of Ophir [אופיר], whither King Solomon, peace be upon him, sent his ships once in three years to bring gold from there (as in I Kings chapters 9 and 10 [Melachim I 9–10], and in [II Chronicles] chapters 8 and 9 [Divrei HaYamim II 8–9]) [?] — they say that this is the kingdom of Peru mentioned above, that *Peru* and

Ophir are close in pronunciation; and their words seem very [plausible]. For without doubt the great distance — which required a journey of three years to go and to return — [accords with this]; and the men of our generation in our country [today] would [likewise] need this span of time to go and return from there. And in truth, gold is found there to this day in abundance, as stated above. For these three reasons mentioned, it is plausible to believe that Peru is Ophir.

Accordingly, this New World of which we have spoken is not [entirely] new — except as regards us; for it was already known in the days of King Solomon, peace be upon him, and afterward its memory was forgotten, until the later ones came in the year 5252 [רנ"ב] [of the sixth millennium] to explore the sea, and this part Peru was revealed to us a second time. If their words are true, [according] to this reasoning, I say [the following]: since the ships were built at Etzion-Gever, which is upon the Sea of Suf [the Red Sea] — as it is written in [the book of] Kings and in Chronicles [I Kings 9:26; II Chronicles 8:17] — it appears that the ships sailed from Etzion-Gever upon the Sea of Suf southward, until they came to the Southern Ocean, and from then on the route was [westward] until their arrival at the land of Peru.

But according to the words of *Ba'al Me'or Einayim* [Author of *Me'or Einayim* — R. Azariah de' Rossi], in [chapter] one of his book *[Imrei Binah]* [?] [Me'or Einayim], [he says that Solomon's] ships [sailed] over the whole length of the Great Sea [the Mediterranean] as far as the edge of the land of Spain, and from there by way of the Western Ocean. But it appears that his words cannot stand, since the known boundaries of the [Mediterranean] sea [are limited]; and one may say [rather] [?] that it is not possible that the ships [reached the New World by that route], [since the ships sailed by way of?] the [Etzion-Gever] [route] [?] upon the Sea of Suf.

Siman 76 (סימן ע"ו)

The sixth part of the terrestrial globe, called *Guinea* [גיניאה / Guinea] [or *New Guinea*?] [?].

Know that in the year [after] [the discovery of] the New World — two years [after the discovery of] the world [?] — [namely] in the [Christian] year 1519 [תקי"ט אלף], which is the year 5279 [רע"ט] of the Creation [?] [— the king of Portugal [פורטגא"ל] [?] sent *Magellanus* [מגלייאנו"ס — Magellan] [?] and Ferdinand [?] [ורדי"גנו"ס] [?] to explore [the seas]…]

[Hebrew dates: 5279 AM [5000+279 = ה' אלף רע"ט] = 1519 CE (1519 − 3760 =...; standard AM−3760 yields 1519 with the autumn/spring adjustment). The printed Christian year reads 1519 = תקי"ט. Consistent.]

שער ג (Section 3) — continued

Continuation of Siman 76 (the sixth part — Guinea)

continues from the western sea, in order to know whether there is yet another inhabited land beyond. In the southwest, along a sloping path, the sea descends [?] and stands [?]. There the strait divides — between the sea that comes [?] and the New World [?], which is called Peru [Peru = Ophir], and the southern part of the world (as the map of the world clearly shows, and as its character will be explained for you shortly).

Our land [Europe] [?] extends some hundred parsa'ot. The length of the meridian [?] from the equator [מקו השוה = the equator] is six over a hundred [106] parsa'ot — and there is no rhumb [?]. As I noted earlier, the pole is advanced toward that side by 21 degrees [?]. (This strait, which lies within the boundary of the sea, is dangerous.) He named the sea after him — [the strait of Magellan / מנגליאנוס] — and he crossed it [?]. From the dangers, the reefs, and the rocks found there, [?]. Going forward, the southern world was on his left and Peru on his right, sailing many wondrous days [?] until he reached one great dry land — wide and broad — and this is the island [?] called New Guinea. There he warred [?] with the inhabitants of that land. And though Magellan, who commanded [a third of?] [?] the fleet [?], was killed in that battle — and in that battle there fell some forty men of the Spaniards [?] [the Spaniards / ספרדים] and men of [?] — [?] until the inhabitants of that land [?] before them were defeated, captured, conquered, and burned [?], and they took from their hand at that time that portion of the land — which is a great [?] portion.

Siman 77 (סימן ע"ז) — The Seventh Part of the World, which is the Northern World

[Body heading, p. 57: סימן ע"ז — החלק השביעי מכדור העולם הוא עולם הצפוני]

For many years it was not known whether Guinea [גיבינא"ה = Guinea] is a province in its own right, or whether it is joined to the southern world nearby. About forty years afterward — that is, in the year 5379 [AM 5379 − 3760 = 1619 CE] [?], which by their reckoning is the year 1618 [?] of [their count] — one

Spaniard named Fernández [?] [פרנ"ץד = Fernández (?)] [?] circumnavigated [?] it then, and made all of Guinea [?] in his ships [?]. And in the year [?] [?] — Thomas Candy [?] the Englishman [טומיס קנדי"ם איש אנגלטיר"ה = Thomas Cavendish, of England (?)] [?] — in the year [?] 5348 [AM 5348 – 3760 = 1588 CE] [?] they again discovered [?] the surface of this land, near to all the surface of our part — Europe [אורפ"י = Europe] — where we dwell.

Therefore, since the surface of this land is close to ours, the sages of our generation agreed [?] to count this land as a part on its own — and it will be the sixth [?] of the parts of the island [?]. And so [?] this distinct part of that sphere, by its position in latitude [?]. This part lies between the equator [קו השוה] and the Tropic of Capricorn [עגול גדי = the Tropic of Capricorn], and [near] [?] to these two lines [?] this island is close, about 3 degrees [?] from each of them. The equator [?] [קו השוה]: this island begins on the western side at 182 degrees [?] west [גרב = west, Arabic غرب], and rests [?] [until?] the east as far as another 200 [= ר"ב 202?] degrees [?] — so that this island [?] is settled [?] for us such that its eastern side [?] is closer to its western [?] [?] to Europe [?].

[The seventh part of] the sphere [?]

Siman 77 continued — The Northern World [?]

Already the ancients [?] knew [?] that beyond [?] the northern Arctic Circle [מעגול הצפוני / the northern circle], up to the pole, no [?] inhabited [region] [?] is found there — [?] and indeed [?] the lines [?] of dwellings [?]. For [?] according to [?] the bounding [?] of the parts of the world it is exceedingly small, [?] since [?] also part of the dry land [?] which [?] [?] full of seas [?].

The reason for this great distance [?] of the sixth part [?] from them [?] [is] that they could not stand there [?] because of the great cold and the chill [?] [?] [?]. And I have already found it written that many of the researchers [?] [Rashi script?] [?] — when they came [?] [?] in the sea and on the dry land along the way of the northern pole [?] — but [?] also such a chill [?] as comes from above [?] [?]. Since the surface [?] of this great part is greater [?] in its quantity, [for] [?] it is more [?] [?] in its circle [?] than [?] — [it] amounts [?] to 117 degrees [?] [סז"ז (?)] which by computation [?] amounts [?] to [?] of surfaces [?].

Combining this with what was found [?] in the day in the provinces known far away [?] [?] — and the (northern) circle [?] [?] (and though they are few) [?] — and the researchers said [?] [?]. Since [?] its surface is large [?], it is proper [?] [?]

to set [?] this great surface [?] as a part [?] in its own right (this is folio 105 [?] / קג"ה [?]).

Now, the surface of the northern world, whose canopy [?] is — (folio 105) [?] [קג"ה] — in [?] six hundred parsa'ot by [?] six [?] parsa'ot [?], [?] each [?] [?]. The line of the northern circle, its distance from the pole, is 23 degrees 51 minutes [כ"ג מעלות נ"א דקין]. For [?] the measure of the diameter [קוטר] that the whole northern circle [?] holds [?] [?] [?] — [?] [?] 23 degrees 51 minutes [כ"ג מעלות נ"א דקין] times [?] 3 [?] — [?] 47 degrees [?] [מ"ז] [?] [?] 46 [?] [?] [?]. According to the Great Computation [?], 3 times [?] [?] amounts [?] [?] to 141 [קמ"א] [?] [?]. [?] [Rashi-script gloss / commentary follows:]

[Gloss: This circle is known to us from the rule of doubling half its diameter together with half [?] [?]. And this is: half its diameter is 23½ [כ"ג וחצי], and half the circle [?] [is] [?]. Doubling 23½ [?] [?] yields [?] [?] [?], [from] [?] which [?] arises [?] [?] [?]. We extract the square root [שורש המרובע] and it yields [?] 400 by 400 [ד' מאות על ד' מאות], so the total [?] is some six hundred parsa'ot by six hundred parsa'ot. And each degree holds [?] 15 parsa'ot [ט"ו פרסה]. This computation is simple [?] for those learned in the science of mathematics [?]. (End of gloss / ההגהה כ"ע).]

Siman 78 (סימן ע"ח) — The Eighth Part of the World

[Body heading, p. 57: סימן ע"ח — החלק השמיני… העולם… הדרומי היותר גדול מכל א' של שאר חלקי עולם]

The largest of all the parts of the world — the Southern World

This part [?] is the greatest [?] island [?] of all the islands of the parts of the world, and its surface holds almost [?] as much as the surface of all three parts of the [old] world — Asia, Africa, and Europe [אסיא, אעריקא, וארופי = Asia, Africa, and Europe] together [?]. It is impossible [?] to come [?] [to it?] [?] except by way [?] of the dry land [?] of one part [?] of the world [?]. By contrast [?], in the three parts of the world [?] [Asia/Africa/Europe] one can come [?] by way of the dry land [?] from any one of them [?] [?] to [the ruin of?] [?] from Peru to America [?] [לאמריק"א מפיר"ו = to America from Peru] [?].

For this southern part has already been [?] [explored?] [?] and circumnavigated [?] by their feet [?] — in particular [?] by Thomas Candy [?] [טומ"אס קנדיס = Thomas Cavendish (?)], the aforementioned [?] — who circumnavigated [?] the whole surface [?] [of it?] [?] across the face [?] of the southern world [?] [?] from all four directions [?]. The world [?] [from] one end [p. = end] [?] to the other end

[?], the surface [?] [?] [?] of [?] this part [?] [?] begins [?]. And know [?] for yourself [?] that the whole southern circle [?] [Tropic of Capricorn / עגול הדרומי] — and from the end [?] [?] [?] [?] [?] [?] close to finding [?] [?] [?] still [?] [?] more [?] [?] — that the whole southern circle [?] [Tropic of Capricorn] [?]. And this [?]: the Tropic of Capricorn [עגול גדי] is at [?] 150 degrees [?] [150 = ק"ן (?)] [?] [?]. In the length [?] of the settled [region] [?] this part [?] reaches [?] [?] [?] to 26 degrees [?] [?] [?] up to the line [?] of the equator [קו השוה]. And [?] the great [?] island [?] close [?] to it [?], about [?] [?] [?] [?] sixty [ס'] [?] [?] [?] [?] [?] [?] parsa'ot [?] [?]. And [in?] [?] from it [?] and beyond [?], [the Tropic of] Capricorn [גדי = Capricorn] [?], until [?] [?] [?] the great [?] [?] is seen [?] [?] Guinea [?] [גיכינאה = Guinea], [?] [?] miles [?] [מיל].

Behold [?] [?], dear reader [?], we have shown [?] you [?] [the rule of?] [?] all the [?] of the world [?] [?], and according to our knowledge [?] from the accidents [?] [?] [?], although it is possible [?] that there will be found [?] [?] still other [?] great islands [?] [?] [?] [?] [?] [?]. To explore [?] the seas [?] [?], they crossed [?] and traversed [?] [?] [?], they circled [?] all the eight parts of the world [?].

כט (p. 29 of section — folio number)

nor were even a single cubit left over [?] that they [?] did not [?] [?] surround [?] [encircle] [?] [?]. The line on the side of [?] [?] this northern [?] [?] — they did not [?] circumnavigate [?] it, because [?] [?] [?] could not [?] [?] go further [?] toward [?] that side [?] [from the great cold?] [?], as I wrote [in siman (?)] [?]. (And in every place where men became known to them [?] who [?] [are?] [?] near to the edge [?] [?] of the sea [?], far off [?] — they wrote them [?] all down [?] [?] according to how they reckoned [?] their bounds [?].) [?] So [?] it [the world] is, [both] in its length [?] and in its breadth [?] of the sphere [כדור = sphere/globe] [?]. It cannot be [?] [?] [that?] their [?] [?] [?]. Behold [?], it is [?] not [?] possible [?] [?] that any [?] further [?] part [?] will be found [?] except [?] one [?] [?] [?]. But [?] in the [northern] [?] part of the world [?] it is possible [?] that there will be found [?] [?] [?] distinct [?] [provinces?] [?] [?] and [?] [?] [?] [?] — but [?] not [?] a [?] great [?] one [?]. To this day [?] it has not become known [?], nor [?] have we found [?] [?].

Siman 80 (סימן פ') — Who Reported to the Researchers the Locations of the World and the Bounds of the Seas?

[Body heading, p. 28-bottom: סימן פ' — מי הגיד להם למחקרי מקומות העולם וגבול הימים]

[Note: the figure-number prose section "How and from where it became known" (Rashi-script rubric: איך ומאין נודע) precedes this on the page — see the heading sequence in the report.]

And if you ask and say: Who is the one who told us [?] [reported] all the places [?] of the world — both [?] those at sea and those on the dry land — and likewise the boundaries [?] of the seas [?] and their breadth [?]? And [?] when [?] was this thing [?] [the survey] done?

Know [?] that this matter became known not [?] by one man and not [?] in one time [?]. Rather, many great men [?] — wise [?] and discerning [?] men of the early generations [?] — already from [?] some [?] two thousand [?] [?] years ago [?] [?]. For all [?] the men [?] who exerted themselves [?] in the science of the stars [?] [astronomy] also gave their effort [?] to know the boundaries [?] of those lands [?]. The ancients [?] [?] — such as Hipparchus [אברכו"ם = Hipparchus] and Ptolemy [ביטולמיא"ם = Ptolemy] — as is found written [?] in their books [?]. And those after them [?] [?] continued [?] [?]. The later sages [?] in every generation [?] and from generation to generation [?] [?] up to [?] [?] [the latest of these who are before us?] [?] [?] investigated [?] and inquired [?] into the boundaries [?] of the dry land [?] by combining [?] [?] [the boundaries of the seas?] [?]. They [?] [?] are men [?] [?], great sages [?], who consumed [?] all their days [?] of life [?] [upon this?] [?]; and the chief [?] of the investigations [?], the great and wondrous things [?] concerning the boundaries [?] of the seas and the dry land — after [the discovery of?] [?] the New World [?] [עולם החדש = the New World] some hundred years ago [?] [?] — [were carried out] by the agency [?] of great kings [?] and officers [?] [פרנימים = magnates/notables (?)] [?]. So [?], after the [matter became known?] [?], almost [?] [?] all [?] [?] the kings [?] of France, Spain, and Portugal [צרפ"ת, ספר"ד, ופורטגא"ל = France, Spain, and Portugal] — who exerted themselves [?] and sought [?] to know the settlement [?] of [the dry-land?] [?] boundaries [?] in their [?] generation [?].

[Gloss / Rashi-script, right column p.29:] And you [?], dear reader [?], who [?] know [?] and understand [?] that the matters [?] [?] which were hidden and concealed [?] from the ancients [?], over which they labored [?] and toiled [?] [?] all the days [?] of their life [?] [?], and upon which the kings [?] also expended [?] many thousands [?] and myriads [?] [?] of [?] [?] — all this has now [?] [in our time?] [?] become known to us [?] readily [?] and easily [?], so [?] that any man [?] of intelligence [?] [?] [?] is able [?] to grasp [?] and recount [?] to his small [?] son [?] [the matter?] [?] and to show [?] [him?] with his finger [?] [?] [?] [?] the provinces [?] [?] [?] [?] [?] [?] and the places [?] of the dwellers [?] of the earth [?]

of all [?] the world [?] [?] in our day [?] [?] [?] [?]. More [?] and more [?] than these [?] [?], may [?] [?] [?] [?] [?] [?] [?] see the [?] [?] [?] [?] [?] in his eyes [?], blessed [?] [?] [?] [?] [?] who [?] [?] showed [?] us [?] wonders [?].

[Right-column body heading, p.29: איך ומאין נודע — "How and from where it became known"]

The boundaries [?] [?]: those who came [?] [?] to investigate [?] [?] [?] [?] [?] [?] [?] [?].

Siman 81 (סימן פ"א) — How and From Where the Researchers Came to Know the Latitude of a Province from North to South

[Body heading, p.29: סימן פ"א — להמחקרי' מדת רוחב המדינו' ביוצפון לדרום ורוחבם בין מזרח למערב (?)]

[Note: the running header for this opening reads with the breadth of provinces between north and south, and their [length?] between east and west.]

To find [?] the latitude [?] [breadth, north–south] of provinces in every place [?] of the world — whether at sea or on the dry land — whether [computing?] [?] its distance [?] [?] in [a straight measure?] [?] [?] from one of the equinoctial points [?] [?] [?] — is a very easy [?] matter. For [?] even [?] mariners [?] [?] [those at sea?] [?] will obtain it [?] in a short hour [?] [readily?] [?] with [?] their instruments [?] [?] [?] — with the quadrant [?] [כלי כרובע = quadrant (?)] [?]. As [?] for its construction [?], its essence [?], and its usefulness [?] [?] [?] it was explained [?] to you somewhat [?] earlier [?] [?] [?] in the second section [?] [שער השני / Section 2 (?)] [?], or [?] more fully [?] [?] it will be explained [?] to you in [?] a section [?] devoted to it [?] [?] — that is, the section [?] [?] [?] in which [?] the finding [?] of the pole's altitude [?] [גובה הציר = the altitude of the pole/axis] will be explained [?] to you, by [?] four [?] ways [?] by which [?] [the latitude?] [?] is itself [?] distant [?] from the equator [מקו השוה = from the equator] [?] — as [in siman (?)] [?].

But [?] for the knowledge [?] of the longitudes [?] [lengths, east–west] of the provinces [?], by [?] the [?] way [?] in which [?] the length [?] of the whole settlement [?] became known to them [?] — as was explained [?] above in siman 61 [?] [?] [סי' ס"א] — and likewise [?] R. Menachem [the Israelite?] [?] [מנחם הישראלי = Menachem the Israelite (?)] [?] wrote concerning this [?] in [?] [?] the treatise [?] "Tzurat Olam" [?] [צורת עולם = "Form of the World"], chapter [?] [?] [?]: how the ancient [?] [?] [sage?] [?] [the ancient sages?] [?] sought [?] to know how

many degrees [?] [?] city X [?] [?] [is from?] [?] the western edge [?] [קצה מערב] [?], or how many degrees [?] [?] city X [?] is distant [?] [?] from city Y [?] [?]. They stationed [?] two observers [?] [?], men knowledgeable [?] [?] and skilled [?], in [?] each [?] of the [?] places [?] [whose mutual longitude they wished to determine?] [?]. Each [?] of the observers [?] aimed [?] with great precision [?] at the moment of onset [?] [?] [?]: at city X [?] [?] [?] [?] the moon entered eclipse [?] [?] [?] at hour [?] X [?] [?], minutes [?] [?] and seconds [?] [?] [?] — before [?] or after midnight [?] [?] [?]. And when [?] all this [?] [?] came [?] from each of the observers [?] in writing [?] to the investigators [?] [?], then [?] it was easy [?] for them [?] to know the manner [?] of the [?] distance [?] [?] of [?] half [?] the day [?] [?] [from this one to that?] [?] [?], according [?] to [?] this [?] [?] distance [?] [?] [?] [?]. As [?] one [?] [?] saw [?] [?] [?] in the eclipse [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] at hour [?] X [?] [?] [?]. And [?] likewise [?], it is known [?] that the distance [?] [?] which appears [?] [?] [?] [?] [?] [?] [?] [?] between [?] you [?] is 15 degrees [?] [ט"ו מעלות] — because [?] the luminaries [?] are borne [?] by [?] the revolution [?] [?] of the sphere [?] [גלגל = the sphere] [?] [?] in [?] the day [?] [?] [?] [?] [?] [?] in [?] all the world [?] in [?] each [?] day [?] [?], which is 24 hours [?] [כ"ד שעות]. And [?] [?] as [?] it is already known [?] [?] that the number of degrees [?] of the sphere [?] is 360 degrees [?] [ש"ס מעלות], divide [?] this number [?] by [?] the count [?] of the 24 hours [?] [כ"ד] of the day [?] — every [?] hour [?] [?] reaches [?] [?] a revolution [?] [?] of 15 degrees [?] [?] [?]. And [?] in the difference [?] of 2 hours [?] [?] [ב' שעות] [?] there will be [?] a distance [?] of 30 degrees [?] [?]; and [?] so [?] always [?] [?]. According [?] to [?] this [?] reckoning [?] [?], every [?] [?] distance [?] of 15 degrees [?] [ט"ו מעלות] [?] causes [?] [?] a difference [?] of one hour [?], up to 12 hours [?] [י"ב שעות], [which is?] [?] the difference [?] [?] between [?] you [?] [?] at the utmost [?] [?] — a distance [?] of 180 degrees [?] [ק"פ מעלות (?)].

Siman 82 (סימן פ"ב) — How to Find the Longitudes of the Provinces, Apart from Astronomical Observations [?]

[Body heading, p.29: סימן פ"ב (?) — למצוא אורכי המדינות זולת עיוני הלקיים — "to find the longitudes of provinces apart from observations of eclipses"]

Know [?] [Rashi-script rubric: דע] [?]...

Siman 81 continued (top of folio כט-verso / p.59)

the longitudes [?] of the provinces [?]. To the ancient [?] sages [?] [?] [?] it became known [?] [?] by the agency [?] of [?] observing [?] men [?] [?] who [?] aimed [?] with great precision [?] [?] at [?] the moment [?] [?] of [?] [?] the [?] eclipse [?] [?]

[?] — at [?] [?] [?] [?] [?] [?] [?] when [?] the moment [?] of the moon's entry into eclipse [?] [?] would be at [?] half [?] [?] sign [?] X [?] [?], or at a portion [?] of it [?] [?] [?]. And [?] if [?] that moment [?] appeared [?] [?] one hour [?] earlier [?] [?] [?] [?], it is known [?] [?] [?] [?] that the [?] distance [?] between [?] them [?] [?] [?] [?].

This [?] is the [?] second [?] [?] manner [?] [?]: by the moment of the moon's entry into eclipse [?] [?] you can find [?] the longitudes [?] of every [?] province [?] and city [?] [?] [?] in the whole dry land [?] [?] — without [?] [needing?] [?] [?] [?] [?] to wait [?] and watch [?] for the time of [?] eclipses [?] [?] [?]. [?] [?] And [?] it appears [?] [?] [?] [?] that the two [groups of?] [?] observers [?] [?] — both [?] [?] [?] the observers [?] [?] at the time [?] of the moon's [?] [?] entry [?] into eclipse [?] [?] [?] [?], and [?] the observers [?] who [observe?] [?] [?] [?] the moon's [?] [?] [?] at half [?] sign [?] X [?] [?] [?] [?] — when [?] the two [?] [?] provinces [?] [?] [?] or [?] the cities [?] [?] in which [?] the observers [?] [?] [are stationed?] [?] [?] both [?] [?] [?] dwell [?] on the equator [?] [קו השוה] [?], or [?] both [?] [?] [?] dwell [?] on one [meridian?] [?] line [?] or one [?] circle [?] [?] drawn from west [to east?] [?] [?] — for then [?] [?] [?] they have [an equal distance?] [?] [?] [?] from [?] the northern pole [?] [?] [?]. And [?] [?] this [?] [?] matter [?] [?] and the aforementioned reckoning [?] is easy [?] and [?] [?] [?] when [?] [?] both [?] [?] of them [?] are not [?] [?] on one [?] line [?] or [?] one [?] circle [?] [?]; [?] there [?] are [?] [?] [?] [?] [?] [?] several [?] [?] [differences of] conditions [?] [?] and rules [?] [?] [?] [?] they have [?] [?] in this [?] reckoning [?] [?], as [?] [?] [?] [?] it will be explained [?] [?] before [?] you [?] [?] further [?] on [?] in the sixth section [?] [?] [שער הששי / Section 6 (?)] [?], in siman 152 [?] [?] [סי' קנ"ב] [?]. I will further [?] say [?] [?] [?] [?] [?] [?] that the sages [?] [?] [?] [?] [?] [?] the ancients [?] [?] [?] established [?] [?] to set up [?] their [?] [?] [?] [?] [?] above [?] [?] and beyond [?] [?] [?] [?]. So [?] [?], when [?] upon every [?] [?] line [?] or [?] circle [?] [?] [drawn?] [?] from west to east [?] [?], [?] for each one [?] [?] of [?] 360 degrees [?] [ש"ס מעלות], [?] [?] [?] only [?] [?] [?] [?] [?] [?] thousands [?] [?] [?] [?] [?]. But [?] [?] only [?] [?] [?] there appears [?] from them [?] [?] [?] [?] [?] [?] [?] [that the longitudes of some provinces became known to them?] [?] in the [?] manner [?] [?] that has been explained [?] [?]. And [?] [?] already [?] [?] [?] it became known [?] to them [?] [?] that the difference [?] [?] in [?] every [?] degree [?] [?] [?] [?] of the equator [?] [?] [קו השוה] [?] is [?] 16 [?] [ט"ז (?)] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?]. So [?] [?], when [?] [?] [?] the count [?] of the parsa'ot [?] [?] [?] [?] [?] [?] became known [?] [?] to them [?] [?] [?] [?] [?], or [?] [?] the count [?] of the day's journeys [?] [?] [?] [?] [?] [?] [between two provinces?] [?] [?], then [?] [?] [?] [?] it was easy [?] for them [?] [?] [?] [?] to reckon [?] [?] [?] [?] [?] how many degrees [?] [?] [?] [are] between them [?] [?].

Siman 83 (סימן פ"ג) — To Find the Longitudes of Sea-Islands, Apart from Observations of Eclipses, and Apart from Two Observers

[Body heading, p.59: סימן פ"ג — למצוא אורכי איי הים זולת עיוני הלקויט (?) זולת שני מעיינים — "to find the longitudes of sea-islands, apart from observations of eclipses, apart from two observers"]

For the knowledge [?] of the longitudes [?] of sea-islands [?] [?] — when [?] [?] [?] the ship [?] [?] [?] stands [?] [?] [?] [?] within [?] the sea [?] [?] [?] [?], some hundreds [?] of parsa'ot [?] distant [?] from the dry land [?] — [?] [?] [?] [?] in places [?] where no observers [?] [?] [?] [?] stood [?] [?] [?], the observers [?] [?] [?] did not [?] [?] [?] aim [?] [?] [?] at the time of [?] [?] [an eclipse?] [?] [?] [?] [?] [?] [?] [?] [?] [?]; [?] [?] [?] [?] [?] it is a hard [?] [?] [?] matter [?] [?] [?] [?] [?] [?] [?] [?]. Very [?] [?] difficult [?]: we have no [?] knowledge [?] [?] of how many degrees [?] [?] [?] [?] they [?] [?] came [?] from the western edge [?] of the world [?] [?].

Know [?] [?] [?] that this matter [?] [?] [?] [?] [?] can [?] [?] become known [?] to us [?] [?] [?] by [?] a new device [?] [?] [?] [?]. And for this [?] you do not [?] [?] need [?] [?] to observe [?] [?] [?] [?] at the moment [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [that] sign X [?] [?] [?] first [?] [?] [?] [?] [?] [?]. By [?] [?] this [?] test [?] [?] [?] [?] [?] I will instruct [?] you [?] [?] [?] how to find [?] — apart from [?] [?] [?] two observers [?] — [for] yourself [?] [?] [?] [?] [?] the longitudes [?] of provinces [?], even [?] [?] [?] [?] [?] the longitude [?] [?] of a sea-island [?] [?] [?] [?] [?] [?] or [?] [?] [?] [?] the place [?] where the ship [?] stands [?] [?] [?] within the sea [?] [?] [?] [?]. But [?] for this [?] device [?] [?] it is required [?] [?] [?] [?] [?] that you have [?] [?] [?] [?] [?] [?] [?] [?] tables [?] [?] [?] of the moon's motion [?] [?] [?] [?] [?] [?] [?] [?] for [?] [?] [?] one [?] [?] place [?] [?] in [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] in [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] every [?] day [?] [?] of the year [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] at its rising [?] [?] [?] [and] its setting [?] [?] [?] [?]. And [?] [?] [?] these [?] [?] [?] [?] tables [?] [?] of the midday [?] [?] of that place [?] are called [?] [?] [?] [?] "luchot" [?] [?] [לוחות = astronomical tables] — [?] [?] which [?] [?] are found [?] [?] printed [?] [?] [?] [?] among all the Christians [?] [?] [?] [הנוצרים = the Christians] [?] [?] [?] [?] [?] [?] [?] [?] in [?] [?] [?] their [?] languages [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] city [?] by [?] city [?] [?], according to [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] for [?] [?] [?] [?] [?] [?] [?] [?] [?] [?].

For example [?] [עד"מ = for example], I say [?] [?] [?] [?] [?]: at the start [?] [?] [?] [?] [?] [?] we begin [?] [?] to observe [?] [?] [?] [?] [?], for example [?] [?] [?], the start of [?] [?] sign X [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?]. For example [?], I say [?] [?]:

on [?] [?] the eve [?] of the 16th [?] [ליל ט"ז (?)] of month X [?] [?] [?] [?] [?] we will find it [?] [?] [?] opposite [?] [?] [?] the head of [the sign of] Taurus [?] [ראש מזל שור = the start of Taurus] [?] [?] [?] [?] [?]. And then [?] [?] [?] the moon [?] [?] stood [?] exactly [?] [?] [?] [?] [?] at midday [?] [?] [?] [?] [?] [?] [?] [?] [?]. We observed [?] [?] [?] [?] [?] this [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] in [?] the aforementioned tables [?] [?] [?], which were drawn up [?] [?] [?] [?] [?] for [?] [?] [?] the horizon [?] [?] [?] [?] [?] [אופק = horizon] of Prague [?] [?] [?] [פראג = Prague] [?] [?] [?] — and we found [?] [?] [?] that [?] [?] on that aforementioned day [?] [?] [?] [?] [?] [?], when [?] [?] [?] [?] the center of the moon [?] [?] [?] [?] reaches [?] [?] [?] the start [?] of [the sign of] Taurus [?] [?], the moon already [?] [?] [?] descended [?] [?] [?] [?] [?] [?] [?] from the meridian [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] half a day [?] [?] [?] [?] [?] plus [?] [?] an hour and a half [?] [?] [?]. And we knew [?] [?] [?] [?] [?] that the difference [?] [?] [?] [?] [?] [?] in [?] [?] the arc [?] of the day [?] [?] which is between the two places [?] [?] [?] is [?] [?] an hour and a half [?] [?] [?], by which [?] [?] [?] [?] the center of the moon [?] [?] [?] [?] over [?] [?] Prague [?] [?] precedes [?] [?] [?] [?] [over?] [?] the place [?] of the island [?] [?] [?] [?] [?] [?]. So [?] [?] [?] [?] we find [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] that the hour [?] [?] of Prague [?] [?] [?] [?] [?] [?] [?] [?] [?], according to [?] [the moon's daily motion?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?]. According to [?] [?] [?] the reckoning [?] of 15 degrees [?] [ט"ו מעלות] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?]. Since [?] [?] the place of Prague [?] [?] [?] [?] [?], for which [?] [?] [?] the aforementioned tables [?] [?] [?] were drawn up [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?]. And therefore [?] [?] [?] [?] [?] we knew [?] [?] [?] [?] that [?] [?] [?] [?] [it is?] [?] [?] [?] [?] distant [?] [?] [?] [?] [?] [?] from the western edge [?] [?] [?] 32 degrees [?] [?] [ל"ב מעלות (?)] [?] [?]. And therefore [?] [?] [?] [?] [?] the second [?] place [?] [?] [?] [?] [?] [?] [?] from the western edge [?] is only [?] [?] 7 degrees [?] [?] [?] [?] [ז' מעלות (?)] and a half [?] [?] [?] [?]. All this [?] [?] [?] when [?] [?] you take [?] [?] [?] [?] [?] [?] [?] [?] the place of Prague [?] [?] [?] [?] [?] [?] [?] [?] [?]. And [?] [?] [?] [?] [?] [?] [?] if [?] [?] [?] [?] you find [?] [?] [?] a city [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?]

[?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] the matter [?] [?] [?] [?] mentioned [?] [?] [?] [?] [?] [?] [?] in the test [?] [?] [?] [?] of the midday line [?] [?] [?] [?] [?] [?] [?] [?] [?] [?]. So [?] [?] [?] [?] the matter [?] [?] [?] [?] [?] can [?] [?] [?] be [?] [?] [?] [?] [?] for [?] [?] [?] [?] the time [?] [?] [?] [?] [?] of [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] the rising [?] [?] [?] [?] [?] [?] of the moon's center [?] [?] [?] [?] [?] over the horizon [?] [?] [?] [?] [?] or [?] [?] [?] [?] its setting [?] [?] [?] [?] [?] [?] [?]. But [?] [?] [?] [?] [?] it is better [?] [?] [?] and more [?] [?] [?] [?] precise [?] [?] [?] [?] [?] [for its arrival?] [?] [?] [?] [?] at the midday line [?] [?] [?] [?] [?] [?] [?] [?] [?] for a reason [?] [?] [?] [?] [?] [?] [?] [?] that will be explained [?] [?] [?] [?] further on [?] [?] [?] [?] [?] in siman 124 [?] [?] [בסי' קכ"ד (?)] [?] [?].

Siman 84 (סימן פ"ד) — To Know the Longitudes of Provinces, According to the Time of the Moon's Revolution, by Its True and Mean [Anomalistic] Motions, Combined with the Daily Sphere

[Body heading, p.59: סימן פ"ד — לדעת אורכי המדינו' לפי זמן סבובו של הירח ע"פ מהלכי העצמי והרצוני בצירוף גלגל היומי — "to know the longitudes of provinces, according to the time of the revolution of the moon, by its proper [mean] and voluntary [true] motions, combined with the daily sphere"]

A further [way]

A further [?] [עוד = "further"] way [?] to find [?] the locations [?] of [places in?] the world [?] is by [the moon's motions?] [?] [?] [?], and this [?] is according to [?] the moon's true and mean motions [?] [מהלכי העצמי והרצוני = the proper (mean) and voluntary (true) motions] [?], in combination [?] with [?] the daily sphere [?] [גלגל היומי = the daily sphere] [?].

For example [?] [עד"מ = for example], I say [?] [?] [?]: suppose [?] [?] we are [?] [?] in [?] [?] a place [?] [?] [?] [?] in [?] one [?] [?] of the [?] places [?] [?] [?] of the world [?] [?] [?], and we wish [?] [?] [?] [?] to know how many degrees [?] [?] [?] [?] of [?] [?] [?] the western edge [?] [?] [?] [?] [?] [?] [?] [?] [?]. We observe [?] [?] [?] [?] there [?] [?] [?] [?] [?] the moon's revolution [?] [?] [?] [?] [?] at [?] [?] midnight [?] [?] [בחצות = at midnight] [?] [?] of the ninth eve [?] [?] [?] [?] of the month of Kislev [?] [?] [?] [כסליו = Kislev] [?] [?] [?] [?] [?], and we find [?] [?] [?] [?] [?] [?] that the moon [?] [?] [?] in [?] [?] its proper [mean] motion [?] [?] [?] [?] [?] [?] [?] which [?] [?] [?] is [?] [?] [?] [?] [from the west?] [?] [?] to [?] [?] [?] the east [?] [?] [?] [?] [?] [?] [?] [?] [?] [is?] [?] at [?] [?] the start of [?] [?] [?] the eighth degree [?] [?] [?] [?] of [?] [?] [?] [?] the sign of Aries [?] [?] [?] [מזל טלה = Aries] [?] [?] [?] [?] [?]. And afterward

[?] [?] [?] [?] we observe [?] [?] [?] [?] [?] [?] [?] [?] according to [?] the reckoning [?] [?] [?] [?] [?] [?] in [?] the tables [?] [?] [?] [?] which were drawn up [?] [?] [?] [?] [?] [?] for [?] [?] the horizon [?] [?] [?] of Prague [?] [?] [?] [?] [?] — and we find [?] [?] [?] [?] [?] [?] [?] that at [?] [?] the midnight [?] [?] [?] [?] [?] of the aforementioned eve [?] [?] [?] [?] [?] [?] the moon [?] [?] [?] [?] [?] enters [?] [?] [?] [?] the tenth degree [?] [?] [?] [?] [?] of the sign [?] [?] of Aries [?] [?] [?] [?]. And [?] there is no [?] doubt [?] [?] [?] [?] [?] [?] in the matter [?] [?] [?] [?] [?] [?]: if [?] [?] [?] the two [?] entries [?] [?] [?] [?] [?] mentioned [?] [?] [?] [?] [?] [?] [?] are [?] [?] [?] [?] [?] either [?] [?] [?] from [?] the side [?] [?] [?] [?] [?] [?] [?] [?] [?] of the midday [?] line [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?], or [?] from [?] [?] the western side [?] [?] [?] [?] of [?] [?] the midnight [?] [?] [?] [?] line [?] itself [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] — because [?] [?] [?] [?] in [?] this case [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] not [?] [?] in the morning [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] only [?] [?] [?] the time [?] [?] [?] [?] [?] [?] [?] of [?] [?] [?] [?] midnight [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] the moon [?] [?] [?] [?] [?] did not [?] [?] [?] [?] [?] [?] come [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] to the midnight [?] line [?] [?] [?] [?] [?] which [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?]. According to [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] its proper [mean] revolution [?] [?] [?] [?] [?] [?] [?] [?] [?] our half [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] that the moon [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?]. In the place [?] [?] [?] [?] [?] mentioned [?] [?] [?] [?] [?] [?] [?] midnight [?] [?] [?] [?] in Prague [?] [?] [?] precedes [?] midnight [?] [?] [?] [?] [?] by [?] [?] two degrees [?] [?] [?] [שתי מעלות = two degrees] [?] [?] [?] [?]. And since [?] [?] we already know [?] [?] [?] [?] [?] [?] that the moon's proper [mean] revolution [?] [?] [?] [?] [?] [?] [?] in [?] [?] its [own] sphere [?] [?] [?] [?] is [?] [?] [?] [?] [?] [?] 12 [?] degrees [?] [?] [?] [י"ב מעלות] [?] in [?] [each?] [?] [?] [?] [?] [?] [?] [?] [?] — as [?] will be explained [?] [?] [?] further on [?] [?] in siman 196 [?] [?] [בסי' קצ"ו (?)] [?] [?] — therefore [?] [?] [?] [?] [?] [?] [?] for [?] [?] [?] the time of [?] the moon's proper [mean] revolution [?] [?] [?] [?] [?] [?] in the two degrees [?] [?] [?] [?] mentioned [?] [?] [?] [?] [?] [?] [?] [?] [is?] [?] [?] [?] [?] [?] four hours [?] [?] [?] [ארבע שעות = four hours] [?] [?] [?] [?] [?]. And we knew [?] [?] [?] [?] [?] that this midnight [?] [?] [?] [?] which is [?] [?] [?] in Prague [?] [?] [?] is at [?] [?] [?] [?] [?] [?] the midnight [?] [?] [?] [?] [?] [?] which is [?] [?] [?] in the place [?] [?] [?] [?] of Prague [?] [?] [?] [?] [a difference of?] [?] [?] [?] four hours [?] [?] [?] [?] [?] [?] [?] [?] [?] [?]; [?] [?] [?] [?] [?] in the time [?] [?] [?] which [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] this [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?]...

[Note: siman 84 continues onto p.60.]

Siman 84 continued (top of p.60)

the daily sphere [?] [גלגל היומי] [?] [?] [?] revolves [?] [?] [?] [?] 60 [?] degrees [?] [?] [?] [?]

Siman 85 (סימן פ"ה) — The Boundaries of the Four Directions of the World — Where They Begin and Where They End

[Body heading, p.60: סימן פ"ה — גבולות ארבע רוחות העולם אנה יתחילו ואנה ישלימו — "the boundaries of the four directions of the world, where they begin and where they end"]

The author says

The author says [?] [אמר המחבר = "the author says"]: After we have shown [?] [?] some of the boundaries [?] of the earth [?], by way of the rule [?] [?] [?] in general [?] [?] [?] — and likewise the finding [?] of the longitudes [?] and latitudes [?] of the provinces — I have seen fit [?] [?] to speak [?] [?] [?] at the conclusion [?] [?] of this section [?] [?] concerning the directions [?] of the world [?] [?] [?]; for [?] this [?] is a great need [?] [?] and of much benefit [?] [?] [?] to the lovers [?] of knowing the science [?] [?], and of measuring [?] [?] the boundary [?] of the earth [?] [?] [?] — and especially [?] [?] [?] for those who traverse [?] the routes of the seas [?] [?] [?] [?], to aim aright [?] [?] [?] and to come to the place of their desire [?] [?] [?].

It is already known [?] [?] [?] that the world [?] in its entirety [?] is divided [?] [?] — according to our holy Torah [?] [?] [?] — into four directions [?] [?] [צדדים = sides/directions] [?] [?], and they are called [?] in the Torah [?] "corners/quarters" [?] [פאות = corners, quarters] [?] [?] — as in "toward the south corner" [?] [?] [נגב לפאת = "to the south quarter"] [?] [?] [?], "the east quarter" [?] [?] [פאת קדמה = "the east quarter"] [?] [?] [?]. But [?] in the words of the prophets [?] [?] [?] they are called [?] "winds/directions" [?] [?] [רוחות = winds, directions] [?] [?] — as [?] Zechariah [?] [?] [זכריה = Zechariah] [?] [?] said [?] in chapter 8 [?] [?] [סי' ח / Zecharyah 2:10 (?)] [?] [?]: "for [as] the four winds of heaven [?] I have spread you abroad [?]" [?] [כי כארבע רוחות השמים פרשתי אתכם / cf. Zecharyah 2:10] [?] [?]. And likewise in Daniel [?] [?] [דניאל = Daniel] chapter 8 [?] [?] [סי' ח / Daniel 8:8 (?)] [?] [?], and in chapter 11 [?] [?] [וכסי' י"א / Daniel 11:4 (?)] [?] [?] [?] he said [?]: "and his kingdom [?] shall be divided [?] toward the four winds of heaven [?]" [?] [ותחץ מלכותו לארבע רוחות השמים / Daniel 11:4] [?]. And we do not find [?] [?] in all of Scripture [?] [?] [?] except [?] four directions [?] [?]. And just as [?] the sides [?] were divided [?] [?], so [?] [?] the languages of every nation [?] [?] [?] from the ancients [?] to [?] the latter [?] times [?] [?] [?] [called?] [?] [?] [?] four chief [?] directions [?] [?] [?]. Before [?] [?] we come [?] to their explanation [?] [?], know [?] [?] [?] that all [?] [?] the four directions [?] [?] [?] are called [?] [?] [?] [?] — especially [?] [?] in our holy Torah [?] [?] [?] — [?] in most [?] languages [?] [?],

according to [?] [?] the way [?] [?] and the action [?] [?] [?] of the sun [?] [השמש = the sun] [?] [?] [?] that operates [?] [?] [?] [?] every day [?] [?] [?].

The first [?] quarter [?] is called [?] **east** [?] [מזרח = east] [?] [?], on account of [?] [?] the rising [?] of the sun [?] [?] [?] [?], which [?] [?] [is] always [?] [?] in [?] [?] [?] every day [?] [?] at the start of [?] [the day?] [?] [?]. The [first] quarter [?] [?] [?] [?] [?] rises [?] [?] [?] above [?] the horizon [?] [?] [?] [האופק = the horizon] [?] to the side [?] [?] [?] [?] [?] [?] [?] [?] [?]. The second [?] quarter [?] [?] [?] [?], which [?] is opposite it [?] [?] [?], is called [?] [?] **west** [?] [מערב = west] [?] [?] — for at the setting [?] [?] of the sun [?] [?] [?] [?] [?] beneath the horizon [?] [?] [?] [?] the evening [?] [?] comes to us [?] [?] [?] [?] [?]. The third [?] quarter [?] [?] [?] is called [?] [?] **south** [?] [דרום = south] [?] [?] — [?] [?] [?] [?] [?] [?] [?] [in?] [?] this [?] [?] side [?] [?] [?] the sun [?] [?] [?] rises higher [?] [?] [?] [?] [?] [?] [?] [?] and its dwelling [?] [?] [?] [is] every day [?] [?] [?] above [?] the horizon [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] more [?] [?] [?] than [?] from any [?] [?] of the rest [?] of the directions [?] [?] [?]. It is also [?] [?] called [?] [?] the quarter of "Negev" [?] [?] [נגב = the Negev / south, dryness] [?] [?] — on account of [?] [?] [?] the dryness [?] [?] [היובש = the dryness] [?] [?] [?]; and [?] [?] [?] [?] [?] "Negev" [?] [?] [?] [?] [?], as in [?] [?] "you have given me a southern land" [?] [?] [נתתני הנגב / cf. Yehoshua 15:19 / Shoftim 1:15 — אֶרֶץ הַנֶּגֶב] [?] [?] [?] — that is, a dry land [?] [?] [פי' ארץ יבש = "i.e., a dry land"] [?] [?] [?]. And this [?] [?] [is] because of the strength [?] [?] of the heat [?] [?] of the sun [?] [?] [?] [?] [?] [?] that [is] in this quarter [?] [?] [?] [?] — as the Radak [?] [?] [הר"דק = R. David Kimchi (Radak)] [?] [?] [?] wrote [?] [?] in [his comment on?] the root [?] [?] [נגב = the root נ-ג-ב] [?] [?] [?]; and Targum [?] [?] [תרגום / Targum Onkelos (?)] [?] [?] [?] [renders?] [?] "and they covered [?] [?] the face of the earth" [?] [?] [חיפו פני אדמה / cf. Shemos 10:15 / Bamidbar 22:5] [?] [?] [?] [?] [as] "[they covered?] [?] [?] the face of the land [?] [?] of the south [?] [?]" [?] [?] [נגיבו אפי דארעא = (Aramaic) "[they covered] the face of the land of the south"] [?] [?] [?] [?].

The fourth [?] quarter [?] [?] is called [?] [?] **north** [?] [צפון = north] [?] [?] — because [?] [?] [?] the sun [?] [?] [?] is hidden [?] [?] [?] [from?] [?] the north [?] [?] [צפונה = northward] [?] [?] [?], and from [?] this quarter [?] [?] [?] it is concealed [?] [?] [?] [?] — [?] [?] [?] [?] [?] [for it [the sun?] does not?] [?] revolve [?] [?] [?] in [?] this quarter [?] [?] [?] [?] [?] [?] [?] [?] not even [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [from?] [?] [the whole?] [?] world [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?]. And the verse [?] [?] [?] [?] [?]: "going [?] toward the south [?] [?] and circling [?] [?] toward the north [?] [?]" [?] [?] [הולך אל דרום וסובב אל צפון / Koheles 1:6] [?] [?] [?] — [?] [?] [?] [?] [?] the north [?] [?] [?] [?] [?] is settled [?] [?] [?] [?]; further on [?] [?] in siman 137 [?] [?] [בסי' קל"ז (?)] [?] [?]. You shall also [?] [?] [?] know [?] [?]

[?] [?] incidentally [?] [?] [אגב גררא = incidentally / in passing] [?] that the east [?] quarter [?] [?] [?] [?] is called [?] [?] "face/front" [?] [?] [פנים = front] [?] [?] [?] and the west [?] quarter [?] [?] [?] [?] is called [?] [?] "back/rear" [?] [?] [אחור = rear] [?] [?] [?], [?] [and the south quarter?] [?] [?] [?] [the right hand?] [?] [?] [?], [?] [and the north quarter?] [?] [?] [?] the left hand [?] [?] [שמאל = the left hand] [?] [?] [?] [?].

And now [we come] to the matter [?]

And now [?] [?] to the matter [?] [?] of investigation [?] [?] [?]: of the four directions [?] [?] [?] [?] [?] — where [?] each one [?] begins [?] [?] [?] [?] [?]. Know [?] for yourself [?] [?] [?] [?] [?] that the researchers [?] [?] [?] [?] [?] [?] [?] [?] divided [?] [?] [?] [?] the earth [?] [?] [?] [?] [?] into four [?] [?] [?] [?] chief [?] parts [?] [?] [?] [?] [?] — by reasoning [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?]; but [?] [?] [?] [?] [?] they did not [?] [?] [?] divide [?] [?] [?] [?] [?] [?] [?] into equal parts [?] [?] [?] [?]. The boundaries [?] [?] [?] [?] they assigned [?] [?] [?] [?] [?] [?] for each [?] direction [?] [?] [?]: [?] [?] [?] [?] to the eastern [?] quarter [?] [?] [?] they assigned [?] [?] [?] [as is fitting?] [?] [?] [?] [?] [?] [?] [?] [?] [?]; [?] [?] [?] [?] on the [?] [right?] [?] [?] side [?] [?] up to the Tropic of Capricorn [?] [?] [עגול גדי = the Tropic of Capricorn] [?] [?] [?], and on the [?] [left?] [?] side [?] [?] up to the Tropic of Cancer [?] [?] [עגול סרטן = the Tropic of Cancer] [?] [?] [?] [?] — [?] [?] which [?] [?] are between the two boundaries [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] from circle [?] to circle [?] [?] [?] [?] the sun [?] [?] [?] [?] [?] passes [?] [?] [?]. From there [?] [?] [?] over [?] [?] the horizon [?] [?] [?] [?] [?] [?] every day [?] [?] [?] [?] always [?] [?] [?] [?], and the sun [?] [?] [?] does not [?] [?] pass [?] [?] [?] over [?] [?] [?] [?] [?] one [?] of the two boundaries [?] [?] [?] [?] [?] [?] [?] [?] all the days of the world [?] [?] [?] [?] [?] [?] [?]. And the midpoint line [?] [?] [?] [?] [?] [?] which is between the two boundaries [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] is the upright [?] [?] [?] [?] [?] [?] [?]. The breadth [?] of the east quarter [?] [?] [?] [?], according to [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] as the degree [?] [?] [?] [?] [?] in siman 7 [?] [?] [כס' ז' (?)] [?]: the boundaries [?] [?] [?] [?] [?] [?], which are [?] [?] [?] [?] the Tropic of Cancer [?] and the Tropic of Capricorn [?] [?] [?] [?] [?] [?] — according to the view of Ptolemy [?] [?] [כטולמיא"ס לדעת = the view of Ptolemy] [?] [?] [?] [?] [?] [?] [?] [?] [?] is 23 degrees 51 minutes [?] [?] [כ"ג מעלות נ"א דקין = 23 degrees, 51 minutes] [?] [?] — [?] [?] [?] [?] [?] which [?] [?] [?] [?] [?] [?] [?] when the two numbers are combined [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] they come [?] [?] [?] [?] to 46 degrees 42 minutes [?] [?] [?] [מ"ו מעלות מ"ב דקין = 46 degrees, 42 minutes] [?] [?] [?] [?]. This [?] [?] [?] [is] the breadth [?] of [?] [?] the [east?] quarter [?] [?] [?] [?]; [?] [?] [and?] [?] [?] [?] to the west quarter [?] [?] [?] [?] [?] [?] [?] they assigned [?] [?] [?] like it [?] [?] [?] [?] [?], [?] [?] [?] [?] [?] [?] [?] [?] [?] [?]

[?] [?] [?] [?] just as [?] [?] [?] [?] they assigned [?] [?] [?] [?] [?] to the east quarter [?] [?] [?] [?]. The boundary [?] [?] [?] [?] and the breadth [?] [?] [?] [?] [?] [?] [?] which [?] [?] the east quarter [?] [?] [?] [?] [?] [?] has [?] [?] [?] [?] [from one side?] [?] [?] [?] [?] up to the Tropic of Capricorn [?] [?] [עגול גדי = the Tropic of Capricorn] [?] [?] [?], and on the second side [?] [?] [?] [?] [?] up to the Tropic of Cancer [?] [?] [עגול סרטן = the Tropic of Cancer] [?] [?] [?] [?] — [?] [?] [?] [?] [?] in its very boundary [?] [?] and breadth [?] [?] [?] [?] [?] [?] [?] [?] [?] so it comes out [?] [?] [?] [?] [?] for the west quarter [?] [?] [?] [?], no less and no more [?] [?] [?] [?] [?] [?].

And since [?] [?] [?] [?] the line [?] [?] [?] [?] [?] [?] [?] [?] that encircles [?] [?] [?] [?] the globe of the earth [?] [?] [?] [?] [חוג הארץ = the circle of the earth] [?] [?] [?] [?] is 360 degrees [?] [?] [?] [360 = ש"ס מעלות degrees] [?] [?] [?] [?] — therefore [?] [?] [?] [?] [?] [?] [?] when [?] [?] [?] [?] [?] there are subtracted [?] [?] [?] [?] [?] [?] from them [?] [?] [?] 46 degrees [?] [?] [?] [מ"ו מעלות (?)] [?] [?] [?] [?] [?] [?] [?] 42 minutes [?] [?] [?] [מ"ב דקין] [?] [?] [?] twice [?] [?] [?] [פעמיים = twice] [?] [?] — [?] [?] [?] [?] [?] [?] [?] once [?] for the east quarter [?] [?] [?] [?], and the second [?] [?] [?] for the west quarter [?] [?] [?] [?] — there remains [?] [?] [?] for us [?] [?] [?] [?] [?] [?] toward the north [?] [?] [?] [?], and likewise [?] [?] [?] [?] toward the south [?] [?] [?] [?] [?]; [?] [?] [?] [?] for each one [?] of them [?] [?] [?] 132 degrees [?] [?] [קל"ב מעלות = 132 degrees] [?] [?] [?] 18 minutes [?] [?] [?] [?] [?] [יו"ח דקין (?)] [?] [?] [?] [?] [?]. And according to [?] [?] the reckoning [?] [?] [?] [?] [?] of 15 parsa'ot [?] [?] [ט"ו פרסאות = 15 parsa'ot] [?] [?] [?] of our land [?] [?] [ארצינו = our land] for each degree [?] [?] [?] [?], as above [?] [?] [?] [?] [?] in siman 62 [?] [?] [בס' ס"ב (?)] [?] [?] [?] [?] [?] [?] [?] [?] [?]. The breadth [?] [?] of the western [?] [?] [?] [?] [face?] [?] [?] [?] [?] [?] [?] [?] [?] of the earth [?] [?] [?] [?] [?] [?] [?] [?] will be [?] [?] [?] [?] [?] [?] [?] 770 [?] [?] [תש"ס (?)] [?] [?] [?] parsa'ot [?] [?] [?] and a half [?] [?] [ומחצה = and a half] [?] [?]. And likewise [?] [?] [?] [?] the east quarter [?] [?] [?] and the south quarter [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] will be [?] [?] [?] [?] [?] — according to this reckoning [?] [?] — the measure of its length [?] [?] [?] [?] [?] one thousand nine hundred eighty-four [?] [?] [?] [אלף ותתקפ"ד = 1984] [?] [?] [?] parsa'ot [?] [?] and a half [?] [?] [ומחצה = and a half] [?] [?]. And likewise [?] [?] [?] the length of the north quarter [?] [?] [?] [?] will be [?] [?] [?] [?] [?] [?] [?] [?], which are [?] [?] all of them [?] [?] [?] [?] [?] [?] [?] [?] five thousand [?] [?] [?] [5,000 = ה' אלפים] [?] [?] [?] [and four hundred?] [?] [?] [?] [ות' פרסאות = and 400 (?)] [?] [?] parsa'ot [?], as above [?] [?] [?] [?] [?] in siman 63 [?] [?] [כסי' ס"ג (?)] [?] [?] [?] [?] [?]. And although [?] [?] [?] [?] there is found [?] [?] [?] a difference [?] [?] [?] and a discrepancy [?] [?] [?] [?] between the measure [?] and the dimension [?] [?] [?] [?] [?] of the four directions [?] [?] [?] [?] [?] [?] — a great and large discrepancy [?] [?] [?] [?] — [?] [?] [?] [?] [?] the measure [?] [?] [?] [?] [?] of [?] [?] [?] [?] each of them [?] [?] [?] [?] [?] [?] [?] [?] [?] one upon three [?] [?] [?] [?] [?]

[?] [?] [?] [?] more than [?] the south [?] [?] quarter [?] [?] [?] [?] [?] [?] [?] [?] [?] upon [?] [?] the east and west quarters [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] — [?] [?] [?] [?] [?] [?] know [?] for yourself [?] [?] [?] [?] [?] that the midpoints [?] [?] [?] [?] [?] [?] of [?] [?] the [points?] of east [?] [?] [?] [?] and west [?] [?] [?] [?] [?] [?] [?] [?] [?], and the midpoints [?] [?] of the points of north [?] [?] and south [?] [?] [?] [?] [?] — [?] [?] [?] these four points [?] [?] [?] [?] [?] [?] [?] [?] are all of them [?] [?] [?] [?] near [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?], and equidistant [?] [?] from one another [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] in [?] [?] [?] perfect equality [?] [?] [?] [?] [?] [?] [?]: as [?] [?] the distance of [?] [?] the midpoint of east [?] [?] [?] from the midpoint of north [?] [?] [?] [?], so [?] [?] [?] [?] [?] the distance of the midpoint of north [?] [?] from the midpoint of west [?] [?] [?] [?] [?]; and likewise [?] [?] [?] there is [?] [?] the midpoint of west [?] [?] [?] from the midpoint of south [?] [?] [?] [?] [?], and the midpoint of south [?] [?] from the midpoint [?] [?] [?] [?] — [?] [?] [?] each one [?] [?] from its fellow [?] [?] [?] [?] ninety degrees [?] [?] [תשעים מעלות = ninety degrees] [?] [?] [?] [?].

Siman 86 (סימן פ"ו) — How the Ancients Divided Their Parts [?] — The Manner in Which the Horizon Is Divided into Twelve Directions

[Body heading, p.60: סימן פ"ו — שהקדמונים חלקו... ארץ... איפן המפריש או האופק לשנים עשר רוחות — "that the ancients divided... the manner of the divider, or the horizon, into twelve directions"]

Know [?]

Know [?] [Rashi-script rubric: דע] [?] that the researchers [?] [?] [המחקרים = the researchers] [?] of the ancients [?] [?] [?] [?] [?] [?] [?] [?] divided [?] [?] [?] [?] [?] [?] their parts [?] [?] [?] [?] — [?] [?] [?] the manner [?] [?] [?] [?] [?] [?] of the divider [?] [?] [המפריש = the divider/horizon-circle] [?] [?] [?] [?] [?] [?], [?] [?] or [?] the horizon [?] [?] [?] [?] [האופק = the horizon] [?] [?] [?]: into twelve parts [?] [?] [?] [?] [?] [?] [?] [?] [לי"ב חלקים = into twelve parts] [?] [?] — [?] [?] [?] [?] [?] every direction [?] [?] [?] [?] [?] [?] [?] [?] [?] of the four directions [?] of the world [?] [?] [?] [?] [?] into three equal parts [?] [?] [?] [?] [לשלשה חלקים שוים = into three equal parts] [?] [?] [?] [?]. For example [?] [?] [?] [?] [?] [המשל = the example]: the eastern direction [?] [?] [?] [רוח מזרחית = the eastern direction] [?] [?] [?] [?] [?] in this [?] figure [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] is divided [?] [?] [?] into three parts [?] [?] [?] [?]; [?] [?] [?] [?] the middle part [?] [?] [?] [?] [?] [?] they called [?] [?] [?] [?] **east** [?] [?] [מזרח = east] [?] [?] without qualification [?] [?] [סתם = simply, "east"] [?] [?] [?], and [?] [?] [?] [?] the part [?] [?] [?] [?] [?] [?] [?] which is to its right [?] [?] [?] [?] they called [?] [?] [?]

[?] **southeast** [?] [?] [מזרחית דרומית = south-east] [?] [?] [?], [?] [?] [?] and [?] [?] [?] the left part [?] [?] [?] [?] [?] [?] [?] they called [?] [?] [?] [?] **northeast** [?] [?] [מזרחית צפונית = north-east] [?] [?] [?] [?]; and likewise [?] [?] [?] the rule [?] [?] [?] [?] for the rest [?] [?] of the directions [?] [?] [?] [?].

And now [?] [?] [?] you should know [?] [?] [?] [?] [?] that even though [?] [?] [?] [?] there is no [?] [?] [?] [?] difference [?] [?] [?] [?] [?] [?] [?] [?] [between?] [?] [?] [?] [?] saying [?] "southeast direction" [?] [?] [?] [?] and saying [?] "[north?]east" [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] — [?] [?] [?] [?] [?] [?] you should know [?] [?] [?] that in its place [?] [?] [?] [?] [?] [?] [?] [?] there is a great [?] difference [?] [?] [?] [?] between saying [?] "northeast" [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] [?] — [?] [?] [?] [?] [?] for the city [?] [?] [?] which dwells [?] [?] [?] [?] [the word?] [?] "qeren" [?] [?] [?] [קרן = corner] [?].

Section 3 (שער ג) — continuation

[Siman 86, conclusion — top of p. 61]

[the city] that sits at point א, which lies in the eastern–northern part [quadrant]; while the city that sits at point ב lies in the northern–eastern part. The difference, gap, and distance between them is close to 60 degrees [קרוב לס' מעלות]. All these matters you will see in the figure here below.

סימן פ"ז — Siman 87

The circuit of the earth, or the horizon, [divided] into thirty-two directions [winds].

Know that the scholars of the later investigators found great benefit in dividing the horizon into thirty-two directions, and they gave names to all of them. This is how they began: to the four directions of the world that we have already established and named "the four directions" — precisely the eastern–northern, the eastern–southern, the western–southern, and the western–northern (not "northern–eastern," nor "southern–eastern," and likewise not "southern–western" nor "northern–western"), for the principal directions are east and west. And although this eight[fold] naming-scheme has been set aside — even though [the points are] near, and these distances are equal to those — nevertheless [for] the four directions of the directions [the corners], since the wind passes over the line at the boundary of the east and over the line at the boundary of the west, this one to its right and that one to its left, [the result follows] as will be explained. Thus, by this reckoning, we have four [corner directions].

The added directions, which are eight in number. These eight added [directions] are: they called the midpoint of the north "north," [then] "north toward east" [צפון אל מזרח] [?], and the "sons" of [the corner-points…] [?]; one of them is added on the north side toward the west — ✻ — and there is none added on the south side; and two of them on the west side [?] — as will be explained later from their own [account]. The early investigators, when they saw fit to add to the aforementioned eight directions yet another eight directions, divided [the circle] in such a way as to separate [it] into sixteen directions; [thus] they added to the six [?] another twelve [?] directions. To these eight added [points] — the "second-order" [secondary] ones — they gave each one a name.

These are their names: (א) they called the eastern–eastern–northern [ENE]; (ב) the eastern–southern; eastern[?]; (ג) the eastern–southern[?]; (ד) the western, and likewise the fourth: the western–southern, western; and similarly (ה) the added [points] in the north: (ו) the eastern–northern–northern[?]; and likewise the second [set] in the north; and (ז) the southern–southern[?], and the eastern–southern[?]. Thus we find that there are sixteen [directions] [?] — and among them: three toward the east, three toward the west, [and] five toward the north — [making] fifteen directions [?]. And the midpoint of the south, they called: south, eastern–southern[?], southern–[?]. And by this same rule, the four directions [are bred]: as the eastern–northern–eastern is to the north; likewise the northern–western to the west; the northern–eastern [?] toward the north; and the northern–western toward the west; and likewise the southern–eastern toward the eastern–southern[?]; and the southern–western toward the western, which is southern–southern–western[?]. All these matters you will see in the figure before us.

[Note: this passage enumerating the sixteen/thirty-two named compass-points is heavily garbled in the print and several point-names appear corrupted or transposed; readings flagged [?] throughout. Strong]

And now, when you scrutinize carefully the [point]s of the figure (the wind-rose) [?], [you will understand] why, although one is [drawn] near another, they differ one from the other: you will find five of them toward the east, [some] toward the west, and eleven [?] toward the north and eleven toward the south. The reason for this is clear: since every wind-direction is a part [of the whole], [and the full circle has] 360 degrees [ש"ס] of the encompassing circle; these are 11¼ degrees [each] — eleven degrees and a quarter-degree. Therefore the third wind-direction, [measured] from the midpoint of the east, is thirty-three degrees and three quarter-degrees [33°45′]. And we have already explained, in the discussion

[above], that the breadth of each wind is not upon [a full degree] but only [N°] 42′ [?] of those minute-divisions (דקין) that are at the midpoint of the east.

[Following these matters, the investigators saw fit to add yet] sixteen further directions beyond the aforementioned sixteen directions [?], dividing [them] in such a way as to separate [the circle] into thirty-two directions. This last addition came about in this manner: each of the [16] directions inherited from "the fathers" — they all assigned [it] two "sons," one to its right and one to its left, and they named [the new points] inwardly[?] [intermediate]. The two "sons" of the midpoint of the east, they called: "east toward north," and "east toward south"; and the two "sons" of the midpoint of the west [?], they called "west toward [north / south]" [?]. Thus each [32-point] wind is only 11°15′ in its breadth. Therefore the third wind from the midpoint of the east, whose distance is 33 degrees and three quarter-degrees [33°45′] from the midpoint of the east — [these are] to its right and to its left [of] the midpoint of the east, [namely] the ninth wind, whose breadth reaches the face [edge] of the east, [is N] degrees [?] of those minute-divisions. Therefore the [resulting] wind-direction [?], [measured] from the midpoint of the east and onward, [is such that] the principle of "midpoint of the east" is set aside from it.

The benefit of knowing this division — let me tell you what I found written [in a source] that there is…

Diagram. A circular wind-rose (compass card) in the left margin, mounted on a flagstaff with a flag flying at the top (the staff representing the figure being held aloft, decorative). The circle is divided into thirty-two compass points radiating from an ornate central star (an eight-pointed star-burst, hatched, with a small rosette at the hub). Around the rim, the principal direction-names are printed in a ring. Readable rim labels (clockwise from top):

- רוח צפונית (top): "Northern wind / North"
- מזרחית צפונית (upper right): "Eastern–Northern" [NE]
- מזרחית למעלה / מזרחית (right): "Eastern" [East] (with intermediate-point labels)
- מזרחית דרום (lower right): "Eastern–Southern" [SE]
- מזרח דרום / דרום (bottom): "South" [the bottom register reads מזרח/דרום, partly worn]
- מערבית דרום (lower left): "Western–Southern" [SW]
- מערב (left): "West"
- מערבית צפונית (upper left): "Western–Northern" [NW]

The central spelled labels "צפון" (north) and the cardinal letters mark the four principal axes. The letter ב appears as a figure-key at the lower left of the staff. Several intermediate-point inscriptions around the rim are too small/worn to read with confidence [?].

[Siman 87, conclusion — bottom of p. 61, continued from the lower text block]

North → west: and likewise [the "sons" of] the midpoint of the south they called "south toward east," "south toward west"; and the "sons" of the midpoint of the south[?]: the eastern–southern[?] toward the south, and the western–southern toward the south… likewise by this rule the four directions [breed] their "sons": the eastern–northern directions toward the north, [and] the western–northern toward the north; likewise the western–northern[?] toward the west; the eastern–southern[?]… the eastern–southern toward the south[?], the western–southern toward the west — as in the [matters] which you will see in the figure.

And now, when you scrutinize carefully the [points] of the figure that we have set [out], and [understand] why — although one is near another — you will nonetheless find five of them toward the east [?]: [some] toward the west by eleven [11], and eleven toward the south. This is well explained: since every wind-direction is one part of the 360 degrees [ש"ס] of the encompassing circle, [each part being] 11¼ degrees — eleven degrees and a quarter-degree. Therefore the third wind from the midpoint of the east [is at] 33¾ degrees [33°45′]; and we have already explained that its breadth is not [a full degree] but only [N°] 42′ [?]. And so [you may know] the rest of the directions [?] [and] the rest of the places of the world [reading uncertain throughout].

[Siman 87, continued — top of p. 62]

as it is, about 300 years ago, around the year 70 of the sixth millennium [≈ 5070 AM = c. 1310 CE], an instrument [device] was found that indicates the hours by means of a tongue [pointer] — this is, in one language [tongue], called: **(מאגנעטיני"א)** [German: *Magnet-Uhr*, "magnet-clock" / the *Magnet*]. This is the magnetic stone (the lodestone), which draws and pulls iron; on it is a tongue [needle/pointer] mounted upon a pivot, which indicates one line [direction] and indicates the meridian line [the line of noon], and by means of the sun's shadow it indicates, at every hour, the [time]; [it indicates] noon-time by the sum of all the daylight hours from morning until the [setting of the sun] in the evening — like a clock [that tells] every hour in the city. And they call it, in the German tongue

[כל"א = בלשון אשכנז]: **צייגר ז(ו)ן** [German: *Zeiger* + *Sonne* → *Sonnenzeiger* / *Zeiger-Uhr*, "pointer-clock" / "sun-dial"; exact German form uncertain] [?].

Now, after the investigators agreed to divide the [course of the] horizon into thirty-two directions, they made a [drawn] circle upon one leaf, and divided the circle into thirty-two parts as in the figure above; and at the center of the circle they set [a marker] indicating the appointed hour [the time], according to the lodestone — **(מאגכיט"א)** [German: *Magnet*, the magnetic stone] — [a device] by means of which sailors know how to come [navigate] along the paths of the seas and to direct, from any place, [toward] the place of their desire — even when it is several hundred *parsa'ot* distant; and likewise [for] other [feats of] great and wondrous wisdom that can be accomplished by means of this instrument [the compass]. For by it [one is] guided, and it tells us [where] the settled regions of his dwelling lie; the globe of the world, too — the position [longitude] of every place; the digging of mines and the quarrying of silver — beneath the earth, [things] otherwise undiscoverable; the seeker after his desire [finds it].

Apart from such an instrument as this — [used in] the building of dukes and kings of the land — [reading uncertain]; this instrument is for them a "teacher of righteousness" [a guide]. And I will not expand upon these matters; their place is not here, nor would a [whole] book contain them. I do not know even one [hundredth] of its benefit, not even one part in a hundred. And know that the larger the circle [the dial] upon which they marked these thirty-two directions, the larger [and] the more precise the measurement and the scale will be by means of it. Know further that the gap [interval] between each wind and [the next] wind — the scholars [draw] with fine rulings [lines]; those rulings are called *daqin* [minutes/fine-lines], or "seconds" (שניים).

סימן פ"ח — Siman 88

A table [arranged] according to the order of the [Hebrew] alphabet, by which to know from it the locations of many of the settled places — also some of the islands of the sea — how [much] they are in the longitude of the world and in its latitude.

I saw fit, at the sealing [conclusion] of this section, to bring to a book [set down in writing] a table — arranged according to the order of the alphabet — in which you will find many places of the dry land, and also the islands of the sea, [showing] how much they are in the longitude of the world and how much they are in its latitude; and [these are chiefly the] places in the European region in which we dwell. And alongside each and every place [there are] inscribed in the

table four numbers: two of them indicate the measure of the world's latitude, and two of them indicate the measure of its longitude.

The example [is] this: alongside Jerusalem is written [20 66 15 32] ל"ב ט"ו ס"ו ך'. Behold, the [first] two numbers — which are the first ones — indicate the measure of the latitude: the first, which is [32] ל"ב, indicates the number of degrees of latitude; and the second, which is [15] ט"ו, indicates the number of minutes (*daqin*) of latitude — that is to say, Jerusalem sits at 32 degrees 15 minutes [of latitude] from the equator. The last two numbers — [their two] degrees and minutes [reading: their] minutes — indicate the longitude: the first of them, which is [66] ס"ו, indicates the number of degrees of longitude; and the second, which is [20] ך', indicates the number of minutes (*daqin*) of longitude — that is to say, Jerusalem sits, in [its] longitude, at 66 degrees 20 minutes from the [western] edge of the inhabited [world] in the west.

By means of this table, any man of understanding can himself construct a table to depict the [globe], according to its size as he wishes — [namely] the globe of the world. And this is how you do it: make one circle [as the meridian]; divide its length [circumference] into 360 minute-fine-rulings — [that is,] 360 degrees [?] — divide them as you wish; and likewise [for] the breadth [latitude], each [half] from its middle, [running] from 90 degrees [at the pole] to 90 degrees [?]; and from whatever [point] you wish, [you may set] from this table the forms of [all the] places [on] the globe of the world, each place upon its proper position.

And I will say, by way of illustration: should you wish to set [the city of] **Prague** upon its proper place, look in the table and you will find Prague at a longitude of 25 degrees 38 minutes [?] and at a latitude of 50 [?] degrees 12 minutes [reading uncertain]. Count, then, in the markers [graduations] of the globe of the world that you wish to fashion: of the 25-degree [longitude] line of the equator [?] [count along], and in [its] latitude count 50 degrees [?]; and at the place where these two lines — the 50[?] line and the 25-degree line — meet and intersect, that is the point of Prague. And from this you may know [the placement of] the rest of the places of the world.

[Lower-text block, p. 62 — partly a continuation of the construction instructions:]

according to your wish; and divide those rulings into 11¼ [?] degrees, and so to its breadth [latitude] 23½ degrees [?] — and [arrange them] in order from this table; the globe [forms] of the world [reading uncertain]. And likewise [in] the order [of the alphabet] you will find Prague the city — set in its proper place — at 38 [?] degrees… [as] the [figures] mentioned for Prague: longitude [25°38′] ך"ה ל"ח [?]

and latitude … of the globe of the world [reading uncertain]. The scholars [draw] with these very fine rulings; those rulings are called *daqin*, the "second-order" [subdivisions]; and from this you will know [how to place] the rest of the places of the world.

The Geographic Gazetteer (Siman 88) — Table

Layout note (load-bearing): The table runs in the source from right to left and is laid out in multiple vertical strips per page, each strip headed by a Hebrew alphabet-letter rubric (אות א, אות ב, …). Each place-name (rightmost in the source) is followed by four numeric columns. Per the worked example for Jerusalem (י"ב ל' / ס"ו ך), the four numbers are, in source right-to-left order: **latitude degrees · latitude minutes · longitude degrees · longitude minutes**. The column-header strip is printed vertically and reads (right-to-left): מעלות רוחב (latitude °), דקין רוחב (latitude ′), מעלות אורך (longitude °), דקין אורך (longitude ′) — though some of the column headers as printed are abraded [?]. I preserve the logical column order below. **Numerals are gematria; many cells are degraded — uncertain digits flagged [?].** Hebrew "10 = "יוד ,50 = "נון spelled out in this table; single-letter forms are expanded.

אות א — Letter Aleph

Place	Lat °	Lat ′	Long °	Long ′
אלכסנדריא [Alexandria]	ל"א [31]	יוד [10]	ס [60]	ל [30]
אלקוירא [al-Qāhira / Cairo] [?]	ל"ה [35] [?]	כ"ט [29]	נ [50]	נון [50] [?]
אנטיוכא [Antioch / Antiochia]	ל"ה [35]	ל"ח [38] [?]	ס"ב [62]	ב"ה [reading?] [?]
אנט ווארף [Antwerp / Antwerpen]	ט"ו דח [reading?] [?]	ך [20] [?]	ט"ז [16] [?]	ך [20]
אקווילי [Aquileia] [?]	מ"ג [43] [?]	ל [30]	—	—
אויקשפרג	מ"ז [47] [?]	י"ח [18]	ס"ב [62] [?]	—

Place	Lat °	Lat ′	Long °	Long ′
[Augsburg]				
אורליגענץ [Orléans] [?]	מ"ז [47] [?]	י"ט [19] [?]	י"ג [13] [?]	—
אולמא [Ulm]	מ"ח [48]	ו [6] [?]	—	—
אויטינגע [Öttingen / Nördlingen ?] [?]	מ"ח [48] [?]	נ"ח [reading?] [?]	ג [3] [?]	דח [reading?] [?]
אינגלשטט [Ingolstadt]	מ"ם [reading: מ"ט 49?] [?]	ו [6] [?]	—	—
אויבען [Ofen / Buda] [?]	מ"ז [47]	יוד [10]	מ"ד [44]	ל"ו [36] [?]
אויך [Aich / Auch?] [?]	—	—	—	—
אולמיץ [Olmütz / Olomouc]	כ"ז [27] [?]	—	—	—
אמשטרדם [Amsterdam]	נ"ב [52] [?]	מ [40]	כ"ז [27] [?]	ל"ד [34] [?]
אנדרינופל [Adrianople / Edirne]	—	—	—	—
אוזן בריק [Osnabrück] [?]	—	—	—	—
צרסטדא [reading uncertain — Aderstedt?] [?]	—	—	—	—
אלונים מרא [reading	—	—	—	—

Place	Lat °	Lat ′	Long °	Long ′
uncertain] [?]				
אים לנד [Emden / "Im Land"?] [?]	ס"ו [?] [66]	ט [?] [9]	—	—
אנדריך [Andrich / Enderich?] [?]	כ"ה [25]	נ [50]	לב [?] [32]	כ"ט [?] [29]
אשקלון [Ashkelon]	ל"ב [32]	כ"ב [?] [22]	ס"ז [?] [67]	נ"כ [reading?] [?]

Parsing notes (Aleph): Several entries have one or two numeric cells blank in the print (or too abraded to read) — left as "—". The four-column alignment for אנט אויטינגע, וואַרף, and אשקלון is the least certain. City identifications for אויקשפּרג (Augsburg), אורליגענץ (Orléans), אויבען (Ofen/Buda) are by phonetic match and flagged. Strong for the full numeric grid.

אות ב — Letter Bet

Place	Lat °	Lat ′	Long °	Long ′
בבל [Bavel / Babylon]	ל"ה [?] [35]	ס [?] [60]	פ [?] [80]	ס [?] [60]
בגדוד [Baghdad]	ל"ד [?] [34]	ך [?] [20]	פ"ה [?] [85]	ו [?] [6]
ביצלוני [Barcelona] [?]	מ"א [?] [41]	ל"ה [?] [35]	יוד [10]	יוד [10]
בומבערג [Bamberg] [?]	מ"ט [?] [49]	נ"ו [?] [56]	ל [30]	מ"ה [?] [45]
באזיל [Basel]	מ"ז [?] [47]	מ"א [?] [41]	מ"ב [?] [42]	כ"ב [?] [22]
בערלין [Berlin]	נ"ב [?] [52]	נון [?] [50]	ל"ג [?] [33]	ל [30]
באנוניא	מ"ג [?] [43]	נ"ד [?] [54]	ל"ג [?] [33]	ה [?] [5]

Place	Lat °	Lat ′	Long °	Long ′
[Bologna / Bononia] [?]				
ברוקו לנדין [Brugge / "Brügge in Flandern"?] [?]	[51] נ"א [?]	[24] כ"ד [?]	[4] ד [?]	[16] ט"ז [?]
ברעסלא [Breslau / Wrocław]	[51] נ"א [?]	[10] יוד	[40] מ [?]	—
ברונשוויג [Braunschweig]	—	—	—	—
ברעשין [Brixen? / Bretzin?] [?]	—	—	—	—
בר סק וליטא [Brisk d'Lita / Brest-Litovsk]	[51] נ"א [?]	[10] יוד	[48] מ"ח [?]	[45] מ"ה [?]
בעלז [Belz]	—	—	—	—
בית לחם [Beit Lechem / Bethlehem]	[31] ל"א [?]	[3] ג [?]	[65] ס"ה [?]	[45] מ"ה [?]
באר שבע [Be'er Sheva / Beersheba]	—	—	—	—
בוסק [Busk] [?]	—	—	—	—
בעלו [Belau / Bila?] [?]	—	—	—	—

Parsing notes (Bet): Many of the smaller towns (Braunschweig, Belz, Be'er Sheva, Busk) have no numeric entries in the print or they are illegible. Bavel/Baghdad longitude figures (80°, 85°) are eastern-Mediterranean-scale and plausible; flagged for digit-check.

אות ג — Letter Gimel

Place	Lat °	Lat ′	Long °	Long ′
געגובא [Genova / Genoa?] [?]	[43] מ"ג [?]	[50] נון [?]	ד"ח [reading?] [?]	[4] ד [?]
געלדריא [Geldern / Gelderland] [?]	[52] נ"ב [?]	[4] ד [?]	י"ן [reading?] [?]	[4] ד [?]
גדאנטי [Danzig / Gdańsk?] [?]	[37] ל"ז [?]	[50] נון [?]	[8] ח [?]	[34] ל"ד [?]
גערליץ [Görlitz] [?]	[50] נון [?]	[10] יוד	[33] ל"ג [?]	[45] מ"ה [?]
גיזין [Giessen? / Gniezno?] [?]	—	—	—	—
גרמיידא [reading uncertain] [?]	—	—	—	—
גרעץ שטיר [Graz, Steiermark / "Graz in Styria"]	—	—	—	—
גראן אונגריא [Gran / Esztergom, Hungary]	—	—	—	—
גרונדא [Gironda /	—	—	—	—

Place	Lat °	Lat ′	Long °	Long ′
Girona?] [?]				
גבעון [Giv'on / Gibeon]	—	—	—	—
גת [Gat / Gath]	—	—	—	—
גראן לנד [Grönland / Greenland?] [?]	עין [reading?] [?]	—	—	—

Parsing notes (Gimel): Identifications heavily phonetic and uncertain. גראן לנד as "Greenland" is conjectural. Numeric grid largely blank/illegible in this strip

אות ד — Letter Dalet

Place	Lat °	Lat ′	Long °	Long ′
דמשק [Damesek / Damascus]	[33] ל"ג [?]	[10] יוד	[69] ס"ט [?]	[10] יוד
דאנציק [Danzig]	[54] נ"ד [?]	[50] נון [?]	ה"ד [reading?] [?]	[2] ב [?]
דרעזין [Dresden] [?]	—	—	—	—
דערטמונד [Dortmund]	—	—	—	—
דן היא לשם [Dan — she is Layish] [biblical Dan = Laish]	—	—	—	—

Parsing notes (Dalet): Most entries lack legible numerals.

אות ה — *Letter He*

Place	Lat °	Lat ′	Long °	Long ′
המבורג [Hamburg]	נ"ד [54] [?]	ד" [reading?] [?]	ל [30] [?]	ט [9] [?]
הלברשטט [Halberstadt]	נ"ב [52] [?]	י"א [11] [?]	ל [30] [?]	ד [4] [?]
היידל בורג [Heidelberg]	—	—	—	—
הנובר [Hannover]	—	—	—	—
הילדסים [Hildesheim]	—	—	—	—
האלי דזקסין [Halle in Sachsen / "Halle, Saxony"]	—	—	—	—
הילני אינזל [Helene-Insel / St. Helena island?] [?]	—	—	—	—
הר סיני [Har Sinai / Mount Sinai]	—	—	—	—
הר כרמל [Har Karmel / Mount Carmel]	—	—	—	—

Parsing notes (He): only Hamburg and Halberstadt carry legible figures.

אות ו — Letter Vav

Place	Lat °	Lat ′	Long °	Long ′
ווינציאה [Venezia / Venice]	[45] מ"ה [?]	[15] ט"ו [?]	[33] ל"ג [?]	[30] ל
ורוני בערן [Verona, [in the territory of] Bern?] [?]	[45] מ"ה [?]	[16] ט"ז [?]	[31] ל"א [?]	[16] ט"ז [?]
ויאון דציפת [Avignon? / "Vienne in [France]"?] [?]	[45] מ"ה [?]	[12] י"ב [?]	ד"א [reading?] [?]	[25] כ"ה [?]
וויטן בערג [Wittenberg]	[51] נ"א [?]	[50] נון [?]	[30] ל	—
וויל‍נא דליט' [Vilna d'Lita / Vilnius, Lithuania]	[55] נ"ה [?]	—	—	—
ווירץ בורג [Würzburg]	[49] מ"ט [?]	נ"ח [reading?] [?]	[30] ל	[30] ל
ווירמיש [Worms / Wormaisa]	—	—	—	—
וויצענץ [Vicenza] [?]	—	—	—	—
וורשא [Warsaw / Warszawa]	—	—	—	—
ווינא [Wien / Vienna]	—	—	—	—

Parsing notes (Vav): Identifications of ורוני בערן and ויאון דציפת are uncertain. Vilna carries a latitude only.

אות ז — *Letter Zayin*

Place	Lat °	Lat ′	Long °	Long ′
זלצבורג [Salzburg]	—	—	—	—
זמשט דפולין [Zamość d'Polin / Zamość, Poland] [?]	—	—	—	—
זינגעט [Zinget / Sinj?] [?]	—	—	—	—
זינט [Zint?] [?]	—	—	—	—
מינן [reading uncertain — strip-misplaced?] [?]	—	—	—	—
זושט [Soest? / Zoest] [?]	—	—	—	—
זיף [Zif / Ziph] [?]	—	—	—	—

Parsing notes (Zayin): no legible numeric entries in this strip.

אות ח — *Letter Chet*

Place	Lat °	Lat ′	Long °	Long ′
חמת אנטוכא [Chamat-Antiochia / Hamath / Antioch-of-Syria] [?]	—	—	—	—
חברון	—	—	—	—

Place	Lat °	Lat ′	Long °	Long ′
[Chevron / Hebron]				
חורב [Chorev / Horeb]	—	—	—	—

Parsing notes (Chet): no legible figures.

אות ט — Letter Tet

Place	Lat °	Lat ′	Long °	Long ′
טלטול ספרד [Toledo, Spain / "Tulaytula, Sefarad"]	[41] מ"א [?]	[30] ל	[10] יוד	[30] ל [?]
טוני דכצרים [Tunis of Egypt?] [?]	—	—	—	—
טוני ברבריא' [Tunis of Barbary / Tunis in the Maghreb]	—	—	—	—
טריר [Trier]	—	—	—	—
טארין [Turin / Torino] [?]	—	—	—	—
טבירי' [Teveria / Tiberias]	—	—	—	—

Parsing notes (Tet): only Toledo carries (uncertain) figures.

אות י — Letter Yod

Place	Lat °	Lat ′	Long °	Long ′
ירושלים [Yerushalayim /	[32] ל"ב	[15] ט"ו	[66] ס"ו	[20] ך

Place	Lat °	Lat ′	Long °	Long ′
Jerusalem]				
יענט [Genoa? / Gent?] [?]	—	—	—	—
יערסלאור [Jarosław? / Jaroslau] [?]	—	—	—	—
יובא אי [Java island / "Yova, island"?] [?]	—	—	—	—
יריחו [Yericho / Jericho]	—	—	—	—
יפו [Yafo / Jaffa]	—	—	—	—
יבנה [Yavne / Jamnia]	—	—	—	—

Parsing notes (Yod): Jerusalem's figures match the worked example in the text (ל"ב ט"ו ס"ו ך' = lat 32°15′, long 66°20′) and are the only fully reliable row in the whole table — they confirm the column order. The remaining Yod rows have no legible numerals.

אות כ — Letter Kaf

Place	Lat °	Lat ′	Long °	Long ′
כרמל דאלי' [Karmel d'Eli / Mount Carmel of Elijah] [?]	—	—	—	—
כרמל דנבות [Karmel d'Navot / Carmel of	—	—	—	—

Place	Lat °	Lat ′	Long °	Long ′
Naboth (the Jezreel Carmel)]				

Parsing notes (Kaf): no legible figures.

אות ל — Letter Lamed

Place	Lat °	Lat ′	Long °	Long ′
לונדן [London]	י"ן [reading?] [?]	ל [30] [?]	—	—
לויפק [Leipzig? / Lübeck?] [?]	נ"ד [54] [?]	מ"ח [48] [?]	—	—
לימן דצרפת [Limoges / "Limon of France"?] [?]	מ"ה [45] [?]	מ"ם [reading?] [?]	—	—
לוינעבורק [Lüneburg]	נון [50] [?]	מ"ם [reading?] [?]	—	—
לייפציג [Leipzig]	נ"א [51] [?]	כ"ד [24] [?]	ל"ד [34] [?]	ל [30] [?]
ליזיבין [reading uncertain] [?]	מ"ם [reading?] [?]	מ"ה [45] [?]	ד [4] [?]	ט [9] [?]
לינץ [Linz]	—	—	—	—
לובלין [Lublin]	—	—	—	—
לעמבורג [Lemberg / Lwów]	—	—	—	—
לאדמער [Vladimir? /	נ [50] [?]	נ"ז [57] [?]	מ"ד [44] [?]	נ"ו [56] [?]

Place	Lat °	Lat ′	Long °	Long ′
"Lodmer" = Włodzimierz] [?]				
לשם הוא דן [Layish — she is Dan] [biblical]	—	—	—	—

Parsing notes (Lamed): the printed list interleaves the place-names and the numeric strips with the Mem strip beside it; alignment of figures to לייפציג, ליזיבין, and לאדמער is uncertain. The two-line numeric pairs in this strip are the hardest to assign.

אות מ — Letter Mem

Place	Lat °	Lat ′	Long °	Long ′
מצרים [Mitzrayim / Egypt (Cairo)]	[34] ל"ד [?]	[50] נון [?]	[10] יוד	[50] נון [?]
מענץ [Mainz / Mentz]	[50] נון [?]	מ"ם [reading?] [?]	—	—
מעביל [reading uncertain — Möbel? / Mechelen?] [?]	[51] נ"א [?]	[14] י"ד [?]	ד"ד [reading?] [?]	[50] נון [?]
מיידבורק [Magdeburg]	[52] נ"ב [?]	[20] כ [?]	[32] ל"ב [?]	[44] מ"ד [?]
מאנטובא [Mantova / Mantua]	[44] מ"ד [?]	[30] ל	[34] ל"ד [?]	[50] נון [?]
מרסלא צרפי' [Marseille, France / "Marsala of	[43] מ"ג [?]	[6] ו [?]	[36] ל"ו [?]	[17] י"ז [?]

Place	Lat °	Lat ′	Long °	Long ′
France"] [?]				
מיודייוויא [reading uncertain] [?]	[45] מ"ה [?]	[30] ל	[45] מ"ה [?]	[30] ל [?]
מיילנד [Mailand / Milan]	[44] מ"ד [?]	[36] ל"ו [?]	[30] ל [?]	—
מרפוגן [Marburg? / Merseburg?] [?]	[51] נ"א [?]	—	—	—
מוינק [München / Munich?] [?]	—	—	—	—
מעץ [Metz]	[30] ל [?]	[50] נ [?]	—	—
מיינשטר [Münster]	—	—	—	—
מינדין [Minden]	—	—	—	—
מאנגאל [reading uncertain — Mongolia? "Mangal"?] [?]	—	—	—	—

Parsing notes (Mem): a populous strip; numeric alignment is uncertain throughout because the source prints the figures in two stacked sub-columns whose row-correspondence is abraded. Identifications of מרסלא (Marseille), מיילנד (Milan), מיידבורק (Magdeburg) are reasonably secure phonetically. for the numeric grid.

אות נ — Letter Nun (begins; continues into next batch)

Place	Lat °	Lat ′	Long °	Long ′
נרבוני דצרפ' [Narbonne, France / "Narboni of France"]	[14] י"ד [?]	[18] י"ח [?]	[33] ל"ג [?]	[10] יוד [?]
ניאפלוס מאיור [Neapolis Maior / Naples] [?]	[41] מ"א [?]	[10] יוד	—	—

Parsing notes (Nun): The Nun strip is just beginning at the foot of p. 64; the entry ניאפלוס מאיור and the next (יין / "Jenin"? — catchword) are cut by the page boundary. **Table continues into the next batch.**

Section Three (שער ג)

Siman 88 (continued) — Alphabetical gazetteer of place latitudes and longitudes

The citation-grade alphabetical gazetteer continues from the previous batch. Columns are **[Place · Lat° · Lat′ · Long° · Long′]** (source reads right-to-left; rendered here left-to-right). This is heavily degraded small type set in two parallel table-blocks per page; many digits are only partly recoverable and are flagged [?]. The whole gazetteer is a (see report).

Letter Nun (נ) — continued (p. 65):

Place	Lat°	Lat′	Long°	Long′
נירן בורג [Nuremberg]	[49] מט	[?] דד	[31] לא[?]	[10] יוד[?]
נומברג דזאל [Naumburg (?)][?]	[49] מט	[4] ד	[32] לב[?]	[10] יוד[?]
נבערן [Nevern / Bavaria(?)]	[?]	[?]	[?]	[?]

Place	Lat°	Lat′	Long°	Long′
[?]				
נייס [Neuss] [?]	[?]	[?]	[?]	[?]
נורט הויזין [Nordhausen][?]	[?]	[?]	[?]	[?]
נורטס [Nordheim(?)][?]	[?]	[?]	[?]	[?]
נינוה [Nineveh]	מג [43]	[?]	פ״ [?]	[?]
נור ווירן [?]	סו [?][66]	ט [9]	[?]	[?]

Letter Samekh (ס) — p. 65:

Place	Lat°	Lat′	Long°	Long′
סיבילאה [Sevilla / Seville]	לו [36]	[?]	ו [?][6]	ל [?][30]
סירז ניאה [Syracuse(?)][?]	יוד [?] דח [?]	[?]	לא [?][31]	יוד [?][10]
סלינעק [Solothurn(?) / Sélestat(?)] [?]	[?]	[?]	[?]	[?]
סיני [Sinai]	[?]	[?]	[?]	[?]
סדום [Sodom]	[?]	[?]	[?]	[?]

Letter Ayin (ע) — p. 65:

Place	Lat°	Lat′	Long°	Long′
ערפורט [Erfurt]	מא [41][?] יוד [?][10]	[?]	ל [?][30]	[?]
נסליקאן [Esslingen(?	מח [48][?] לה [?][35]	[?]	[?]	[?]

Place	Lat°	Lat′	Long°	Long′
)][?]				
ערלא דאונגרי [Erlau, Hungary (Eger)][?]	[?]	[?]	[?]	[?]
עמרן [Amran(?)] [?]	[?]	[?]	[?]	[?]
עצינן גבר [Etzion Gever / Ezion-Geber]	[?]	[?]	[?]	[?]

Letter Pe (פ) — p. 65:

Place	Lat°	Lat′	Long°	Long′
פראג [Prague]	נח [58][?] יב [12]	[?]	כה [25][?] לח [38][?]	[?]
פ״פ דמיין [Frankfurt am Main]	נב [52][?] לג [33][?]	[?]	לב [32][?] לד [34][?]	[?]
פ״פ ראדרה [Frankfurt an der Oder]	נב [52][?] לג [33][?]	[?]	לב [32][?] לד [34][?]	[?]
פיררא [Ferrara(?)] [?]	מד [44][?] דג [?]	[?]	לב [32][?] טי [?]	[?]
[?] פאנצישטי	לה [35][?] [?]יוד [10]	[?]	[4] ד[?]	[?]
פנים ראפרן [?]	לד [34][?] מצ [?]	[?]	[?]	[?]
פרייבורק [Freiburg(?)][?]	נון [50][?] [?]נח [58]	[?]	[?]	[?]
מייסן	[?]	[?]	[?]	[?]

Place	Lat°	Lat′	Long°	Long′
[Meissen — out of alpha order][?]				
פרייבורג [Freiburg / Fribourg]	מח [48][?] יג [13][?]	[?]	[?]	[?]
פריסן [Friesen / Prussia(?)] [?]	[?]	[?]	[?]	[?]
פולרענץ [Florence(?)][?]	[?]	[?]	[?]	[?]

Parsing notes: the right-hand block of p. 65 (letters Pe etc. continued) is so degraded that only fragmentary digit-pairs survive; the left-most block (above) carries most readable data.

Letter Pe (פ) — left-block continued, p. 65:

Place	Lat°	Lat′	Long°	Long′
פאביאה [Pavia]	מד [44][?] ד [4][?]	[?]	לא [31][?] כב [22][?]	[?]
פארמה [Parma]	מג [43][?] ל [30][?]	[?]	לב [32][?] יד [14][?]	[?]
פאריבה [Pereira(?) / Paribah][?]	מה [45][?] נ [50][?]	[?]	לב [32][?] נון [50][?]	[?]
פאריס [Paris]	מה [45][?] נב [52][?]	[?]	מב [42][?]	[?]
פאס [Fez(?)][?]	[?]	[?]	[?]	[?]
פיזנא [Pisa(?)][?]	נב [52][?] מה [45][?]	[?]	[?]	[?]
פיטרקוב [Piotrków]	[?]	[?]	[?]	[?]

Letter Tzadi (צ) — p. 65:

Place	Lat°	Lat′	Long°	Long′
ציען מצרים [Tzo'an / Zoan, Egypt (Tanis)]	] נון [?] דט [?][50]	[?]	[?][61] סא [?]נון [50]	[?]
צוריך שווייץ [Zürich, Switzerland]	[?]	[?]	[?]	[?]
צוויקאמייסן [Zwickau-Meissen(?)] [?]	[?]	[?]	[?]	[?]
צעמלאגובא [Sambor / Zamlagova(?)][?]	[?]	[?]	[?]	[?]
צור [Tyre / Tzor]	[?]	[?]	[?]	[?]
צרון [Tziron / Sidon(?)] [?]	[?]	[?]	[?]	[?]
צפת [Tzfat / Safed]	[?]	[?]	[?]	[?]
ציין [Tzo'an(?) — duplicate?] [?]	ו [?][32] לב [6][?]	[?]	[?]	[?]

Letter Kuf (ק) — p. 65:

Place	Lat°	Lat′	Long°	Long′
קראקובא [Kraków]	[?][50] נון [?]יב [12]	[?]	[?][37] לז [?]נון [50]	[?]
קרישונא [Cremona(?	[?][44] מד [?]מ [40]	[?]	[?]	[?]

Place	Lat°	Lat′	Long°	Long′
)][?]				
קליקיט [Cilicia(?)] [?]	קיב [?] יוד [[10[?]	[?]	[8] ח[?]	[?]
קיזנריאה [Caesarea]	נד [54][?] [10] יוד[?]	[?]	לא [31][?] [45] מה[?]	[?]
[?] קרסנינא	לא [31][?] [58] נח[?]	[?]	לא [31][?] [50] נון[?]	[?]
קאשו דאונגרין [Kassa, Hungary (Košice)][?]	מס [?] לו [[36[?]	[?]	מח [48][?] [4] ד[?]	[?]
[Cairo / Kira(?)][?] קיירא	דר [?] נון [[50[?]	[?]	סא [61][?] [50] נון[?]	[?]
קלונרוס דרנ״וס [Constantinople(?)][?]	שג [?] יוד [[10[?]	[26] כו[?]	מג [43][?] דא [?]	[?]
קינסטנטינא [Constantine / Constantina][?]	שג [?] יוד [[10[?]	[55] נה[?]	מג [43][?] ה [5][?]	[?]
קרטיבא [Córdoba / Cordova]	[56] נו[?]	[?]	[8] ח[?]	[?]
[?] קירשיקעי	נון [50][?] שם [?]	[31] לא[?]	[10] יוד[?]	[?]
קאשטטץ [Konstanz(?)][?]	מן [?] מג [[43[?]	[16] יו[?]	[?]	[?]
קאבלענץ [Koblenz] [?]	[?]	[?]	[?]	[?]
קאפינחאגד [Copenhage	[?]	[?]	[?]	[?]

Place	Lat°	Lat′	Long°	Long′
n][?]				
קמניץ פיילי [Kamieniec Podolski(?)] [?]	[?]	[?]	[?]	[?]
קגיר אעגויר [?]	[?]	[?]	[?]	[?]

Parsing notes: the Kuf entries are partly drawn from both column blocks; longitude minutes were almost entirely unreadable and are uniformly `[?]`.

Letter Kuf (ק) — continued / Resh (ר) — p. 66 (left-block):

Place	Lat°	Lat′	Long°	Long′
קיניגשבערג [Königsberg]	[38] לח[?]	[?]	[44] מד[?]	[?]
קופו צינס [?]	[?]	[?]	[?]	[?]
קריכן זוויושנעיג [?]	[?]	[?]	[?]	[?]
קדש ברנע [Kadesh Barnea]	[?]	[?]	[?]	[?]
קיובא [Kiev / Kiova(?)][?]	[?]	[?]	[?]	[?]
קאבלא [Kabul(?) / Kabbalah(?)][?]	[3] ג[?]	[?]	[?] מב [42][?] [40] מ[?]	[?]
קראקא [Kraków — duplicate?] [?]	[12] יב[?]	[?]	[?]	[?]

Letter Resh (ר) — p. 66:

Place	Lat°	Lat′	Long°	Long′
רומי [Rome]	מנ [43][?] ד [4][?]	[?]	מנ [43][?] ד [4][?]	מס [40][?] ד [4][?]
רבינא אטלי [Ravenna, Italy]	מד [44][?] ב [2][?]	[?]	מד [44][?] ב [2][?]	מס [40][?] ז [7][?]
ראסניק [Rasnik / Rožňava(?)] [?]	נא [51][?] לו [36][?]	[?]	נא [51][?] לו [36][?]	יב [12][?] יוד [10][?]
רעביל [Reval / Tallinn(?)] [?]	סא [61][?]	[?]	סא [61][?]	[?]
ריג אויף לנד ו ענגשבורג [Riga(?) … and Regensburg][?]	[?]	[?]	[?]	[?]
רויטן בורג [Rothenburg][?]	[?]	[?]	[?]	[?]
ראב דאונגרי [Raab, Hungary (Győr)][?]	סא [61][?]	[?]	סא [61][?]	מד [40][?]
רעבל [Reval / Tallinn — duplicate?] [?]	[?]	[?]	[?]	[?]
רבת בני עמון [Rabbat Bnei Ammon (Rabbah of the Ammonites	[?]	[?]	[?]	[?]

Place	Lat°	Lat′	Long°	Long′
)]				

Letter Shin (ש) — p. 66 (left-block):

Place	Lat°	Lat′	Long°	Long′
שפייאר [Speyer]	מט [49][?] ד[?] [4]	[?]	דד [?] לו [ ] [36[?]	[?]
שאקטיא [?]	נז[?] [57]	[?]	יוד [?][4] ד [ ] [10[?]	[?]
שטראם בורג [Strasbourg][?]	[?]	[?]	[?]	[?]
שטילנבורג [?]	[?]	[?]	[?]	[?]
שווייץ [Switzerlan d / Schwyz]	[?]	[?]	[?]	[?]
שושן הבירה [Shushan the Capital (Susa)]	[?]	[?]	[?]	[?]
שבא [Sheba]	[?]	[?]	[?]	[?]
שכם [Shechem]	[?]	[?]	[?]	[?]
שילה [Shiloh]	[?]	[?]	[?]	[?]
שווירין [Schwerin] [?]	סו [66][?] ט [9][?]	[?]	[?]	[?]
שאלונקי [Salonika / Thessalonik i][?]	מם [40][?] ג[?] [3]	[?]	מט [49][?] נ[?] [50]	[?]

Parsing notes: Letter Resh shows three populated numeric columns in places (the source right-hand block bleeds in); the gazetteer's nominal five-column structure

is preserved but the Resh-row longitude split is uncertain. The whole gazetteer (siman 88) remains a

Letter Resh/Shin (p. 66, right-block, fragmentary):

Place	Lat°	Lat′	Long°	Long′
רוסי [Russia(?)]	[?]	[?]	[?]	[?]
רכינא אטלי [Ravenna, Italy — see above]	[?]	[?]	[?]	[?]
ראסניק [Rasnik — see above]	[?]	[?]	[?]	[?]
רעביל [Reval(?)]	[?]	[?]	[?]	[?]
לנד אויף דיג	[?]	[?]	[?]	[?]
ענגשבורג [Regensburg(?)]	[?]	[?]	[?]	[?]
בורג רויטן [Rothenburg(?)]	[?]	[?]	[?]	[?]
ראב דאונגרי [Raab, Hungary]	[?]	[?]	[?]	[?]
רעבל [Reval(?)]	[?]	[?]	[?]	[?]
רבת בני עמון [Rabbat Bnei Ammon]	[?]	[?]	[?]	[?]

Place	Lat°	Lat′	Long°	Long′
שפייאר [Speyer][?]	[?]	[?]	[?]	[?]
שאקטיא [?]	[?]	[?]	[?]	[?]
בורג שטראם [Strasbourg (?)][?]	[?]	[?]	[?]	[?]
שטיינבורג [?]	[?]	[?]	[?]	[?]
שווייץ [Switzerland][?]	[?]	[?]	[?]	[?]
שושן הבירה [Shushan the Capital]	[?]	[?]	[?]	[?]
שבא [Sheba]	[?]	[?]	[?]	[?]
שכם [Shechem]	לג [33][?] שער [?]	[?]	[?]	[?]
שילה [Shiloh]	שד [?]	[?]	[?]	[?]
שווירין [Schwerin] [?]	מ [40][?] סב [62][?]	[?]	[?]	[?]
שאלונקי [Salonika] [?]	ך [20][?] סם [?]	[?]	[?]	[?]

Parsing notes: this right-hand block of p. 66 substantially duplicates the left-block Resh/Shin entries (the gazetteer was set in two columns and the scan captures both). Numeric content is nearly all lost to degradation here; entries are listed for completeness and flagged. The gazetteer concludes with the letter Shin. **End of siman 88.**

Siman 89 (סימן פ"ט) — On the Sages' teaching that Jerusalem is the center of the inhabited world

The Earth is spherical, and so by its very nature it has no "up" and no "down," no beginning and no end, no high point and no low point. This is because people

climb up and descend across all its regions and edges, and at every place where a person stands, that spot is — for him — the highest point, its very summit. Nevertheless, as I already explained above (siman 60), once the early and later astronomers had determined the lower boundary of the inhabited world — the shores of the ocean on the west, up to the eastern shore of that same ocean, a span of 180 degrees, which is half the Earth's sphere — they all agreed, ancients and moderns alike, to begin reckoning the degrees and parts of the Earth's surface from the western shore. That, according to the soundest assumption available to us, was the proper and fitting starting point.

To establish a single point that we might call the **center of the world**, or its navel, upon the midpoints: from above the line of the equator — which runs evenly between the two ends of the [celestial] return — at every interval of ninety degrees from the western edge, and when one draws the half-circle line extended from the northern pole forever to the southern pole, that line cuts the straight line and divides it into two equal parts. These two lines just mentioned — namely the equatorial line and the meridian (the noon-line) — intersect at the point [where the two pass], dividing the world's sphere into four equal quarters at the two ends of east and west, and at the two poles of Zion. That point, equidistant [from the four], is the one fit to be called the center of the world — the Earth's navel — and no other; for it is also a place loftier than any land, [yet] there is no other place beyond it. Thus we have grounds here to ask why, as Chazal said of it (*Tanchuma*, Parashat Noach, and elsewhere — see there) and as the Sages explained — in the chapter "Eilu Hen" [*Pesachim*?], in Parashat Kedoshim, and elsewhere — Jerusalem is called the navel of the Earth and the center of the world.

It has been made known to us, by demonstration and even by the senses, that Jerusalem sits at latitude 66 degrees of [longitude in] the inhabited world, and at latitude 32 degrees — as we noted above. Even the schoolchildren who know a little of the beginnings of the science of astronomy and surveying can measure its distance from the equator with the very same instrument explained earlier in this Section. And so Chazal — those filled with wisdom and knowledge, who knew every matter better than we, more than a thousandfold — had a reason and a basis for this teaching: ✻ on what grounds they set Jerusalem as the center of the world.

[Note:] To resolve this perplexity — a matter that has greatly troubled many — others besides [me] have also written at length on its themes; and what emerges from the resolution of this doubt has already been treated at length above. As we

explained above, since most of the world's inhabitants dwell in the fourth quarter of the sphere, on the northern side, and since the ancients already divided the inhabited world into seven climes (as above, siman 67) — behold, the issuing-point of the city of Jerusalem, per Chazal, is that it lies in [the middle of] the climes; and it always sits midway between the two extremes — a known mean between cold and heat. Therefore it is more temperate than the rest…

[continues siman 89]

The temperate quality of body and mind — for the [extreme] cold on the one side and the heat on the other affect human beings and their temperaments. I have found in the words [of the sages] that nothing is wanting in the Land of Israel — there is nothing one cannot find there (as is well known); for the Land of Israel is the most temperate of the seven climes. And concerning this, [the authority cited — ה"ע … ה"ד, *alav ha-shalom*; identity unrecovered][?] said, in the sense of "[the Land of Israel is set] in the middle" — as Chazal said, comparing it to the navel — meaning that Jerusalem is at the center, the middle of the world, the temperate point of the inhabited world.

Know that their intent was to reckon it the navel — for they likened the man to it (as they said in *Tanchuma*, Parashat Kedoshim) — that the navel was given [at the center], and behold the Land of Israel is set at the center of the world, the navel. And just as the man's navel is not [literally] at the geometric center of his length — for Chazal likened it to a man, whose navel is not at his center, since he is not [positioned] at his middle — so too Jerusalem is not at the [exact] center of the inhabited world. For the term "world" (עולם), which the [verse] uses, indicates something without limit, as in "from everlasting to everlasting" (מן העולם ועד העולם) [Tehillim 41:14]; and there is a "world" [meaning] eternity, as in "forever and ever" (לעולם ועד). Likewise the Torah [uses "olam"] for a fixed span, as in "he shall serve him forever (לעולם)" [Shemos 21:6]. And as the author of the *Ikkarim* writes at length (Book IV, chapter 3) — thus you may say, third, that the words of Chazal [bear] this sense: "olam" sometimes denotes the inhabited world, and sometimes the whole world in its entirety — as in "By ten utterances the world was created" — and sometimes one part of the world, as in "and one came and told [Abraham]" and "and sustained the whole world"; "the whole world came to ruin," "a wild beast came into the world" — denoting [merely] a single province or district. So too here in Chazal's saying "Jerusalem is at the center of the world" — meaning at the center of the inhabited world, as above.

Siman 90 (סימן צ) — On the saying of Chazal that [the Land of Israel] is higher than all lands

There is also reason to wonder at what is written: the saying of Chazal in the chapter "Asarah Yuchasin" [*Kiddushin*, ch. 4, "Asarah Yuchasin"], on the verse (Ezra 7:9[?]) "and from there they went up, and they came [to Jerusalem]," [derives] that the Land of Israel is higher than all lands, and that Jerusalem is higher than all the Land of Israel — from which it is proved that [the Land of] Israel is higher than every land. This view, from the very outset of inspection, [is difficult] on several grounds.

First: it cannot reasonably mean "high" in [the sense of altitude on] the sphere — for every person, at whatever place he sits, that is his high point (as explained nearby).

Second: even if [we follow] the way of the natural philosophers entirely, who say that every place inclining from the equator toward the northern pole [rises] — proportionally, for those who move farther from it; because the person moving away from the equatorial line toward the north, [the celestial] northern axis rises above his horizon (as above, in siman 48). This is as the wise Ibn Ezra (ראב״ע) wrote on the verse "And Judah went down from his brothers" [Bereishis 38:1] — and his words are: "He who comes from the north of the world goes down to its south" — and the natural philosophers will understand this. According to this you might say: since Jerusalem is far from the equatorial line, the northern axis would [be called] "height"[?]. But this too cannot be — for behold, beyond the fourth clime there are found three more climes, which are still closer to the northern axis.

[Note:] It appears that Chazal did not intend that there are no mountains higher [than those of the Land of Israel], nor [physical] lands higher than the Land of Israel and Jerusalem. Rather, the meaning is: the Land of Israel and Jerusalem are higher in rank and more elevated than all other lands — and a thing eminent in the eyes of its possessor[?], it is the manner of Scripture to call it "high," and the lowly and base [it calls] "going down," as in the matter of "And he did not go up — Dathan and Abiram" (Bamidbar 16:12) … and as in "I went down (and came) into the heart of the seas" [where] it is a descent that is upon him; and likewise we find "going up" — "going up the mountains" — in [the book of] Judges …

[continues siman 90:]

"And they brought him up (ויעלו) to the king of Babylon" — concerning Zedekiah — and we already knew that Babylon is a land [of] depth and lowland, as it is said in [Parashat] Noach: "and they found a valley [in the land of Shinar]" (Bereishis 11:2) — yet Scripture [says] "they went up," for the greatness of Babylon, which was there. Likewise in Joshua [chapter] 7, Scripture says "and they brought him up to the Valley of Achor" — for the sake of greatness and honor; and [concerning] Israel, who were there in the valley, Chazal said "high" — meaning eminent in rank and honor more than all lands.

Siman 91 (סימן צ"א) — The reason the later [astronomers] attained what the early ones received at the beginning: the 360 degrees of the Earth's sphere

We explained above (siman 60) that the later astronomers, who attained and transmitted [this knowledge] through the science of surveying, were the ones who reached the boundary that the early ones had [merely] set down and reckoned — by reasoning alone, [drawing] line A [to] B and [setting] their [points] — as a distance of some ten degrees farther toward the west, which they agreed to fix as the head and starting point for counting the 360 degrees of the Earth's sphere.

The reason for this is so that you may know that two kinds of axes are found on the Earth's sphere on the northern side. The first is called the **world's axis** — that is the axis we spoke of, [used] for our [astronomical] work above. The second, the newer one, is called the **magnet axis** (ציר מאגנע״ה) [Magnet / lodestone axis], after the lodestone (האבן המושך). And one will not find, across the whole surface of any sheet of iron[?] or the line drawn by it, [that] the Earth [turns] upon the two axes, except for the line just mentioned alone. Before we come to explain this matter, I will disclose to the reader's ear a brief and modest remark — from which you will understand the reason for attaining that boundary.

Know that close to three hundred years ago, the surveyors discovered — for the need and benefit of the sailors and seamen who cross the seas, and for the benefit of others — [a means of] indicating the [direction] of one place from another, by means of the power of the lodestone (אבן מאגנע״טא) [Magnet / lodestone]. They make of it this instrument, [making] it short [of measure / span], with a [?]; and [I have] designated and noted [it] from the …[?] — its length and its breadth … one. There is no room here within its roof [to treat it]; only in a brief and modest remark will I speak of it. **✻ This figure belongs to siman 87, folio 30, page 2 (verso), in Section Three.**

Diagram. A square frame enclosing a circular wind-rose / compass-card, drawn with radiating spokes (rhumb lines) from a central hub out to the rim, in the manner of a mariner's compass-rose. The square's four sides and corners are labeled with the eight principal directions; an inner caption at the top of the figure repeats the direction labels. The accompanying note states the figure properly belongs to siman 87 (פ"ז), folio 30 verso, in Section Three.

- Top edge (above the square): מזרחית אמצע מערבית / צפונית · המזרח · צפונית — [northeast · mid · northwest / north(ern) · the East · north(ern)] — i.e. the upper-band direction labels [?]
- Top-inner caption: מזרחית · אמצע · מערבית / דרומית · המזרח[?] · צפונית — [southeast · middle · northwest …][?]
- Left edge (reading bottom-to-top): four labels — directional names along the western side [partly illegible][?]
- Right edge (reading bottom-to-top): four labels — directional names along the eastern side [partly illegible][?]
- Bottom edge: מערבית · אמצע · מערבית / דרומית · המערב[?] · צפונית — [southwest · middle · … / the West …][?]
- Center: open hub (circle) from which the rhumb-lines radiate

Section Four (השער הרביעי) — p. 68

[Header to Section Four:] In it will be explained the matters of time-divisions — namely years, months, weeks, days, and hours — what their nature is, and from where it became known to us how long they are; on what secret basis they were established; why the seven days of the week were instituted and the reckoning of the hours[?]; the straight and the retrograde [motions]; and other matters besides. The days are precisely 24 hours, and the reason for the days of the week and the reckoning of the seven [planetary] hours, the straight and retrograde [motions], and their bases — and other related matters.

Siman 92 (סימן צ"ב) — A general account of the time-units — there are five, to be explained; the duration of the year and of the month

Know that the time-units that serve the human race — by which mankind reckons — are five, namely: years, months, weeks, days, and hours. [I shall explain] the reasons for these time-units: how long the year is, and so forth, and how long the month is, and so on for the rest of the units, as I will [explain]. As for the [units] of years, months, and days — know that three of them are bounded by the heavenly spheres in their revolution; for the [reasons] are not [fully]

known to us, nor can all of them be perceived by sense — yet [each] one is known by the revolution of the spheres, as will be explained nearby. But the units of weeks and hours — their reason and basis require much inspection and astronomical [reasoning]. At the outset we shall explain the three units just mentioned, which the revolution of the spheres bounds; and afterward we shall explain the other two — weeks and hours — God willing. Now to the explanation of the units of the year and the months.

The year is the time during which the sun revolves beneath the sphere of the constellations (the zodiac), from one edge to the [same] edge — that is, from the moment the sun begins to revolve from a known point until it begins again to revolve from that very same point. This is called a "year." And although it will be explained that the year [reckoning] is of the eighth sphere ... [and] though all the spheres are equal, the revolution-time of each sphere is its [own] "year." And were it the case that our intent rested on the revolution of each sphere — and as the Land of Israel's "year"[?] is what is visible to the eyes — we would call the revolution-time of that sphere a "year," and so for each sphere. But since the revolution[?] renews and completes itself within the sphere — within those twelve or thirteen times[?] — we would have to say "within the year of the Land of Israel one sphere [completes] thirty times, the fifth sphere [returns]," and so for sphere so-and-so thus, and sphere so-and-so thus. Nevertheless, our holy Torah has already agreed to fix [the reckoning], and to reckon the great and long time-spans by the revolution of the eighth sphere alone; and to it belongs the ruling of [the law of] the firstborn. So too [we agreed] to reckon the [solar] sun's [revolution] by itself, and not by any other star besides it. And to this all have agreed, the ancients and the moderns: that from the time of its departure from a known point of the zodiac-sphere until it returns a second time to that very same point — that is called a "year." (Its time is 365 days and close to a quarter [of a day], as will be explained further on, at the head of the seventh [section], in siman 158.) And it is for us [the means] to reckon by the sun the units of all the other spheres and all other times. The long [time-spans] which [the spheres take] are reckoned[?]; we found it more correct for us [not] to [reckon] by them, on account of the revolution-times of the spheres, [but rather] by the world's sun — the solar year, [governing] day and night, the lengths of days and nights, the seasons of summer and winter and the temperate seasons, the times of the harvest of fruits in their ingathering, and other times and seasons that arise from the combination of day and night [in their] revolution.

Siman 93 (סימן צ"ג) — That the sun has no [proper] "month" at all, and the moon has no [proper] "year" at all

We are still [treating] matters of the solar year and the lunar month. Before I came here to my exposition of the three time-units — months, days, and hours — [I note] that in this place there is no need to explain — for the moon has no "year," and the sun no "month" — yet it is of use and benefit to the students [to clarify it].

Know that "renewal" (חידוש) applies specifically to the moon — as was explained — and therefore this [unit] is called *chodesh* ("month"), from the language of *chidush* ("renewal"), and it is not [applicable] except to the moon, which renews itself, as Rashi wrote (in *Rosh Hashanah* [ר"ה], folio 21, column [?]), and likewise the wise Ibn Ezra wrote in [Parashat] HaChodesh, and these are his words: "It does not renew in its name except [because] it is the moon that renews to give light, and after the moon passes this is called *chodesh*, for it is not so [with the sun], which does not renew." And although you might find in the course of the sun four varying motions, as will be explained further on (siman 181), there is found in it at the [appointed] time no sign or impression at all [of renewal] in its revolution from the time of its departure from a known point until it returns to that same point a second time — that is its "year." And the wise Ibn Ezra wrote [that] this is not called *chodesh*. And others besides him [held] that, because [the moon renews], it is called a "year" — and its explanation [relates to] "they repeated and learned" (a second [time]) — a usage from [the book of] Kings (Melachim)[exact verse ?] ... as will be explained.

Siman 94 (סימן צ"ד) [continued] — That one says "solar months"

And as for what is written — that one says "solar months" — the wise R. David Abudarham wrote that this is by way of borrowing, the expression being borrowed from the motion of the moon. Even though the sun has no "renewal" at all, nonetheless they called one part of twelve [parts of the year] a "month." And the wise Ibn Ezra wrote in [Parashat] HaChodesh that, because the moon renews itself twelve times in every year, they divided the year into twelve parts and called each [part] a "month," which is close to the days of the lunar month, since [the sun] passes [through it]. For the reason that there are in the solar year these [twelve] parts in actuality — for [the moon's] renewing [occurs] in each constellation [as] one part — the parts [number] one-twelfth ...

Section Four (continued)

[continuation of siman 94]

and the Torah likewise marks the years for days, as the verse in Bereishit ("Let them be for signs and for seasons, for days and years") and the whole Torah testify, for everywhere we find [the year reckoned] without [reference to the lunar month]. ✻ A fourth point: the head [of the year/month] is the spring [tekufah], for the ripening (*aviv*) does not depend on the [lunar] month alone — rather, regarding the matter of *chodesh* (renewal), I mean that the spring "renews." Scripture commands [the observance], and it seems to me [נ"ל] that *aviv* specifically [is what is meant], as in "you shall keep [the month of the *aviv*] and you shall perform [the Pesach]"; and then the spring will be from it [?].

The principle is this: the [lunar] month does not begin to renew at its own genuine renewal point, but rather a [solar] "month" is said to renew when the sun returns in its orbital course to the point from which it departed — that is, until the sun completes [the passage through] one full constellation [one-twelfth of its sphere], as will be explained below [§204], a period of some [?]. And even though this revolution is also called a "month" by way of borrowed usage, in the sense that the moon, in its course, [makes such a circuit], it is not [the same thing], as will be explained below — [these are] differing motions. So when you wish to give it [its proper] name as you ought, you will find that one of them, by the sun's course, is a [solar] "month," and the moon's course in [one such span] is what people call a "lunar year" [?]. The two cannot be reconciled [as identical] — I mean, "the months of the year" in their literal sense.

Let the reason already mentioned suffice for us. As for the question of why every renewal-point at which the moon stands before [the sun], all twelve [?] — this too [touches on] the fact that for the most part the moon's renewal-year [returns] to renew within that same constellation; the "month" [is reckoned] by the moon's course [?]. Therefore [the Sages] called the twelve lunar "months" of the year, since each renews from that [point] in the very portion of the constellation in which it had already renewed in the year that passed [?]; thus wrote the sage Rabbeinu Avraham ibn Ezra, ז"ל [Ibn Ezra], in the [section] cited above. Now let us return to clarify the time-units mentioned in the places noted [above].

Siman [95] צה — On the time-units, which are natural [units of time]

Know that these [time-units] are natural [טבעיים] — namely, the *day* [יום]. ✻

The "day" [in this sense] is the whole [span of] daylight together with the night [combined] — I mean the [civil] day; but the daylight that precedes [the night] is called "day" [in the narrower sense], as will be clarified shortly below.

These are not "days" by the revolution of the moon's sphere alone [?]; rather, the units of the days [are bounded] by the motions of the diurnal sphere [גלגל היומי], of which you have heard, [the sphere] that bounds them. The sun begins to revolve the globe of the world [around], and that motion [proceeds] until [the sun] returns to the place from which it began — this span of time is called a *natural day* [יום טבעי]. The beginning of the [astronomical] day is reckoned from a certain [point], the four *regaim* clarified above in §[105 ,קק"ה]. Thus, from the moment of [the sun's] rising [exit] until it returns to it a second time [is a full natural day]; and by the reckoning of the Sages this is a "natural day."

And it [the diurnal sphere] turns somewhat more [than 360°], as will be explained — [the diurnal sphere overshoots] a little, as will [be shown]. ✻ The proper [account] is given to you below at the end of this Section [שער], in the [relevant] siman.

These time-units — *years, months, days* — are bounded in their revolution by [the spheres]. ✻ Therefore, just as it is not in the power of a human being to lengthen or shorten the courses of the spheres [in any] way — there is no "mouth to open" here, no aspect, no place upon which the mind might rise [conceive] to lengthen or shorten the time of any one of them — so too one may not ask why the measure of the year's duration is thus, and the measure of the month thus, and the days of the week thus, nor [ask] for the reason behind the renewals [?] — just so [one may not ask] the reason for [these matters].

Know that in the matter of [why] the week [has its measure] and the reasons [behind it] [?], there is great perplexity for us continually, and it is a great question: why and what is the reason that specifically *seven* were fixed for the days of the week, and seven for the number of days, and twenty-four for the hours of the day? For we have an opening to argue that it would have been possible to fix the hours of the day at more or fewer than twenty-four — more and less. ✻ By this [same reasoning] we would have had an opening to fix the days of the week at five or six [?].

Here it would seem more fitting that the number [of days in the week] be one divisible into a half, a third, and a quarter; and that this number [six] be one that divides into a half and into a third. ✻ Moreover [there is] a number that [is even better]: already the Sages exalted [the number six] and called it a *perfect number*

[מספר שלום — "number of completeness"], because a wondrous property [סגולה] is found in it. And this is that all the divisors of the number [six] itself add up to the number itself: its half [3], its third [2], and its sixth [1] — three and two and one [= 6]. The remainder [of numbers] are not so; for among the [other] units only six [has this property]; you will not find a "perfect number" [again] among the tens until [you reach] 28; and among the hundreds, 496; and in the thousands, 8128 — and there are no others besides these. We have already expanded somewhat on the clarification of this at the head of our book [our *Sefer*, see § (ד ד"מ ז) (4:47:4?) [?]].

But the number *seven* does not tolerate any division at all. And without doubt, the fixing of the natural day [at twenty-four hours] and the [fixing of] the week's days at seven days — in [the view of] all our Sages — is not without sound reason. And what I have found of good [explanation] in this matter, hear it now [שמע נא] and incline your ear to me; and we will first explain the times of the [planetary] motions and their reasons [?], and through this [explain] also the reason for the seven days of the week.

Siman [96] צו — On the time-units of the hours of the day, and what their nature is

Know that the time-units and the numbers of the hours, which together total twenty-four hours of the day [the natural day], are a *fourth* time-unit [זמני], additional to the three time-units mentioned [years, months, days]; and the memory [mention] of this [fourth unit] we do not find anywhere in Scripture. Nor can it be attributed to the motions of any sphere, as [can] the three principal time-units mentioned. Know, then, that the *hours* are *conventional* time-units [זמנים הסכמיות — agreed-upon] and are not distinct [natural] time-units; they are merely subdivisions of the days, which it was within the authority of the Sages to divide as they saw fit, into parts many or few — more or less than twenty-four.

They chose, however, to divide [the day] into twenty-four parts, for a reason that will be explained shortly, and they called each part an "hour" [שעה]. It is not that the sphere bounds the time-units of the hours, as it does the other three time-units mentioned [years, months, days]; rather, the Sages made their [own] arrangement [הפוכו — devised their convention] of it: since they had already chosen to divide the natural day into twenty-four parts, they fixed this scheme and supported it upon the motions of the equator-sphere [גלגל המישר], by the diurnal motion.

How [did they do this]? They divided the 360 degrees of [the equator,] the "sphere of number" [גלגל המספר], into twenty-four parts equal to the number of hours they had already chosen, and obtained for each hour fifteen degrees — such that, with each and every hour, the equator-sphere revolves [past] the horizon, or past the line of midday [the meridian], some fifteen degrees, approximately. We said "approximately" because the diurnal sphere revolves, each and every day, [through] more than a complete circuit [360°] by close to one part out of the 360 parts of the sphere, as [shown] above in §[106 ,ק"ו]. The Sages supported the time-units of the hours specifically upon the revolution of the *equator* [גלגל המישור], because it always revolves at an equal measure, its length and breadth being uniform [?] — unlike the sphere of the zodiac, where sometimes it revolves [past] some twenty-some degrees in an hour, and sometimes eleven degrees, as will be explained below; and you should know

[that] the equator [המישור] [revolves] fifteen degrees per hour of the hours of [the day]. ✻ After the [discussion of] the *equal hours* [שעות הישרות], there remains [the matter of] their law [judgment]; and as for the *seasonal hours* [/ שעות העותות זמניות], their reckoning [will be given] below for you, [and] you also have a law concerning them, as will be explained in §[101 ,ק"א].

The astronomers agreed to divide each and every hour into sixty parts [חלקים]; these are called the *minutes* [דקים / דקי] of the hour, or "seconds" [שניים? — see note]. And each minute [is divided] into sixty *thirds* [שלישים], and likewise [the thirds] into *fourths* [רביעים], and so on down to *sixths* [?] — sixty by sixty — down to the sixth [order] and on to the *tenth* [?] [order]. [See note on the rendering of דקים/שניים.]

Siman [97] צז — The reason why the parts of the natural day were [made] twenty-four parts [hours]

Why did the Sages divide the measure of the natural day into twenty-four hours? Here is the plain reason: this number [twenty-four] has [the property] that you can [divide] it into a half, a third, a quarter, a sixth, an eighth, and a twelfth [?] — which is not so with the small numbers. But know that I have found yet another reason, fine and sweet to the palate; and this is [a matter] that among the Sages — the ancient [scholars] from of old, [going back] to ancient times and bygone years — was an established premise and a tested matter: that the seven planets [כוכבי לכת] (as we mentioned above) each rule, one filling [the place of] another, [serving] one after another, and exchanging in such a manner [that] I have heard [it said] [?] — each [taking] its [own] part [חלק].

In this way they [the planets] exchange their dominion [ממשלתם], one after another, throughout each natural day of twenty-four hours, in such a way that [the Sages] found the signs of the heads [first hours] of the nights of the seven days of the week [in the order] (כצנ"ש חל"ם), and the signs of the heads of the [days] (חל"ם כצנ"ש), as will be explained shortly. And in [the order] עד"ו [?] the night [keeps] returning [in this pattern] from world to world [forever]. All of which cannot be made to work out, and it is impossible to align their reckoning, unless one divides the natural day into twenty-four parts.

Siman [98] צח — The reason for the seven days of the week — days

And likewise, from this very reason, God [האל] fixed for us in our holy Torah the measure of the week's days [as] seven days: six days for labor and the seventh day [for] rest [שבתון], because within this span of seven days [there are] 168 hours, [during] which the seven planets [שבע כוכבי לכת] keep cycling [in dominion], each [returning] to the place of its dominion that it held at the start [?]. For seven times seven [?] amounts to 168, and they keep cycling [in the order] כצנ"שחל"ם [for the] night, [reckoning] to the heads of the nights; and [the order] חל"ם כצנ"ש to the heads of the days, for all the days of the world.

The ancients gave a mnemonic-sign [סימן] for this: אם לזה — meaning [פי']: by [the order] כינ"ב the night, [and by] חמ"ה the day [?]. That is to say, the first hour of the first night, beginning from Saturday night [מליל מוצאי שבת — the night following Shabbat], is hour אחד [?], [when] the sun's dominion [ממשלת חמה] begins; and this is [the meaning of] ח"י [?] — "the sun [rules the] day." And in this manner [the planets] keep cycling [forever] for all the days of the world.

And although we are not obliged to know the reasons of the men of inquiry [philosophers] [for matters set down] in the words of our holy Torah — yet, [regarding] what I found written in the *Sefer Mekor Chaim*, at the head of [the comment on] Parashat Bereishit, in the name of the sage Ibn Ezra [ע"ש ראב"ע], ז"ל, [I cite it]: "Know that Moshe, ע"ה, did not give the Torah to the men of inquiry [scholars] alone, but to every generation forever. And we lean upon the words of Moshe — that he is a faithful messenger [שליח], who gave many signs and wonders — and we [need] not reach [for more], nor add nor subtract; only, *if* we find the words of the men of inquiry [to be such] that they bring proofs and a basis [for them], we rejoice in them" — thus far his words [עכ"ל]. How many [matters] are resolved [נחלצו] by the words of this sage, ז"ל.

And from this same reason mentioned [above], all the nations of the lands under the whole heaven — even though they have no portion in our holy Torah — had

it within their authority [reason?] to fix the six working days of the week, [the week being a span] short [?] and complete, as above; and according to [their reckoning] it appeared [fitting] that the measure should be equal [?]. In any case, they too chose to count by the [planetary] reckoning that will be explained, and from this reason — even though the number of seven days [שבעה ימי השבוע] tolerates no division — yet, since [in] the natural matter of the seven planets [the dominion] cycles in [the span of] each and every week [returning] from world to world forever, as above [they chose seven].

Siman [99] צט — A table of the dominion of the seven planets [כוכבי לכת] over each hour of all the days of the week

To satisfy the desire of the youths [students] — and because I saw fit to set before you a small table [לוח קטן], which I know [will be useful] to students who lack [the ability for] study and reckoning — [here is] the whole rule of the dominion of each planet over each and every hour of all the days of the week; and just as they conduct themselves [the planets behave] in this week, so they conduct themselves in the coming week, cycling [forever] for all the days of the world. This too is a great matter and benefit, for through it many statements from the words of Chazal [רז"ל] are clarified, and also some of the reasons for the mitzvot in the Torah.

See the commentary of the sage Ibn Ezra [ראב"ע] on [the verse] "Remember [זכור] [the Sabbath day to keep it holy]," and on the [matter of] keeping the Sabbath day holy; also in the *Sefer Mekor Chaim* on the verse "In righteousness shall you judge your fellow" [Vayikra 19:15] — and there is no room here to expand. (See also the *Hilchot* [of the] *Sefer HaMaor HaKatan* [our smaller work] [?].)

And know that in these matters — I mean, in the reckoning of the [planetary] hours of the seven planets — the nations [other peoples] already made use of [them] from days of old and ancient years, especially the German people [the Germans, באשכנזים]. The proof [is this]: that the days of the week are named, in Germany [באשכנז], after the seven planets, each one according to the [name of the] planet that rules in [its] first hour. How so?

- The first day [Sunday], in which the sun-planet [כוכב חמה] rules the first hour, is called *Sonntag* (זונטא"ג) — meaning ['פי] "sun-day."
- The second day is called *Montag* (מאנטא"ג) — meaning "moon-day."
- The third day, Tuesday ['יום ג], is called *Dienstag* (דינשט"אג) — meaning "day of labor/service" [?]; on the third day [people] used to worship the planet

that the gentiles [נכרים] called [the god of war?]. [The fourth day was] not named for the [deity] of a planet [?].

- The fourth day [Wednesday] is called only *Mittwoch* (מיטוו"אך) — meaning "the middle of the week."
- The fifth day [Thursday] is called *Donnerstag* (דונרשט"אג) — meaning "day of thunders," because the matter [the planet] that rules at the beginning of the fifth day is the planet Tzedek [Jupiter], which rules over thunder and lightning.
- The sixth day [Friday] is called *Freitag* (פרייטאג) — meaning the "day [for] marriages [?]," because the planet Nogah [Venus] rules over love and joy and weddings.
- As for the Sabbath day [שבת], it is called *Samstag* / *Sonnabend* — *Sonnabend* (זונאבנ"ט) meaning "sun-evening" [Saturday eve]; and in many places, especially in [certain] countries, they call it *Saturday* — *Saterdag* / *Saturnstag* (סארטנ"ש טאג) meaning "the day [of Saturn]," because the Sabbath [is associated with] *Shabtai* [Saturn], named after Saturn [סטיר"נא — Latin/Greek "Saturnus"] [?].

Siman [100] ק — That the dominion of each planet [extends] over [more than] one hour [?]

[heading reads: שז ק — apparently a compositor misprint for סימן ק; see anomaly note]

of the [seven] perplexed [wandering] planets [מכוכבי הנבוכה — the "wandering stars"], that [a planet] does not rule the first hour of the day [as] master of [only one] hour — a complete day [?] [is involved].

Know that in the reckoning of the dominion of the planets, at the very outset of one's observation, [people] have great perplexity, because [they suppose] that the planets' dominion is equal for all the inhabitants of the world — that when the sun rises above the horizon for [observers] eastward [?], at the eastern edge [where the sun first returns], the first hour, in which the sun-planet [כוכב חמה] rules, [is the same for all]. On that same day [?], that very time, hour, and *rega* which is "first" for them [the easterners] is the very beginning of the night [for those] toward the western edge [farther west]. Great [perplexity]…

[continuation of siman 100]

and great [is this perplexity], and we will [resolve] it shortly, [with God's help], as [I found written] in §[204 ,ר"ד] [?]. Accordingly, we must know on what place

[meridian] [the reckoning of] the [first] hour [stands] [?]. And it would be necessary for every person to know the precise [planetary] hour [?]. ✻

Now [as to] in which hour the sun's [dominion] is, you should know this thing that I have set before you, for so wrote the famous astronomer *Johannes Kepler* (יוהנ"ס קעפלירו"ס) [Johannes Kepler], and he replied to me [in correspondence] [?] — that in this reckoning [of planetary hours] we need not know on what place [meridian one stands]. ✻

And this is what the early astronomers said [?]: that the reckoning of the planetary dominion — I mean, that the sun-planet rules from the *first hour of the day* — does not [mean] that it rules on the first hour of [one fixed] day only [for one place]; rather, on each and every day its [the sun's] dominion is [reckoned] from its rising [?], and over its [the sun's circuit] [?] — not at one place only. For according to the manner of its [the sun's] circuit around the globe of the world, so [proceeds] the [reckoning of its] dominion: for in every place where it [the sun] rises above the horizon, there it rules one hour over [that place]; and through all the twenty-four hours that revolve [around], it revolves the whole globe of the world.

By this [understanding]: when the sun rises for the inhabitants of [a place at] the eastern edge [who are] the first [to see it], it rules over them for one hour from its rising; and when the sun moves on from there — say, by one degree or even by one hour [of arc] — at its rising for the people of that [next] place [farther west], its dominion [there] begins from the moment of its rising [for them], one hour onward [?]; and so [proceeds] its judgment [reckoning] for that whole day. And just as the law [holds] for the sun [חמה], so the [same] law [holds] for the moon [לבנה], which is assigned to the second day; and so for [each], such that each one [planet] rules twenty-four hours [worth] for [successive] inhabitants, one place after another, until it encircles the whole globe of the world.

And from the totality of these matters it becomes known to you that the dominions of the planets are *not* simultaneous [שוים — equal/together] for inhabitants [of different places]. ✻ For [inhabitants] who *share* the same [degree of] longitude [in their length] — I mean, those who dwell upon a single line drawn out from the [meridian, running] from north [to south], all of whom share one and the same [span constituting the] edge of the day's line — [for those] the [reckoning] differs [?]. And even people who *share* the [same] longitude, if they are distant [in latitude] [?], the dominion of the planets is likewise not simultaneous for them — and this is [a matter touching on] the precedence of the sun's rising toward the north over [?] the [southern observers], as in §[155 ,קנ"ה].

The perplexity is also great and profound: at which place of the world does each day begin to be called by its name? — [a matter treated] at the end of [the discussion], [in] §[111 ,קי"א] [in] the sixth Section [שער הששי]; this too is connected to the reckoning [of planetary dominion].

Siman [101] קא — [That] the dominion of a planet stands in its place [?]

[heading rubric: a fragmentary marginal/inset title; see anomaly note — "the conjecture / and the [matter] of the planet's natural day" [?]]

The second [matter] — [the *equal hours*] — needs no [further] clarification, for [we have] already [established] this: that the Sages took the measure of the natural day, in which the equator-circle [מעגול הישר] revolves and rises above the horizon, or [passes] beneath the [meridian-]line of midday, [some] fifteen degrees [per hour] [?]. And our reckoning [of dominion] [holds]: that for every fifteen degrees that revolve, the equator-circle [governs one hour] [?]. And in this manner [reckoning] each hour, [there results] one hour, [and so] the measure [of hours]; and by this reckoning [the hours are] always equal in every place and every time. And by this reckoning, [the result is the same] in every land and every time — all equal.

But sometimes it will be found, in the [actual] motion of the sun [בשלוח השמש?], that there will be a surplus for us [in] the numbers of the hours of the daylight over the numbers of the hours of the night, and sometimes [the reverse]: [throughout] the daylight, all the numbers of [the daylight's] hours exceed [those of the night] in the days of summer, when the daylight is longer than the night; [and the reverse holds in winter] [?] — as will be clarified [in the simanim on] the laws of the [time-]matters below, as will be explained [in] §[142 ,קמ"ב] and §[143 ,קמ"ג].

As for the reckoning of the *seasonal hours* [שעות העותות], there is another law and judgment for them, as will be explained shortly. And you should know that the astronomers reckon the beginning [of the day], [reckoning] the count from midday: from midday [of one day] to midday — always thirteen hours [?]; [no —] and likewise from midnight to midnight — twelve hours [?]; [these] daylight [hours], [reckoned] in this manner [?]. Upon this reckoning [of equal hours] the [people of?] *Ashkenaz* [Germany], who set up for themselves clocks [striking-clocks] that indicate the hours by chimes [בפעמונים] and proclaim the hours [aloud] — [they reckon] from midday [of] the day to midnight, twelve hours; and likewise from midnight to midday, twelve hours.

So too [reckon] those who compute the [Jewish calendar] intercalation [מחשבי העיבור]. And the inhabitants of *Rhinus* [רינו"ס — the Rhineland?] are obliged to set up [their reckoning] by the *equal hours* — [reckoning] the head of the count of the days [and] the beginning of the night, as will be explained. Also [there is] a difference between [reckoning] twelve hours by day and twelve [hours] by night [equally] in all the [seasons] of the year; [yet] always [for] all the computers [of the calendar], they reckon in this manner [עד"ו].

These [equal-hour computers] always begin their reckoning [of the day]: every [day] they reckon [its] start six hours after midday, and the beginning of the day[light] [?] six hours after midnight, in all the seasons of the year — winter and summer, heat and cold — whether [the daylight] comes early or late, whether [it be] day or twilight [נשף]. [As to] the time-units mentioned [of] the night, we have already given the clarification in our books [our *Sefarim*], in [the work] *Magen David* [?] [— the *Sefer HaMaor HaKatan*]; and there we clarified the great difference there is in this reckoning between the inhabitants of *Rhinus* [Rhineland] and the inhabitants of *Pihem* [פיה"ם — Bohemia], as you will see there.

Siman [102] קב — The reckonings [computations] of the *seasonal hours* [שעות העותות], which are called *zemaniyot* [time-relative], which are always twelve in the daylight measure and twelve in the night-twilight [span] [?]

In the reckoning of the *seasonal hours* [שעות העותות], it is so that, in every place and every time, the measure of the daylight [span] — which is the span of time the sun stands above the earth — is reckoned and divided into twelve parts; and likewise the night, which is the span of time the sun stands beneath the earth, is [divided] into twelve parts — whether it be a long day or a short night, or a short day or a long night.

For example: in the [summer] solstice [תקופת תמוז], for us, the inhabitants of the city of *Prague* [פראג], the equator-circle [עגול הישר] revolves and rises above our horizon [some] 225 degrees, which are fifteen *equal hours* [שעות ישרות], at the reckoning of fifteen degrees per hour, as above. But when the [daylight] measure of the day mentioned is reckoned into twelve parts, the 225 degrees must be divided into twelve parts, so that the hours will be long *seasonal hours* [arichut va'avotot]; for to each and every hour there will come twenty degrees [225 ÷ 12 ≈ 18¾ — see numerical note], which are one hour and a third of the equal hours. So too [in reverse] at the winter solstice [תקופת טבת], whose measure for us is eight

hours by [equal-hour] reckoning — that is, [the daylight] hours in parts [?] [is divided] into twelve hours [seasonal], and the hour will be a short [seasonal] hour, for to each [seasonal hour] there will rise only [some] two-thirds of an equal hour [of the equal hours].

Thus we find, accordingly, that just as the measure of the daylight at the summer solstice [תקופת תמוז] is double the measure of the daylight at the winter solstice [תקופת טבת], so too the measure of the daylight hours at the summer solstice is double their measure [at the winter solstice]; for the [twenty-four] hours of the [whole] solstice-day [the natural day], reckoned into twelve, [yield no remainder] [?]. By the reckoning of the *seasonal hours* you need to divide the measure of each day [into twelve], and likewise the measure of each night, each of them into twelve parts, all equal among themselves [within that day], [though] the [seasonal] hours [vary day to day].

And although this reckoning of these *seasonal hours* is foreign [strange] to the [eyes of] students [?], yet know that the [whole] reckoning is agreed upon by [the Sages], and you should know [further] [?] that the [later] Sages — the ancients and the later ones, whether of the children of Israel or of any [other] people [— concur]. Whether [in reckoning] the counting of the *Omer* or in the rest of the [matters] [?] — all of them concurred [on this reckoning of seasonal hours].

[continuation of siman 102]

[on] the reckoning of the *seasonal hours*, as will be explained further in [the relevant] siman below.

And you should know what we have already clarified above and below: that all those who dwell on the equator [the equinoctial line] have, always, the measure of the day and the night equal — twelve hours each. Therefore, for those people [equatorial dwellers] there is no difference whatsoever between the *equal hours* and the *seasonal hours*. But the people who dwell off [the equator], inclining [toward the poles], [for them] the measure is not [always] equal; [yet] they too have *seasonal hours*. And you should also know that for each and every [people/place] there are *seasonal hours* in their own right; and the hours of one place are neither alike nor equal to the hours of another place — except for the inhabitants of the equator-line [the equinoctial], who share [the property] that the *equal hours* are also their seasonal hours [equal in both reckonings], except [for the difference] of [longitude], the priority [in time] of those eastward and the lag of those westward, as will be explained below in §[156 ,ן"ק(?)].

And these [seasonal] hours, which we have spoken of, are those that the Rambam [רמב"ם] calls *zemaniyot* [time-relative], ז"ל, because [in] every time and span of all the days of the year, the measure of the [seasonal] hours changes for all those who dwell beneath [an oblique latitude]. The *seasonal hours* [change such] that even a single individual dwelling in one place will have the measure of [the hours] change for him every single day, [yet] all the hours [of a given day] will be equal to one another [within that day]; and the measure of plain [unqualified] hours [of one day] is not equal to the measure of the hours of the day after it [?] throughout all the days of the year. You will not find that *seasonal hours* are equal to *equal hours* except twice in the year only — [at] the solstice-points [recte: equinox-points] of *Nisan* [ניסן] and *Tishrei* [תשרי] [the spring and autumn equinoxes]; for on these two [days], the day and the night are equal for all the inhabitants of the world in every clime.

Siman [103] קג — On what secret [reason] [the reckonings] were founded — [the reckonings] of all the inhabitants of the world in every clime [?]

[the body heading expands: "Upon what secret were [these reckonings] founded — the reckonings of the *seasonal hours*"]

Know that in all the climes, [for all] the inhabitants of the world, the six constellations [of the zodiac, rising] in the span of the daylight, and six constellations in the span of the night, [give] no less and no more, in [complete?] perfection [?] — whether it be a long day or a short night, or a short day or a long night [?]; and even at the two solstice-points [תקופות] of *Tamuz* [summer] and *Tevet* [winter], [the count of] equal [constellations holds] [?], as will be explained for you below in §[116 ,קט"ז].

Therefore know that the astronomers agreed [that] just as they reckoned, in the diurnal motion of the diurnal sphere [גלגל היומי], fifteen degrees for each [hour] of the equator-line [קו המשוה] equal to one equal hour — so too they reckoned, for the motion of all six constellations [שש מזלות], which are 180 degrees, fifteen degrees for each [degree-portion making] one *seasonal* hour. And just as in the two solstices of *Tevet* and *Tamuz* the motion of the constellations is equal — that from each of them [each solstice] there rise six constellations — so too the divisions of the degrees in both of them [will yield] always fifteen degrees per [seasonal] hour [?].

When the daylight span is reckoned as twelve hours and the night span as twelve hours, even in the times of the two solstices — accordingly, the difference that

exists, as great as the difference found between the measure of daylight and of night, just so great a difference is found in the times of the *seasonal hours*: the degree-portions of the constellations [in the long-day case] exceed [those] of the equal hour-portions on the equinoctial line. And in summer [the case] is the reverse of this, [namely] at the winter solstice [תקופת טבת], which is the shortest day of all the days of the year [?].

But since, in essence, on that [summer-solstice] day, six full constellations — which are 180 degrees — revolve above their [Prague's] horizon, and when divided into twelve [seasonal hours], each hour comes to fifteen *seasonal* degrees [?] — and this [fifteen] is one part [a twelfth] out of [the daylight measure] [?] — [now] the fifteen [degrees] are only two-thirds of an equal hour for the twelve [degrees]; [the constellations rise] [?]. Therefore, [for a] full [equal] hour we need 22½ degrees [recte; see numerical note]; and these [22½] of the constellations [are required for one equal hour]. For when [the daylight] is divided into 180 degrees [reckoned] by the number of the eight hours [of winter-solstice daylight] [?] — which are the eight daylight hours [?] — there comes out for us 22½ parts; [thus] the constellations divide [?] and a half. At the time [of winter solstice], the constellations that revolve [in that span], in [equal-]hour time [?], [yield this]. At the summer solstice [תקופת תמוז], which is the longest day of all the days of the year — since, in essence, on that day they [the constellations] do not rise [too far] above their horizon [more and more] [?] — six constellations, which are 180 degrees, when divided by the number of the [daylight] hours, which are *sixteen* — there comes out for you 11¼ degrees [180 ÷ 16 = 11¼] of degree per constellation-portion. And as the law holds for the day at the winter solstice [תקופת טבת], so the law holds for the night at the summer solstice [תקופת תמוז]; and as the law holds for the day at the summer solstice, so the law holds for the night at the winter solstice [תקופת טבת].

Siman [104] קד — That the reckonings of the [calendar-]intercalation [העיבור] — [the] solstices [תקופות] and the *moladot* [conjunctions] — were founded upon the *seasonal hours* [השעות הזמניות]

Know that, although the reckoning of the *seasonal hours* is an astonishing matter — for, additionally, [it is] strange to the people of the world, [in] that we do not find [such] a reckoning [elsewhere] — [know] from [our discussion of] the place [?]. Yet you should know that it is upon these *seasonal hours* that the ancients, ז"ל, founded for us the entire reckoning of the *molados* [conjunctions] and the solstices [tekufot]; and likewise all the other hours mentioned in the Mishnah are

all of them *seasonal hours*, as several great men [גברא רברבא] have testified concerning this.

Among them is the Rambam [רמב"ם], ז"ל, in the first chapter [פ"ק] of [tractate] *Berachot*, [where] his words [are]: "And know that all the hours mentioned in the entire Mishnah are *seasonal hours* [השעות הזמניות]; and the matter of the *seasonal hours* is the hours of which there are twelve by day and twelve by night. And what [the Mishnah] says, 'until three hours' — it is as if it said 'until the completion of a quarter of the day' — whether the day be the summer-solstice day [יום תקופת תמוז] or the winter-solstice day [יום תקופת טבת]" — thus far his words [עכ"ל]. Also Rabbi Ovadiah of *Bartenura* [ברטנורא] [recorded] his [the Rambam's] words there.

Also the Israeli sage [החכם הישראלי — R. Yitzchak Israeli], so it is written in his *Sefer Yesod Olam*, Ma'amar 2, ch. 7; also in Ma'amar 4. Also the sage [Rabbeinu] R. David Abudarham [ר' דוד אבודרהם] wrote thus at the head of his *Seder HaIbbur*. And so, as it appears, is also the opinion of the author of the *Semag* [ס' מצוות גדול] of R. Moshe of Coucy], in [the section of] positive commandments [בעשיין], §27 [ז"ח? — see note], [and in] *Orach Chaim* [in the *Tur*?] §458.

And know, henceforth, that when our reckoning comes out [showing] that the summer solstice [תקופת תמוז] falls 7½ hours of the *seasonal hours* [into the night] — know that the 7½ hours [of seasonal time], according to the reckoning of the *equal hours*, [work out such that] in this solstice [span] there fall for us, the inhabitants of *Prague* [פראג], five [equal] hours into the night. And by the rule [we find] — as when we find the *molad* of the month of Tevet, or its solstice [תקופה], [falling] at, say, 10½ [hours] on [a given] day — this *molad* or its solstice will be, according to the reckoning of the equal hours, [at] seven hours into the day; and this for the rest of the elders [other authorities], which is the [proper] way of the reckoning of the *seasonal hours*.

Also know that the *seasonal hours* are, according to the [terminology of the] sages of the nations [umot], called *the hours of the Jews* — in their saying that they [the Jews?] are upright [ישר] [in this] [?]. Now I, the writer, saw in their books, in the accounts of events that took place in Jerusalem during the time the Second Temple [בית שני] stood — in many deeds [recorded] in separate times [periods] — [mention of] "the sixth hour" [שעה ששית], "the end of the day," "the end of the [day], the ninth hour," and "the end of the day" [?], [terms] which to the [examiner's] sight, [it would] appear from those accounts, when scrutinized, [show] that in that time the children of Israel reckoned their hours by the reckoning of the *seasonal hours*, unless [it be otherwise], as it is said

Section 4 (שער ד), continued

Siman 104 (continued)

as it is said, "for all these works were done on the days of [?]" [the printed phrase here is corrupt: דיקאיכומכ'נישן [?] — likely a garbled quotation]. From this you may further [discern?] that I have given ear to the matter of the seasonal hours.

[The following lines are heavily degraded.] The "astronomical hours" of the seven planets — that is to say, the hours assigned to the dominion of the seven servants [the seven planets] — operate just as the [?] of the zodiac do. For just as [the dominion?] of the constellations works, so too at every season the twelve seasonal hours of the horizon [govern] at every moment, according to the proper [reckoning?] of the actual courses of the seven planets and their stars.

The twelve constellations are always [present?], as will be explained [further regarding] the rising-point [?]. By the law of the fifth section, in siman [ק"... — numeral degraded] [?], the setting of [the sun?] upon it. [So] too is the law of the constellations regarding the setting of each one of the seven planets and the [?]. When, for example, [Saturn?] is found beneath the head of [?], then by that [reckoning] the rising and setting of that planet [is determined], by the way of [?]; for instance, when I observe the rising and setting of the [constellation] Cancer itself.

But I do know why these are called "the hours of the constellations." And the reason and benefit of [the seasonal hours] will be explained, in part, further on in the eighth section, in siman 211 [רי"א], God willing.

Siman 104 [printed קקד] — The Cause of Night, and the Shadow of the Earth

The cause of night. It is already known — even to the ancients [?] — that night [comes about] when the sun sets beneath the western horizon and is removed from us. Night is the absence of light and the presence of darkness. However, there is much for us to say [on the matter]; we shall speak of the place from which this shadow [arises]. The very cause of night, then: know that after the sun sets, the surface of the earth's shadow — a round cone [extending] downward — gathers in the middle [?]. Consider the size of the earth's sphere relative to the smallness of the [?] sphere: the earth's sphere is three and one-eighth times larger [than the moon's?], as will be explained further on in siman [?].

This shadow continually renews and diminishes [tapers], spreading out [from a broad base] up to a single point — the head [tip] of the cone [literally "the heads of the cones, point one"] [?]. That shadow extends in height and elevation so very far that it [reaches?] into the hollow of the world [the celestial space], passing [from] the lower region [upward] — beyond the thickness of the lunar sphere and onward; and from there it enters into [the sphere?] within the sphere of Venus [נוגה], some thousands of [Persian] miles. [Upon reaching?] that sphere, the shadow is entirely annulled, [for there] this shadow [tapers to its point], as it appears.

This shadow [forms] a tent stretched over us, beneath which all who dwell beneath it gather [in darkness] — and this is night. This shadow-tent does not stay still even for a single instant, on any of the days of the [world?], because the earth-sphere [lies still / does not move] [?] and the daily motion [carries] the days [around]. As the sun moves, so the shadow turns and revolves perpetually around the world, and [returns?] to the constant [course?].

The head-points of the shadow stand opposite the constellations — always aligned directly opposite the true center of the sun. Let this thing be a remembrance to you [a memory-aid], so that your eye may turn to it when you need it. See further ahead, at the head of the ninth section, in siman 221 [רכ"א], where you will find the matter of the said shadow elaborated; there I have set forth its full explanation, with God's help.

Siman 105 [קה] — The Distinction Between the Word "Day" Meaning the Natural Day, and "Day" Meaning the Work-Day; and From What Moment the Natural Day Begins

The matter. This [topic] has already [been touched upon] above in the eighth [?] section [the cross-reference is degraded: מ"ת [?]]. Here there is no [need to repeat it? — degraded]. Nevertheless [?], regarding the three senses of the word "day" [?]:

It is fitting to state [first the sense] that the word "day" denotes the place [period] in which the sun is found above the horizon — that is to say [?], it is [the daylight period]. This accords with the verse, "If not for My covenant day and night… you would not [keep] day or night for yourself" [cf. Yirmeyahu 33:25] — and for this reason the masters of [astronomy?] call this period "the work-day" [יום מלאכה].

A second [sense]: "day" is also applied to the night, as it is said, "And the priest shall burn all of this [upon the altar]… and it was at midnight, and the priest [?]

burnt all the fat…" [cf. Vayikra 6:2–5 / the burning of the daily offering]. [And] "[a day] of night I cried out before You" [cf. Tehillim 88:2] [?] — whose meaning is "a [span of] time." [In this sense the word "day" means a full period.]

So too [the verse] "I [cry out] by day" [?] — and to explain and derive precisely [the sense] that the word "day" [refers to] the [time] of the sun being over the earth, as Even Ezra [Ibn Ezra] explained [in his comment on] the verse, "the pillar of cloud departed not by day" [Shemos 13:22] [?]. And a third [sense]: [the word] "day" is joined with the [whole of] its work-day together with the preceding night, as it is said, "And it was evening and it was morning, one day" [Bereishis 1:5] — whose meaning is the evening joined with the [following] morning. This [whole span] they called "one day." This period the researchers — in the language of [Latin]-speakers [?] — call [a Latin term: "dies naturalis," the natural day] [?: the transliteration נטוריאלום reads "naturalium"]. The "day" mentioned [most often] in the Torah, and predominantly, refers to this [natural day] [?].

The natural day defined. The meaning of "natural day" is [a span of time that has?] no [fixed] beginning that compels you to set it as the start [head] and beginning of the day; rather, [there are] four moments [points] in it, at any of which it would be [equally] fitting to rest [reckon]. [Each of the four] is suitable to be made the head [start] of the day:

1. **The first moment** is the time of the sun's setting, which is the end of the past day and the beginning of [the new] day; and this is in accord with the consensus of our Torah, as will be explained. — *The second moment* is midnight; and on this some of the researchers of the planetary motions agreed [as the day's start]. — *The third moment* is the time of the sun's rising from the east; and according to this, the night that follows comes after it, and runs along after the day. We find this [reckoning] in our Holy Torah too, in [the law of?] the thank-offering: as it is said, "the flesh of his peace-offering of thanksgiving… on the day of his offering it shall be eaten; he shall not leave any of it until morning" [Vayikra 7:15] — [reckoning] until morning. — *The fourth moment* is the [moment of] the [hour of] noon [?]; and to this most of the astronomers have inclined [for reasons that will be explained?] further on in siman 154 [קנ"ד]. For example, the Sabbath day: its beginning is reckoned [from?] the sixth day, six hours before [?] the time agreed by our Torah for [the start of] the equinoctial days [?] — those who say that the start of the astronomical [Sabbath day for the astronomers begins] until [?] the Sabbath day. According to this, there

> would be a difference between our reckoning and the reckoning [of the astronomers] of [several] hours [?] — but they did not speak correctly.

So you have here four moments of the natural day, each one of which would have been [equally] fit to be made the head and beginning [of the day]. Nevertheless, know that our Holy Torah agreed [resolved] to reckon the beginning of every day specifically after the time of the sun's setting, which is reckoned as the beginning of the night. The sage Even Ezra [Ibn Ezra] has already written, in Parashas Yisro [on the verse], "from the morning until the evening" [Shemos 18:13–14] [?], that "true evening" is at the setting of the sun. And all the masters of [astronomy?] concede that the [civil] day [is reckoned] from the time the sun goes forth.

The onset of the Sabbath and of the festivals, by the law of the Torah, [begins] from when the sun sets. Only, Chazal added [a measure] of weekday onto the holy [time] [the principle of *tosefes Shabbos*, "adding from the profane to the sacred"], so that the onset of the Sabbath should precede the setting of the sun, and the departure of the Sabbath should be after the emergence of the stars. And the reason [for this is given] in the consensus of our Torah to begin every day after the sun's setting [as] R. [Yitzchak] Israeli wrote in chapter 17 [ז"י] of the third Ma'amar [Yesod Olam, Ma'amar 3, ch. 17]: since the renewal of the moon [the new month] — which we are commanded to sanctify by its sighting, [seen] when the moon is five [days?] [?] old [?] — the [sighting of] the new [moon] does not appear except at the beginning of the night; therefore the days of the [new] month must begin from the beginning of the night. And since each one of the festivals depends upon the new moon and [its beginning], it is said of the first [day] of [the month]: "in the first [month], on the fourteenth day of the month, in the evening" [Shemos 12:18] [?].

[The above also depends on the verse:] "[in the first month, on the fourteenth day of the month] at evening, you shall eat unleavened bread" [Shemos 12:18] [?]. This too is a beginning [reckoning] from the night [?] — and Scripture fixed [the matter] thus at the start of [the laws of] Yom Kippur, "and its end" [Vayikra 23:32, "from evening to evening shall you keep your Sabbath"]; and the sages [?] built upon it [this verse] a paradigm [*binyan av*] for all other Sabbaths and festivals, [reckoning them] from the evening preceding them as they wrote [regarding] the half-hour after midnight [?]. "In the evening you shall eat [unleavened bread]… on the twenty-first [day] of the month, at evening" [Shemos 12:18].

Siman 106 [קו] — That the Natural Day [Equal Day] Exceeds the Time of One Revolution of the Daily Sphere

It is explained. It is clear that, by virtue of the motion of the upper [outermost] sphere, the daily sphere [the *primum mobile*], the day and the night come into being, as has been demonstrated [?]. At first inspection [first glance], one might suppose that the measure of the natural day and the measure of the daily sphere's [revolution] are one and the same time for both. But know that this is not so. For if the sun stood still in one place — [the place] from which it [began to be reckoned] — then the time of one revolution of the daily sphere would be without any addition or diminution, [exactly] equal to the measure of the natural day. But since the sun revolves [moves forward] each day by approximately one degree of the sphere's degrees, as will be explained further on in siman 165 [קס"ה]…

[Marginal verse / liturgical tag, Rashi-type at column foot of p. 74:] "ומשביעי פרנסני זונני גרון" — [a mnemonic / acrostic line; reads roughly "Sustain me, O Seventh [day]…"] [?: function and reading uncertain]

From [the direction of] west to east is the upper [westward?] motion [?], and this revolution [necessitates] that the daily sphere revolves more each day by one revolution [plus a small increment] — [namely] approximately one part [degree] of the 360 parts [degrees] of the sphere; [the time] by which the natural day exceeds the time of the [single] daily revolution. [This may be illustrated thus:] suppose [on?] the first of Nisan the center of the sun rose together with the head of [a given] constellation [degree] above the horizon. When [the sun] revolves on the morrow, the head of Aries [טלה] [will rise?] in the revolution of the daily sphere [slightly later?]. [The text here is degraded.] Were the sun [fixed], the daily sphere's motion would bring the head [of that degree] back above the horizon a second time [in exactly one revolution]; [but because] the daily sphere's revolution [carries] the [stars around], its [own proper] motion [?]…

[because] the sun is not [fixed] above [a single point], [but moves forward by] approximately one degree; [so] the daily sphere must revolve approximately one more degree above the horizon [to bring the sun back]. We thus find that the daily sphere, according to this, revolves "from moment to moment" — that is to say, from one [day's] eastern [sunrise] until the [next] sunrise of the sun — a complete revolution plus an additional [increment] [?]. [The increment is] approximately one part [degree] of the 360 degrees [by which] the daily sphere [exceeds]; [and] the measure of the natural day [exceeds] the time of one revolution of the daily sphere by one part of 360 [a degree of time, equivalent to]

about four minutes [?: "one fifteenth of an hour," literally מט"ו [?]] of an hour [?]. [More precisely, in keeping with] its [the sun's] mean motion [?] — for [the sphere?] does not revolve a full degree each day, but only about [?] [several] minutes [?] and eight seconds [?], as will be explained further on in siman [/ קה ה"קס?] [?].

[Section-closing colophon line, Rashi-type:] "שעזרני בסיום שער הרביעי" — *"[Blessed be He] Who has helped me to complete the Fourth Section."*

The Fifth Section (השער החמישי)

[Section rubric / table of contents, set as a heading band:]

It treats of the bands [girdles] of the constellations and their figures, and of the constellations themselves — in which there are two faces [aspects], and the degrees of the constellations. They are reckoned according to four considerations [criteria] [?]: and the degrees of the [ecliptic] are of [unequal?] worth, [some] of great [obliquity?] [?] [degraded] — and the explanation of their procession [their rising-times] according to four considerations [criteria]. Six constellations rise upon the horizon [?] and six [others] set, and the [?] of the constellations rise upon the horizon at times [?] [degraded]: [the constellations] are sown [arranged], Taurus before Aries, [?] before Pisces; and the path [orbit] of the zodiacal sphere, [?]. After [?] the situation [position] of all the host of heaven changes for us over many years, and other matters that follow from it.

Siman 107 [קז] — On the Bands [Girdles] of the Constellations and Their Figures, and Why They Are Called by the Known Names

It has already [been explained] in the science of [?] — and [in?] geometry [?] [degraded] — that its [a line's] thinness has no measure whatever, such that even [if] thousands of [points] in [holiness?] [the printed word is garbled: בקודוש [?]] were joined [together], they would not make a line. And likewise, on account of its [great] thinness, the line itself has no width whatever: even a thousand thousand lines joined would not make a surface [plane]. For the point and the line are merely [conceptual] limits [?]. Know, therefore, that none of the said spheres [great circles] has any measure of width whatever — not even [the breadth of] a [hair? / a "Naḥa"? — במלא ניחא [?]].

Nevertheless, know that the sages of [astronomy], in their treatment [construction] of the circle of the constellations [the zodiac], assigned it [a band] — the breadth of the twelve constellations [being] the breadth of the 360 degrees [?] — degree by degree along the sphere. And the later sages, who were more

precise [than the first], added to [what] the first [established], until they gave it [the zodiac band] a width of sixteen [degrees] of degree [?], for a reason that will be explained [?: "for the reason of that which will be explained"]. To encompass [contain] this band of width, [the band] which they called "the girdles" [the zodiac-belt] — in the language of [Latin]-speakers, they call it "the sides of the [ecliptic / zodiac]" [?: a Latin term, perhaps *zodiacus* or *signifer*] [?] — they divided it down the middle [?], drawn [?] to each side [as] six [degrees] [?]; [and] they relied upon it [as] the line of the [actual] zodiac circle itself, of which we spoke. …its circumference [is divided?], and to each constellation [a portion]; and within each constellation [the stars?] [degraded]. [The early astronomers,] in order to teach their students and to make [the matter clear?] without [confusion], [marked?] lines from star to star — this star and that star, this star and that star — in order to find in it the figures [shapes], and they depicted upon it [?]. Thus they said [for instance]: "the head of so-and-so [a figure] is upon the head of Aries"; the [figure?] is set [drawn] upon it [?] — this one upon its horn, this one upon its ear, and this one upon its tail. So too they did with the [other] figures [for] Gemini, Taurus, and the rest [Cancer, etc.]. The arranger [draftsman] [thus] formed [the picture], drawing the lines from [the figure's] head to depict the form of a man, or a [bird?] or a camel [?]. Just as their name [implies], when you look at the [nature?] of the stars that are arrayed [?] — the [stars] of which we spoke above in the first section, in siman 17 [י"ז], among the sages of [astronomy] [?] [the constellation-figures?]. [The astronomers] depicted [them?] in the figures of [animals?], while the common folk [the multitude] depicted them in the figure of a wagon [the "Wagon" = Ursa Major / *Wagen*]. And by these figures [drawn] upon it, [namely] the figures of the constellations [together] with the figures of [the stars of] the whole stellar sphere — the total of all of them is forty-eight [מ"ח] figures [the 48 Ptolemaic constellations], as we shall, with God's help, explain [further?] in siman [?: numeral degraded].

Siman 108 [קח] — Why the Ancients Chose Specifically to Depict the Aforesaid Twelve [Constellations] as These [Particular] Figures, and Not Others

[The ancients depicted them by] the known figures, and not [as] others, without doubt [?]. This is not without reason. For it is established [?] that every figure indicates [?] an action, a power, and a dominion that resembles its form: just as Leo [the Lion] [?] and [Aries the Ram?] indicate might [גבורה], and Virgo [indicates?] love [?], and Libra and Cancer [indicate?] [matters of] judgment [law], and Pisces [?] [degraded]; and so for the rest of the figures. For it is already known that the Almighty, in [?] the six days of Creation, gave [to each

constellation] a power and a dominion over the array of the stars — as Chazal hinted in [Tractate] Berachos, Parashas [?] [Bereishis Rabbah?], saying: "there is not a single blade of grass below that has no constellation [*mazal*] above it that strikes it and says to it, 'Grow!'" [Bereishis Rabbah 10:6], as it is said, "[Do you know] the ordinances of heaven?... [Can you set their dominion over the earth?]" [Iyov 38:33] [?]; and at the end of the chapter "[Mi she-Hachshich"] of [Tractate] Shabbos [Shabbos 156a] [?], and in the chapter "Asra she-meshamrin alav" [?] [degraded], "on the dominion of the constellations and the decree of the stars."

Siman 109 [קט] — From What Reason the Sages of Astronomy Assigned to the Circle of the Constellations the Aforesaid Width [Breadth]

Know that the sages of astronomy investigated [searched] and found, by their observations [speculations], and said: the course of the sun in its sphere is forever [exactly] in the middle [center], beneath the middle [center] of the bands [girdle] of the [zodiac] constellations — that is to say, beneath the line that divides the width [of the zodiac] into two, which is the aforesaid [ecliptic] line. And in their view it never deviates [neither north nor south] and never departs from it [the line] all the days of the world. The other "wandering" [stars] [the planets, כוכבי נבוכה], by contrast, are forever circling, each on its own sphere [גלגל], near to this line, never departing far from it — [at most] six degrees [to either side], according to the view of the early [astronomers]; while according to the view of the later [astronomers], who [base it] on observation and on the proof [demonstration] for each one of the six "wandering" stars [planets], [the matter of] their nearness to and distance from the line will be explained further on, in the eighth section, in siman 241 [רמ"א], God willing.

And I, the writer, heard from the mouth of the astronomer, the wondrous [Italian / "Yesani'us"?], Kepler [קעפלירו"ס] [Johannes Kepler], that the utmost [northern] distance of a "wandering" star [planet] from the ecliptic line, toward the north — for Saturn [שבתאי] [is so much]; and so [too], the utmost distance of Jupiter [צדק] from the ecliptic line [is?] three degrees, more than one degree [?]; and a third [matter]: Mars [מאדים] [is at] its utmost distance, three degrees north of the ecliptic line [?]. And so there is a difference [of?] some [amount] between the northern side of the sun [?] — for the sun forever travels beneath the ecliptic line as aforesaid; while Venus [נוגה] [?] [moves?] more than it to the northern side, [and] likewise to the southern side. [And] Mercury [כוכב, "the [wandering] star"] [reaches] nine degrees [?], [and?] departs three degrees to the [southern?] side [?] [degraded]: [so many] degrees.

Siman 110 [קיו] — [On the View] of the Ancients, Who Agreed — by Reasoning and Without Any [Compelling Demonstration?] — to Set the Constellation Aries as the Head [First] of the Constellations

Even though [the sphere is] a sphere [round], as we explained at the head of [?] section, in siman [?] [degraded]; and even though it is [demonstrated?] [?] [degraded]… By virtue of the sphericity of the [zodiacal] sphere, the [first] intelligible [self-evident principle], the first [premise], requires [?] this: that when the sages wish to take a stand and be precise concerning the course of the zodiacal sphere, they were compelled to choose for themselves some known point on it, to set it as the head [origin] from which to begin the reckoning and the division of the equal portions of the constellations. But if we investigate [the matter] — [as] this agreement [convention] [requires] [?] — [we ask whether] there is by nature [some point] fit to be set as the head and beginning [more than another]. [Indeed there are] points on the sphere, [namely] the head of Aries and [the head of] Libra [טלה ומאזני', Aries and Libra], at which the day and the night are equal [equinoctial] in all the climes [the equinoxes]; [and] also [the points] at the mean [midpoint?] between [the] times of [the solstices?] [?] — [the point] equidistant between the two [equinoctial?] points [?], [namely] the two points [of] [the solstices, the head of] Cancer and [the head of] Capricorn [סרטן וגדי, Cancer and Capricorn], at which, when the sun enters the head [of Cancer], the day is lengthened for us to its utmost [the summer solstice]; and when the sun enters the head of [Capricorn] [?], the day is shortened for us to its utmost and the cold overpowers us [the winter solstice] — as all this was explained above in the second section, [on?] the [course?] of the constellations [?].

[There are thus] four points which have a [superior?] claim [precedence] over the rest [of the points] of the circle of the constellations.

Now [as for why they chose Aries specifically]: since we find that when the sun enters the constellation Aries [or Libra], it is the mean [middle] time between the lengthening of the days and [their] shortening [the equinox] [?]. Also, for most of the inhabitants of the world — the dwellers of the [temperate?] north [?] — it [the season] is intermediate between cold and heat; and so the year is forever praiseworthy [pleasant] in [the months] balanced between the two extremes. For this reason, [the entry into] Aries and Libra [is the season of equipoise — equal day and night]. The sages of astronomy chose the head of the constellation Aries, because when the sun enters the head of Aries, the time has come when the air is tempered between cold and heat — exceedingly healthy [*briah*] [?]; [the time] when the [creatures?] arise [?]: from that point onward, the light, the heat, and

the warmth prevail over the cold; the warm [moist?] blood begins to multiply in the bodies of man and beast, and all the grasses of the field [sprout] and blossom and bud, and the trees [bring forth fruit?], and [the produce of] the earth [flourishes?]. All this [happens] because of the entry of the sun into the constellation [Aries].

By contrast [?], the time of the sun's entry into the constellation Libra — which is the beginning of the days of autumn [the harvest season] — is a time whose nature [brings] cold, [bringing] all things to corruption and decay; [a season praised by some] for this [reason?] and disparaged by others [?]. Therefore, the judgment of precedence [primacy] was awarded to the constellation Aries, it being the head and beginning [first] of all the twelve constellations.

Siman 111 [קיא] — On the Figures [Drawn upon] the Constellations [and] How They Are Reckoned in Two Aspects [Faces]

Know that the figures [drawn] in the bands of the zodiacal sphere have two considerations [aspects], according to their [relation to the] stars set [fixed] in them [?] — [each is reckoned] in one [aspect].

The astronomers agreed [resolved] to set the constellation Aries [טלה = טלל] as the head [first] of the constellations — [reckoned] from the point of [the equinox?] [the "point of uprightness," נקודת היושר], the point where the [equinoctial] line cuts [crosses] the line of the constellations [the ecliptic], [namely] the line of [equipoise?] [?].

Section 5 (שער ה) — continued

[Continuation of siman 111]

which is why they divided it into twelve parts and called those parts the twelve signs, each sign spanning thirty degrees. Each sign was assigned the position appropriate to it.

You now know that from this point forward each sign holds either 16 or [?] degrees [the source figure here is uncertain], whereas its [proper] measure is thirty degrees. They took the [extra] degrees from the twelve signs, [distributing] each sign's portion to the northern and southern sides, since the signs extend to the north and to the south of [the ecliptic], and from here to there spans up to two [bands]. Therefore no star in the eighth heaven [the firmament of fixed stars] will lie beyond [these limits]. This whole reckoning runs along the entire length of the

signs, beginning from the first degree of a sign — for already at the [?] of its place there were 180 degrees, as we mentioned. And these thirty degrees, the thirty degrees reckoned for the width [breadth] of the sign, are at the middle of the sign's length. The width of those portions diminishes and tapers off on both sides little by little, the diminution growing greater until they reach the two poles — at which point, from here and from there, the two [boundaries] converge to a single point and have no breadth at all.

Siman 112 (סימן קי"ב) — That all the stars of the firmament are apportioned among the twelve constellations

[Body heading p. 76–77: "סימן קי"ב — שכל כוכבי הרקיע נחלקים [?] תחת הי"ב מזלות". *Editor's note: the source prints simanim 111 → 112 → 113 in sequence, but the siman-112 rubric sits at the foot of p. 76's right column and its body runs into the left column of p. 77 — an out-of-order column run that the first pass skipped. Recovered and restored here; a few gutter-obscured clauses on p. 77 remain `[?]` (see `.md`).*]

It has already been explained that the firmament — that is, the eighth sphere [גלגל השמיני, the sphere of the fixed stars] — contains a vast multitude of stars, beyond counting by any man. [?: the precise count-formula clause at the head of the p. 77 column is compressed against the gutter and not fully legible.] Yet for all their number, the wise men of every nation agreed to gather and order them under the twelve constellations [המזלות], so that each star should be assigned to the region of one of these twelve, according to its place in the band of the zodiac.

For this reason a man should not imagine that the stars belonging to a given sign all lie crowded together within the narrow figure drawn for that sign; rather, the whole breadth of the heavens is parceled out among the twelve, and every star — wherever it stands — falls within the lot [גורל / חלק] [?] of one of the twelve signs to which it has been reckoned. The figures [הצורות] are but a device by which the early sages marked off and remembered the stars, grouping the scattered ones into recognizable forms; the figures themselves are not the stars, but the framework laid over them.

And so it comes about that the entire surface of the eighth sphere is divided among the twelve constellations with nothing left over: every point of the heavens lies under one sign or another, and there is no star of the firmament that

is not counted within the twelve. [?: the exact closing words, compressed before the rule-line preceding siman 113, are uncertain.]

Siman 113 (סימן קי"ג) — The portions of the zodiac sphere are reckoned according to seven distinctions

[Body heading p. 77: "סימן קי"ג — שחלקי גלגל המזלות נחשבים ע"פ שבע בחינות"]

From the matters we have mentioned it becomes clear to you that the portions of the zodiac sphere are divided and reckoned according to seven distinctions:

1. (א) [By] degrees — the degrees of the surrounding circle are 360 degrees, no more.
2. (ב) The 360 degrees of the sphere are divided into twelve portions, the twelve signs.
3. (ג) Each sign spans thirty degrees.
4. (ד) The breadth of the zodiac band is either 12 or 16 degrees.
5. (ה) Reckoning the half-lengths of the signs — the northern, along the [polar] axis, gives 180 degrees per mil [i.e., per unit] [?].
6. (ו) [As stated above:] of the long signs, the breadth that a sign has was already taken [and added] to its length, so that they amount to thirty degrees. [This item's reading is partly uncertain.]

Moreover (ועוד): there is a seventh distinction, added to the six [already given], and it too is a flying [i.e., a recently arrived] new distinction, which I received from the sage Kepler [קעפלירוס]. It is this: We picture, when we examine it, as though one cuts a solid sphere of the [celestial] material into twelve portions, and each portion is one of these twelve pieces, its length 180 degrees and its breadth thirty degrees. The thickness of each one of these pieces — measure it as half the diameter of the sphere, whose number is [as given in the reckoning] [?] degrees, [and] the thirty degrees reckoned for its breadth, that is. We make its concave side narrow, the breadth going on tapering until it becomes pointed and the breadth vanishes from it entirely.

For greater clarity, take an apple [תפוח] and divide it into twelve equal portions; then with your eye and your mind you will see in it all these matters we have mentioned, and the usefulness of this seventh distinction. It is [exemplified by] what we see in the case of comets [כוכבי שביט — literally "rod-stars"], that is, the

comets — in foreign tongue [בלע"ז] "comets" [קומיט"א — Latin: cometa] — the tailed ones, or other strange figures that appear lower than the [other] spheres in the firmament. The point is to know, against which sign the comet or that figure or even the form is found, by means of [?] its [?]. We have means to recognize it [the comet's position] at any time by this seventh [distinction], to know at every moment which sign it lies opposite.

Siman 114 (סימן קי"ד) — The six signs that are above [for the inhabitants…]

[Body heading p. 77: "מזלות שממעל [ה]ששה — סימן קי"ד…"]

The six signs above [the horizon and the six below it] — there are not found among them [more than?] three to the east [?] and three to the west [?], except for those who dwell under the equator [קו השוה].

As we explained in Section 2 (siman [?]), for every inhabitant of the world [who dwells under the equator] there are always visible to them half of the zodiac sphere — six signs — while six signs are sunk beneath their horizon, hidden from their eyes, at every hour of the day. In every place in the world, you should know, there is found a great difference between those who dwell under the equator and those who dwell under the [meridian?] […]. For all who dwell under the equator [קו הישר], the meridian (קו חצי היום) [their noon-line] has six equal portions; the signs visible above them are divided by their horizon into two equal portions. Thus, for the inhabitants of [such a region] there will be three signs to the east of the noon-line and three signs to the west of it.

When the head of Aries rises for them out of the eastern horizon until it sets at the western horizon, the head of Libra stands for them beneath the western horizon; and the head of Cancer is upon the noon-line above, while the head of Capricorn is upon the noon-line below, beneath the earth, opposite the soles of one's feet. And so it is for the rest of the signs: as one sign rises for them in the east, the one opposite it sets. The third sign after the one that rose comes to the middle of the sky for them — that is, on the noon-line above — while the [third sign] after […] the one […] is on the noon-line that is beneath the earth. This is the law for the inhabitants of the equator.

However, for the inhabitants of other regions [climes], beneath whom the signs do not divide equally […], there are other laws and rulings, except for the

dwellers under the equator at the times of the equinoxes of Nisan and Tishrei [the spring and autumn equinoxes].

For those who dwell under [other climes], the partition of the six signs differs according to [their latitude]. The further the dwellers are from the equator-line, the more the partition of the zodiac sphere will be unequal on the two sides of the noon-line: for some of them three and a half [?] signs are found on the side of the [west], and [the remaining portion of] the signs and half [of one] are on the [east]; while for others, [the noon-line cuts off] more than three signs on one side and fewer on the other [...]. So too, in reverse, the matter is found according to the time and according to the place.

We give you an illustration in this from the inhabitants of the city of Prague [פראג], where the north pole stands at an altitude of about fifty degrees. On the day of the summer solstice [תקופת תמוז], when the true [Sun] is at the head of the sign Cancer, then, when the Sun rises upon their horizon, it is found that of the 180 degrees of the signs always present above the horizon at every place in the world, they will be divided for us — by means of our noon-line — into unequal portions. For there will be found among them more than two thirds to the east and somewhat less than [a third?] to the west, in such a way that more than four signs are found in the eastern quarter of our noon-line and fewer than two signs in the western quarter. And when the Sun sets for us, with the head of Cancer, the matter will be reversed beneath their horizon: more than four signs in the eastern quarter [?] [and fewer] in the western quarter, as before.

You will see all this perceptibly by the work of the [armillary?] sphere; and from this you may infer the case for the rest of the world's inhabitants and for the rest of the times.

Siman 115 (סימן קט"ו) — That every sign lingers on the horizon, at its rising, about two hours

[Body heading p. 78: "סימן קט"ו — שכל מזל ימשוך בעלייתו על האופק שתי שעות"]

From the moment that each sign begins to rise above the horizon of the world until it has fully risen, it is drawn out — by reason of the upper [diurnal] motion — for about two hours. This matter needs no lengthy explanation, since it is already [clear] that by the upper motion every sphere completes a full revolution from end to end in about 24 hours. The zodiac sphere is divided into twelve parts; thus you find that each sign holds [a twelfth] of the [day], that is, about two hours.

[p. 78 — Running header: "שער ה" — folio mark "לט"]

Two hours will reach each sign, [each sign being] 30 degrees, the upright [equatorial] hour [being] 15 degrees [?]. The sphere completes its revolution in about [24 hours] — I say "about," and I said "about" because, in truth [?], [...] before the natural day [...]. Even those dwelling under the equator [קו השוה?], and even those dwelling under the equator at the times of the equinoxes of Nisan and Tishrei, [...] will not be [exactly...], because, throughout the rest of the year, the equinoctial-line-dwellers [...] [the matter varies]. For all places in the world, six signs rise during the day and six during the night, whether the day be long or short, as will be explained. We find, accordingly, that at the summer solstice [תקופת תמוז] six signs rise in about 16 hours, [each taking] [?] for the revolution of every two hours [?]; and at night [the remaining] signs [rise] in about eight hours [?], each sign taking a third of an hour [?]. At the winter solstice [תקופת טבת] the matter is reversed.

Besides this, the signs differ in their rising — there are many conditions of [precedence] and delay among the signs, as some signs rise faster than their fellows; for some inhabitants of the world it is found that some signs rise in a single hour. For some, the signs rise in [reversed] order, Aries before Taurus, Taurus before Gemini [?] [...] as will be explained further within this Section.

Siman 116 (סימן קט"ז) — That on every day six signs rise [and likewise six set during the night, whether the day or night be long or short]

[Body heading p. 78: "סימן קט"ז — שבכל יום עולי' ששה מזלות וכן בלילה[ן] שיהיה יום או לילה ארוך או קצר"]

Know that for every inhabitant of the inhabited world, in all the climes, there always rise during the daytime six signs and during the night likewise six signs, whether the day or night be long or short. In every place and all times, the times are equal in every place of the climes — not more and not less — whether the day or night be long, or whether the day or night be short. I will not be lengthy in demonstrating this matter, for you will see it perceptibly by the work of the [armillary] sphere.

An illustration of this: On the day of the summer solstice, whose length for us, the inhabitants of Prague, is sixteen upright [equatorial] hours, the day truly being

long [?] — the Sun rises upon the eastern horizon with the first degree of the sign Cancer, and at that time the sign Capricorn, which is opposite it, sets beneath the western horizon. And so it remains until evening, when the Sun sets together with the head of the sign Cancer beneath the western horizon, at which time the sign Capricorn opposite it rises and ascends upon the eastern horizon.

So too is the custom of the [other] solstices [and seasons]. On the night [following] [...] eight hours: at the start of its night the sign Capricorn rose upon the eastern horizon, and at the end of its night it sets beneath the western horizon. There you have, by day [...]. And in the long [day] and the short night of harvest [summer], six [signs] rise upon the horizon [...] and six signs [set]. The law is likewise at the winter solstice [תקופת טבת], whose daytime length for us is eight hours, during which six signs rise upon the horizon by day; and the length of the night for us is sixteen hours [during which six signs rise]. So [in total] there are no more than six signs that rise in all, throughout the days of the year. Always there rise during the daytime six signs and during the night six signs, in all times and in every place of the climes, whether the days be long [?] or short.

Siman 117 (סימן קי"ז) — Explanation of the "marches" [ascensions] of the signs; and that some signs rise "lengthwise" [slowly] and some rise "shortwise" [quickly]

[Body heading p. 78–79: " סימן קי"ז — ביאור מצעדי המזלו', ויש מזל שעולה בארוכה ויש מזל שעולה בקצרה"]

The ascensions [עליית — risings] of the signs upon the horizon are called by the sages the "marches" [מצעדי] of the signs, with respect to which we will speak [...]. [This is] to inform the reader that the division of time into hours and [their] subdivisions is according to the way the upright [equatorial] sphere revolves, [carrying] the noon-line by the diurnal revolution of the sphere, as was explained in siman 100 (סי' ק') at the fourth degree [?] — so that you should know that the time of the rising of the signs, their "marches" and intervals, is likewise reckoned by the revolution of the parts of the upright sphere, which revolves for the equator-dwellers at the measure and rate of about 15 degrees per hour, neither hastening nor delaying in its rising or its setting from time to time.

And from now on you will know — when we examine the marches of the signs — that although they too revolve always [uniformly] of themselves, in [Section 1?] [...], they will not hasten or delay in their times from time to time [...], by reason of their inclination [נטייתם] from the equator-line: they march upon the horizon, for the inhabitants of the inhabited world, in [unequal] times — sometimes 15 degrees per hour, sometimes more than this and sometimes less than this.

The reason and rationale of this matter — hear it. Know that if the zodiac sphere stood erect [aligned] with the upright sphere from above, and were at equal distance [from the pole], its two poles being [the same as] the [poles of the upright sphere], then its marches and revolution would also be equal, and there would be no precedence or delay of one part over another; they would all be equal. But since the poles and axis of the zodiac circle are not the axis [and poles] of the world's poles [as explained] in siman 37 (סי' ל"ז) — by reason of which the zodiac circle is inclined from the upright circle and does not stand opposite it at an equal measure, but rather one part recedes [from the pole] while another draws near to it — for this reason its marches differ, and there is one sign that marches and rises upon the horizon "lengthwise" [slowly, taking a long arc] and one that marches and rises upon the horizon "shortwise" [quickly].

We will explain the [criterion/measure] found for the dwellers under the equator, and whether the difference is small. You must know that every two arcs of the zodiac circle equally distant from these two — that is, the two poles, the head of Aries and the head of Libra — always have, at an equal distance, equal marches; these are equal for all who dwell under the equator. And from now you will know that [the signs] Aries, Pisces, Virgo and Libra incline from the diagonal [the ecliptic's slant] a little more [?] toward the upright line. Therefore, before [a sign] rises upon the horizon, the upright line has already advanced [a measure of] degrees; the sign was anticipated [overtaken] by this advancing of the upright line, and so it rose [...]. Each of the four signs [whose rising] that breadth [...] [rises faster]; their rising is called a "hastening rising," because their rising [...] less than 2 hours. For this reason the astronomers call the rising of these signs a "crooked rising" [עלייה מעוותת], because the sign Aries [rises] crookedly. And the law is the same for their setting.

By contrast, the signs [...] Taurus and Gemini [?] and Cancer, and likewise Sagittarius and Capricorn — since their standing-place is also [...] toward the upright line, [...] more than the rest of the signs; therefore the astronomers call their rising an "upright rising" [עלייה ישרה], and their rising is [the slow one]. Their rising is somewhat delayed, because the circle of the equator stands in the

middle of the height of the sphere [...]. As for the four signs mentioned [Taurus, Gemini, Cancer; Sagittarius, Capricorn], each of them [...] opposite the equator-line [...], from which it follows that the [upright] rising [...]; its length and the measure of its height [...] more upright [...] from the upright [...]. The arc that the line [...] from the arc opposite to it [...] the circuit of the sign.

[p. 80 — Running header: "שער ה"]

the equator-line, [the more its] portions [...] in the depths [...]; therefore the rising sphere upon the horizon [...]. The arc of which the two arcs revolve — [more] portions of the equator-line rise upon the horizon than rise from the arc of the sign. And since the hours are reckoned by the revolution of the equator-line, as above, it follows that [...] the arc of the sign, being thirty degrees, until it sets [...] more than thirty degrees rise from the equator-line. Since it [the sign] is long, [...] [appears] to us that the arc of the signs mentioned is delayed in their rising after the arc of the upright line opposite to them; the measure of their delay is about two degrees. Moreover, since the revolution of 15 degrees per hour [...], their rising is delayed by one part [degree?] in about [a fifteenth of?] an hour, approximately.

The signs Taurus, Aries [?], Virgo [?], Capricorn [?] [— the reading of this list is uncertain] — since their standing-place [...] [they are] intermediate, standing neither fully on the diagonal nor fully upright opposite the upright line; therefore they do not differ greatly in their march from the arc of the upright line, only delaying a very little in their rising. And because of this near-equality they are reckoned within the general class of the "crooked" risings.

The upshot that emerges from our words on this matter is: there are eight signs that incline [from the upright], namely Aries, Taurus, Virgo, Libra, Leo [?], Pisces, Capricorn [?] and Aquarius [— the list as printed reads טלה שור בתולה אריה מאזנים בתולה דלי, which is corrupt; flagged], for they all incline toward the diagonal, and so they are reckoned within the general class of "crooked" risings, settings, and the quarter [of the year that is] crooked. [And there are] four other signs — Cancer, Gemini, [...] up to Sagittarius — which, since they do not incline toward the diagonal, are reckoned within the general class of upright risings and settings.

Siman 118 (סימן קי"ח) — Explanation that the portions of the signs vary [in their rising] with the portions of the upright line

[Body heading p. 80: "סימן קי"ח — ביאור שישתנו חלקי המזלות [בעלייתם] עם חלקי קו הישר"]

Know that for the inhabitants of the upright [equator], the portions of the signs equalize, day by day, with the portions of the upright line, at four places of the zodiac sphere — the same places where the day and night are equal: namely, the two equinoctial points, which are the heads of the signs Aries and Libra [קו"לי — i.e. ראשי מזלי טלה ומאזנים], and the two places where the Sun stands [at the solstices], which are the heads of the signs Cancer and Capricorn. What one [portion] lacks, the other supplies; for at the signs Aries and Libra, the diagonal [ecliptic] anticipates [the upright], and their rising is less than two hours, so that by the end of the signs Gemini and Sagittarius they become equal again [?]. There [at Cancer/Capricorn] the upright manner anticipates, and their rising is delayed more than two hours [?]. The same law holds for the two quarters that follow, those that are delayed — for as at Cancer, [so] Capricorn anticipates the rising of the upright line; and at the end of the signs Virgo and Pisces, where [the rate] changes, the upright line is delayed in its course according to the same measure as it had earlier anticipated.

Siman 119 (סימן קי"ט) — The order of precedence and delay according to the order of the four quarters of the sphere

[Body heading p. 80: "סימן קי"ט — סדר הקדימה והאחור ע"פ סדר ארבע רביעי הגלגל"]

In the first quarter, Aries hastens; Taurus [is] about equal; Gemini delays. In the second quarter, Cancer [delays] — Leo about equal — that of [...] Virgo hastens. In the third quarter, Libra [hastens]; Scorpio about equal; Sagittarius [...] about equal [?]. In the fourth quarter, Capricorn delays; Aquarius about equal; Pisces [...]. As the law is for their rising, so the law for their setting [is the reverse]: that which hastens in its rising hastens [delays] in its setting, and the law of precedence and delay [in rising holds in the reverse] in their setting; and so

likewise is the law, in precedence and delay, for their passage across the noon-line.

Siman 120 (סימן ק"כ) — A small table [showing] how many degrees, and how many fine-parts [arc-minutes, דקין], the rising of every sign takes, whether upright or crooked

[Body heading p. 80: "סימן ק"כ — לוח קטנה כמה מעלות וגם דקין כמה שעות ודקין עליית כל מזל הן ישרה הן מעותות"]

To present before you a small table in which you will find the rising — both the upright and the crooked — [showing] how many degrees each sign anticipates or delays, reckoned at the rate of 15 degrees per hour. And I will explain to you one entry of it, from which you may understand the rest of the rows. It says: the sign Aries rises in full, at the time of the rising [of the corresponding portion] of the upright line, in [...] degrees and [...] dekin [arc-minutes] [?], and these rise in [...] minutes [?] of the hour. And likewise the rest.

Table — "The rising of the signs" (עליית המזלות).

Parsing notes: This is a numerical table, transcribed below as a markdown pipe-table per the table rule. The table reads right-to-left in the source: the rightmost column is the row-label column, and the twelve data columns are the twelve signs running from Aries (rightmost) leftward. The body cells are in heavily degraded Hebrew-numeral type and are largely illegible at the available resolution; nearly every numeric cell is flagged. (numeric body almost entirely [?]).**

Row \ Sign (R→L: Aries first)	Aries	Taurus	Gemini	Cancer	Leo	Virgo	Libra	Scorpio	Sagittarius	Capricorn	Aquarius	Pisces
מעלות (degrees)	[?]	[?]	[?]	[?]	[?]	[?]	[?]	[?]	[?]	[?]	[?]	[?]
דקות (arc-minutes)	[?]	[?]	[?]	[?]	[?]	[?]	[?]	[?]	[?]	[?]	[?]	[?]
* (asterisk row — function unclear, possibly	*	*	*	*	*	*	*	*	*	*	*	*

Row \ Sign (R→L: Aries first)	Aries	Taurus	Gemini	Cancer	Leo	Virgo	Libra	Scorpio	Sagittarius	Capricorn	Aquarius	Pisces
a mid-table separator/marker)	[?]											
שעות (hours)	[?]	[?]	[?]	[?]	[?]	[?]	[?]	[?]	[?]	[?]	[?]	[?]
דקות (minutes of time)	[?]	[?]	[?]	[?]	[?]	[?]	[?]	[?]	[?]	[?]	[?]	[?]

[From the body text, the worked example for Aries gives values that I read only partially: Aries rises in full in about "[?]יג" degrees and [?]נא dekin" and "[?]נג

dekin of an hour" — all flagged [?]; do not rely on these without a further review.]

Siman 121 (סימן קכ"א) — The laws of precedence and delay in the marches of the signs, for the inhabitants under [the line] of the crooked [signs]

[Body heading p. 80 (continues onto next batch): "סימן קכ"א — דיני הקדימה והאחור במצעדי המזלות ליושבי תחת המעוות"]

Know that everything we said above regarding the precedences and delays and differences found in the marches of the signs applies strictly to the dwellers under the upright line; whereas for the dwellers under the crooked [oblique] [signs] [קו המעוות], the matter goes otherwise. There are other [signs] [...] that anticipate [...]. With them you should know that the precedence and delay that apply to the upright line are only a small matter, for the greatest difference does not reach five degrees, so that [even between] the swiftest sign of all and the most delayed sign of all, the difference between them is not even a third of an hour. But for the dwellers under the crooked [line], between the precedence and the delay there will be a great and substantial difference, close in proportion and measure to half the length of a sign…

Section 5 (שער ה) — continued

Siman 122 (סימן קכ"ב) — The Setting of the Signs (ירידת המזלות)

[The page opens with a table headed by the section title שער ה ("Section 5") and the rubric ירידת מזלות ("Setting of the Signs").]

Table: The Setting of the Signs (ירידת המזלות) — for Prague. This is the table announced for siman 122. It tabulates, for each of the twelve zodiacal signs, the time taken in setting (descending below the horizon). The table reads right-to-left in the source; the logical column order — the twelve signs running from Aries through Pisces — is preserved below. The column headers are written vertically and are partly degraded; each header names a sign of the zodiac. Four data rows

follow under the signs. Many cells are heavily degraded single-letter Hebrew numerals; they are transcribed as best read, with `[?]` where the letterform cannot be resolved at this resolution.

The twelve column headers (right-to-left in source = signs in zodiacal order):

(1) Aries טלה	(2) Taurus שור	(3) Gemini תאומים	(4) Cancer סרטן	(5) Leo ארי ה	(6) Virgo בתולה	(7) Libra מאזנים	(8) Scorpio עקרב	(9) Sagittarius קשת	(10) Capricorn גדי	(11) Aquarius דלי	(12) Pisces דגים
(Row 1) [degraded numeral, ~כ"ב/כ"ז?] [?]	[?]	[?]	[?]	[?]	[?]	[?]	[?]	[?]	[?]	[?]	[?]
(Row 2) ח [?8]	[?]	[?]	צ?/o [?]	o [?]	o [?]	[?]	[?]	] ח [?8	[?]	[?]	] ח [?8
(Row 3) [?]	[?]	[?]	[?]	[?]	[?]	[?]	[?]	[?]	[?]	[?]	[?]
(Row 4) [?]	[?]	[?]	[?]	[?]	[?]	[?]	[?]	[?]	[?]	[?]	[?]

Parsing notes: The table is severely degraded — the vertical column headers are legible enough to confirm they are the twelve signs in order, but the great majority of the numeric cells cannot be resolved at the available resolution. The structure is four rows of twelve columns. **This table for further high-resolution recovery.** The four rows appear to parallel the ascension table of the prior batch (right ascension / oblique-related quantities for the signs and their setting durations), but the values cannot be confirmed here.

[Continuation of siman 121 / lead-in to 122]

A small note (הערה קטנה). Know that everything we have said above regarding the ascensions of the signs and their "marches" (מצעדי) applies equally to the setting of the signs and their descent. Just as we discussed this at length for the inhabitants under the right (upright) line, so too should you understand it for the inhabitants of the various climes (אקלימים) whose northern pole [of the world] lies tilted toward them. [The behavior of] the signs' setting in such a country is among the most remarkable and wondrous things. [?]

Then know that just as one of the twelve signs ascends above the horizon each day, six signs stand above the horizon and six stand beneath it. As one sign rises [in roughly] one hour, [another sets]; the signs are arranged in pairs — one ascends "before" and one ascends [after]. There are some [signs already risen] before a given one, and one rises before others. [?] The six signs that remain above their horizon do not all set from it [at once]; from each of them something descends, while the six other signs that follow rise. From now on, I shall explain to you these four matters in order [i.e., the four points illustrated by the four small diagrams below].

Diagram. A small schematic figure (one of a series of four small inset figures distributed across pp. 81–82) accompanying the four explanatory points. It depicts a great circle (the celestial sphere) divided by the horizon line into an upper half (above the horizon) and a lower half (below). The accompanying prose reads: for inhabitants under the right (equatorial) line, every day each one of the twelve signs is seen [crossing], with half of it above the horizon and half below the horizon. The figure is too small and degraded to resolve individual point-letters. [?]

The accompanying text: For the inhabitants on the equator (those dwelling at the meridian/right line), every day each of the twelve signs is seen [in turn], with half of it above the horizon and half beneath the horizon.

[**Inhabitants at 66° north — the second figure.**] For those dwelling north of the equator at latitude 66°, the [pole] is raised some 70° [?] above the horizon — these are fine [degrees]; therefore they are near the northern pole [?]. They are likewise [at] 51° [?] of latitude, like the people of the chief cities of [England — אנד"לאנד = England?] [?], and the dwellers within the cities of Sweden (שוויד"ן [Sweden]) and [Norway / Norwegen — וכורוזיג"ן? [Norway?]] [?] — as has been explained — all of them [dwell] under the polar circle, that is, the northern circle. [?]

The point of their zenith touches... [?] forever. And because it has already been explained above, in chapter [section] two, [?] that the northern... is only a mark [trace] of [?]... When the celestial sphere lies [in such a position], then the pole of the signs stands [fixed] at one place upon the northern pole. From this it follows that every day and every day [continually] there is found at one instant [the moment when] the circle of the signs [lies] opposite the zenith of each and every one of the aforementioned people dwelling beneath [it]. As has already been explained above in the second section regarding... [?] for a person, that is, the point of his zenith is the axis (ציר) of the circle of his vision. [?]

It follows that at that instant in which the axis of the points of the signs [is at the zenith], the middle [center] of the signs — which is the ecliptic line (קו הלקות [the ecliptic]) — will be [coincident with], and its horizon will be the ecliptic line for them; the ecliptic line and their horizon will [coincide] together. [?] One who sees their horizon at that moment will imagine that the ecliptic line is, as it were, [identical to] his horizon forever — though this is not so; it is so only for that one hour [instant], at which moment their horizon will [coincide with] the ecliptic. At that instant they will have the head of Aries [טלה] at the point of the eastern center [point of due east] and the setting sign [at due west]; Cancer (סרטן [Cancer]) [?] at the center [zenith]; Capricorn (גדי [Capricorn]) at... [?] at the center; and [the sign] at the center of the south [and] at the center of the north [?]. At that moment all twelve signs will be seen, each and every one of them, half of it [above] the horizon and half beneath, with six of the twelve signs above the horizon and six beneath their horizon. They do not at that instant emerge from the line of the horizon either upward or downward at all — not even by a hair's breadth. [?]

Diagram. The second small inset figure. It illustrates the case of the heads (zeniths) of people dwelling under the polar (northern) circle, when the axis of the signs mentioned above [stands at the zenith]: one of the six signs is rising above the horizon while six [others] set from it within one hour. The figure is too small/degraded to resolve point-letters. [?]

Accompanying caption-text: When the axis of the aforementioned [circle of the] signs [stands at the zeniths] of the heads of people dwelling under the northern circle — one of the six signs rises above the horizon, and six set from it in one hour.

[**Third point.**] Know now that at the moment their vision [horizon] is no longer along the ecliptic line — that the ecliptic line no longer coincides [with their horizon] — once their horizon ceases [to lie along it], the horizon cuts the ecliptic line into two parts. [?] At that moment the rule for both great circles [is as follows]: from the head [of]... to the end [tail]... [?] one half of the signs is rising above the horizon at once, while the six signs opposite them set at once. [?] You should further know that in the [places] nearby [under] the northern circle, no single sign of Capricorn [גדי] [?] — that is, for the inhabitants [under it] — fully [ascends]; rather more than half of it descends [?]... and the sign Cancer (סרטן), its opposite, descends below them entirely, [while] what does not [descend] of it [remains] for them above the horizon forever. [?] But the rest of the signs rise for them and [set] for them forever. All these matters are plainly perceptible by [observation with] the [armillary] instrument or the [armillary sphere — הספירא? = the sphere instrument] [?], for which it is impossible [adequately] to depict upon the [flat] page.

[top]

Diagram. The third small inset figure. It illustrates: of the [twelve] signs, six rise [in turn] for [these inhabitants] forever, while the [other] six beneath [the horizon] set; [the signs] rise and set in reversed order. The figure is too small/degraded to resolve individual point-letters. [?]

Accompanying caption-text:... the remaining [signs]; six rise above the horizon forever, and six set beneath it — rising and setting in reversed [order].

[**Inhabitants at latitude tilted toward the northern pole, ~70°.**] For those dwelling [north] of the right (equatorial) line and tilted toward the northern pole [by] some 70° [?] of latitude — such that, as stated above, the [pole/axis] is raised 70° [?] for them (as [explained] above in siman 48) [?] — and [where] the axis recedes from the point opposite their zenith by only twenty degrees: such as the people of the lands like [Greenland — מדינות גרא"ן? = Greenland?] [?] and [England — חאנג"ל? = England?] [?]. For those people, three of the twelve fixed signs remain forever [removed/lost] from their horizon — namely the sign Cancer (סרטן) and the two signs on either side of it (which are Gemini תאומים [and Leo אריה]) — and the three signs opposite these (which are Capricorn גדי and the

two signs on either side of it, namely Sagittarius קשת and Aquarius דלי) are hidden from them beneath their horizon forever. There remain six signs that both rise and also set for them.

Among these are found things astonishing and most wondrous: the three signs Pisces (דגים), Aries (טלה), and Taurus (שור) rise for them in the reverse of the order and manner of their rising for the rest of the inhabitants of the world. For there [in those lands] Taurus rises first, then Aries, then Pisces; and they set [as follows]: Pisces [first] in their proper order, then Aries, then Taurus, then [Pisces? — text repeats] [?]. The three signs opposite these — namely Virgo (בתולה), Libra (מאזנים), Scorpio (עקרב) — rise [reversed] and set [reversed] in [their] order: Scorpio first, then Libra, then Virgo.

The reason for all these matters: know that the signs Gemini, Cancer, and Leo (תאומים, סרטן, אריה) remain above the horizon for them forever, because of their height (גובה) and their tilt toward the more-northern side; therefore, since all the other signs [behave] by reason of the change of the tilt of the line [of the ecliptic relative to] their horizon, the aforementioned signs remain above their horizon forever. And the three signs opposite these — namely Capricorn (גדי), Sagittarius (קשת), Aquarius (דלי) — since they tilt toward the southern side and are lower and farther [removed] from the inhabited region surveyed [from the north], are therefore hidden from them forever.

And because [of this]: the signs Pisces, Aries, and Taurus (דגים, טלה, שור) [?] rise for them in reverse order. Because the sign Taurus tilts more toward the north than the sign Aries, therefore it appears above the horizon first — Taurus before Aries, and Aries before Pisces. And the same reasoning [applies] to the signs opposite these — pay attention to the [signs] of [the ecliptic]: [?] because the sign Scorpio is the more southerly and the farthest removed from the north of them all, it sets first [in setting]; after it the [sign] Libra sets; and the sign Virgo, which is the [highest] for them and tilts most toward the north, it sets last of them all.

All these matters it is impossible to depict upon the [flat] page, nor will a writer's pen suffice for the beginning student of this science to explain and elucidate it in words. [?] But to demonstrate it to the [armillary] instrument-maker is an easy thing... [?] for [him] to demonstrate to the student [?]... that a sphere upon which the [pole] is raised some 70° above the horizon [?], and which you rotate, [or] the very eye [of an observer], will see by direct perception all the aforementioned matters with the instrument's [own] eye, without any trouble at all.

And you should know that all we have said is [stated] according to the path and rotation of the fixed signs as they are pictured as fixed in the ninth sphere (גלגל התשיעי [the ninth heaven]). But if you seek [to verify] this with a sphere [model] constructed according to the signs themselves — that is, the [constellations] which are the figured living-creatures (בעלי צומח? = the figured forms) fixed in the eighth sphere (גלגל השמיני [the eighth heaven]) and visible to our eyes — you will find that the signs Taurus, Gemini, Cancer (שור, תאומים, סרטן) remain forever above the horizon and [draw near] [?]; Sagittarius and Capricorn (קשת, גדי) are hidden; Aquarius, Pisces, and Aries (דלי, דגים, טלה) rise [reversed]; and Leo, [Virgo] in [their] sign [?] [rise reversed]; [and] Libra (מאזנים) [and the rest] remain [reversed]. [?]

Diagram. The fourth small inset figure. It illustrates the case where, of the [twelve] signs, four remain forever above the horizon and four forever below, while [the remaining] portion — six [signs] — rise above the horizon and six [are] beneath it, [some] always [visible] and [some] always [hidden]. The figure is too small/degraded to resolve individual point-letters. [?]

Accompanying caption-text:... that for some [of them] four signs remain [above], and for some of them six rise above their horizon while six [are] below it always.

[**Inhabitants midway between equator and the polar regions.**] And know further that for the places midway, those removed [some 50°? — degraded] from the equator [?], we find that there are four signs — Taurus, Gemini, Cancer, Leo (שור, סרטן, תאומים, אריה) [?] — that remain above their horizon always and never set from them; and the four signs opposite them — namely Sagittarius, Capricorn, Aquarius, [Pisces?] (קשת, גדי, דלי) [?] — are hidden beneath their horizon always. [Of the remaining signs, six rise:] Aries, [Taurus,...] (טלה...) [?] — six signs rise for them, [namely those abbreviated] בא"ב טס"ח [acronym for the six rising signs] [?], remaining above their horizon; and six signs set, [namely those abbreviated] גד"ד גע"ק [acronym for the six setting signs] [?], hidden beneath their horizon forever. All of this you will be able to see — and it will be clearly illustrated for you in the work of the [armillary] sphere — in the section nearby [later], in simanim 145–147 (קמ"ז–קמ"ה). [?]

Siman 123 (סימן קכ"ג) — Reckoning the Ascensions of the Signs at the Horizon: Eastern (Evening) Ascension and Morning Ascension (חשבון עליית המזלות על האופק מצד עליית ערבית ומצד עליית בוקרית)

Know that for each sign — and likewise for each [planet/star] — we find at the horizon two kinds of ascension: the first is called the **evening ascension** (עליית ערבית), and the second is called the **morning ascension** (עליית בוקרית).

The **evening ascension** is when a sign rises then on the eastern horizon shortly after the sun has already set below the western horizon. This ascension is called the **visible ascension** (עלייה נראית), since for it we need no reckoning, instrument, or sighting whatever — the matter is what is seen by the eyes, as plain as anything in the world.

The **morning ascension** is when a sign or a [planet] rises together with the sun upon the horizon. Then the sense of sight cannot apprehend that ascension, because of the obstruction of the sun's brilliance to the eye; rather, only the intellect testifies to it by way of reckoning. Therefore this [morning] ascension is reckoned by way of calculation; hence it is by analogy [called the rational/computed ascension]. Therefore know that this ascension is an **apprehended** [computed] ascension (עלייה מושגת), since it is apprehended only in the intellect. Therefore know, in order that you may reckon the ascensions of the twelve signs — of Aries (טלה) on the first of Nisan, of Taurus (שור) on the [27th of Iyar?] [?] — that all this foregoing reckoning is according to the reckoning of the morning ascension, which is an apprehended [computed] ascension.

Siman 124 (סימן קכ"ד) — On the Ascension of the Twelve Signs in a [Single] Year, and Whether This Constitutes the Rotation of the Sphere of the Signs (מעליית י"ב מזלות בשנה ואין זה מצד כבוב גלגל המזלות)

Know that [as our Sages, may their memory be a blessing, said — ר"ח?] [?] [Rashi script / gloss-form abbreviation] in the days of the year — and every day there is a... [?] — that at the true [vernal] equinox (תקופת ניסן האמיתי), which is the beginning of spring, the head of the sign Aries (טלה) rises on its day above the horizon first.

And so [it continues]: on the [day] the head of Taurus (שור) rises [above] the horizon first... [?] And so on the new moon (ר"ח) of Sivan the head of Gemini (תאומים) rises first; and so on the new moon of Tammuz [the head of Cancer rises] above the horizon first. [?] And so [run] the rules of the ascension of all the signs — [a fresh] sign at the head of [each] month [?] — until the end of the year, [which is] the new moon of Adar, [when] the sun [is] in the sign Pisces (דגים), [and] the head of the sign Pisces rises first; and [on] the following new moon, the sign Aries returns to rise above the horizon first [at] the beginning [of the cycle]. And so [it returns], by this [pattern], the matter recurring forever.

You should know that, even though it appears as though each month a fresh sign rises above the horizon, do not reckon this to mean that the sphere of the signs itself rotates and turns the matter of the world around once each year. For this is not so. For the sphere of the signs itself — according to the careful reckoning and scrutiny of all the later sages — does not turn the celestial sphere about the body of the world by its own motion, except by some 54 [degrees? years?] [?] in [a long span], as will be explained to you [later] at the end of this section.

Rather, the cause that produces the matter of the ascending and the rising above the horizon of [a fresh] sign each new month is the motion of the sun (סבוב החמה) — through its own essential motion (מהלכה העצמית) toward the east each day, [advancing] close to one degree above [the prior day's place], as will be explained, God willing. For if the sun stood always at one place [in the heavens], then, just as [the head of] Aries [rises] at the [equinox] above the horizon at its zenith by the diurnal motion, it would follow that each day forever the head of this sign Aries would rise above the horizon, and it would neither begin nor cease, nor [vary] its ascension ever. But because of the second motion [the sun's own eastward motion] — when the sign Aries rose above the horizon [on the second day], it did not find the sun [there], for the sun had already departed in this month-span [the span of one solar mean motion] by some thirty degrees of its own essential motion eastward, [arriving] at the head of the sign Taurus. Therefore [Aries] does not [appear to] rise [alone] above the horizon; rather, [by] the diurnal sphere [carrying] the sphere of the signs around these thirty degrees, that place — between the head of Aries and the head of Taurus — [rises], until the sun [on] the new moon of Sivan rises above the horizon together with the head of the sign [Gemini], and so on by this [reckoning] its rule [runs] until the end of the year, the matter recurring forever.

There you have the cause why a fresh sign rises above the horizon each new month — it is the rotation of the sun, not at all [the rotation] of the [sphere of] the signs.

Or [you may] reckon it by another way: when, on the new moon of Nisan, the sun rose [and] Aries [rose], the head of the sign Aries [rising] together with the sun, on the first degree [of Aries], above the horizon first — then behold, on the morrow, on the second day, when the head of Aries rises above the horizon, the sun will not be found there at the head of the sign, for it has already departed by its essential motion [by] one degree [more]; therefore the sun will rise on that [second] day above the horizon on the second degree of the sign Aries, and on [the third] day [the sun] will rise above the horizon together with the third degree, and so on from day to day until the completion of the thirty days [of the month], when [the sun] rises together with the head of the sign Taurus, as above.

You should know that all we have said is the approximate reckoning, for the sun does not rotate exactly one full degree each day; rather, in thirty days [it covers] thirty full degrees, while in the [whole] year, which is 365¼ days, it rotates 360 degrees — for which reason the reckoning does not yield a full degree per day, but only some 59 minutes [59 = נ"ט] [?] [of arc] in [a degree's] rotation [per day], with about 8 seconds [8 = ח' שניות] [?] approximately, as will be explained in section [9?] [?] siman 285 (רפ"ה) [?]. And besides this there are still [other] matters [showing] that the aforementioned reckoning is not [exactly] precise (הצמצום), as will be explained.

Siman 125 (סימן קכ"ה) — The [Times in which the] Signs March [Across the Horizon], that the Reckoning Is Not Exactly the Same for Every Inhabitant of the World (שזה אינו בצמצום שוה לכל יושבי חלד)

The [fixed] times in which the signs march across the horizon, as above, contain [a source of] perplexity and great doubt in this matter.

What [the Sages] said — that on the new moon of Nisan [the sun is at the head of Aries], or at the true [vernal] equinox (תקופת ניסן האמיתי) the head of the point of Aries rises together with the center of the sun above the horizon first — you should know that this reckoning is not exact in every year. For the sun does not enter the head of the sign Aries in every year specifically at the beginning of the day, at the moment of the sun's ascension above the horizon. On the contrary, this matter occurs in only a few of the years; for sometimes the sun enters at the

beginning of the night, or at its third, or its fourth [watch], whether by day [or by night] — sometimes a number of hours before these [reckoned] times, and a number of times after them.

You should also know that this matter is not the same for every inhabitant of the world. For when the reckoning came out for us that the sun rises above the horizon together with the first degree of the sign Aries (say), we need to know for which country this reckoning was established. If we say that this reckoning was established for the inhabitants at the eastern edge — for them it [would be] the beginning of the morning [day]; then at that moment it would be midnight for the dwellers at the navel of the earth [the central meridian], and for the dwellers at the western edge it would be the beginning of the night. And when, after this, the sun rises for the dwellers at the western edge above their horizon, then surely the head of the sign Aries has already preceded [it] and risen above their horizon before the ascension of the center of the sun by about one part in thirty [1/30] of an hour [as reckoned] for the easterners. [?]

The ascension of the sign will appear to begin twelve full hours earlier for the westerners; nonetheless, when they look at the parts [degrees] of the sign, there will be no difference between them in its ascension except about one part in thirty of an hour. This is because when the sun rotates half the sphere of the world in thirteen hours [?] — for the sun has not [yet] rotated, in its volitional [diurnal] motion, [more than] from east to west, to descend from the head of the sign Aries by only about half a degree of the 360 degrees of the sphere; and the time of the rotation of half a degree by reason of the diurnal sphere (its rate being some 15 degrees per hour) is about one part in thirty of an hour. [?] There will still be found a slight difference, very small, between the dwellers in the north and the dwellers in the south, since the rising of the sun is earlier for the dwellers in the south, as will be explained below in siman 152 (קנ"ב).

Siman 126 (סימן קכ"ו) — The Time of the Rotation of the Sphere of the Signs (מזמן סבוב גלגל המזלות)

Concerning the time of the rotation of the sphere of the signs there are [a source of] corruption of reckonings and disputes and differing opinions among the ancient sages, and there is a great difference among them — more than [for] any other rotation of [a] sphere of the heavens. The reason for this is the long, heavy, slow motion that this sphere has, and [that] the days of human life are too short to wait, to observe, and to test it by experiment. Even if a man were to live a hundred years, the whole span of his years would not suffice to observe and to

test this sphere's motions [as it moves] from one degree of the 360 degrees of the sphere.

The Sages of blessed memory already said something great [on this] (in the Yalkut, Bereishis, [chapter 26 / siman ?] [?], folio 23, which the Yalkut Shimoni brings) — that the ancients labored for some 23 days [?] [recte: years] in order to test the cycles of the signs. [?]

And I have found it written that the early sages who lived in their days [?]... before Abulafia [?] [אבלג"ס = Abulafia? / al-Battani?] and the ancients before [him], and from [their] times...

[the ancients] sensed this motion forward and backward — that the sphere [moves] without any uniform motion. The sages who came before the ancients [?] — the [Greeks — קלקירמי"דו"ם? = the geometers/Greek mathematicians?] [?] Archimedes (ארקמידו"ס [Archimedes]) and [Hipparchus — אברכ"וס = Hipparchus] [?] — sensed some motion in it, but we do not find in their words that they gave any measure or fixed time for its rotation, until [the time] when Ptolemy (בטולמי"אוס [Ptolemy]) came — the foremost of the writers on astronomy — and he sensed a motion in it; but because he had not the leisure to scrutinize its [exact] amount, he therefore made a coarse estimate ([by] dream/conjecture) [?], even though he himself knew that this estimate was not exact and precise. And after [establishing] that the motion of this sphere [is] from west toward east by about one degree in a hundred years according to [his] reckoning — [a rate by] which this [sphere] would not complete its rotation from point to point until 36,000 years had passed (a thousand years after [each] hundred — by the count 36,000) [?] —

[that is, the sphere of the signs] would complete its rotation in **36,000 years**. With this reckoning the Arab sage al-Battani (חלכתינ"י [al-Battani]) [?] agreed; and [Ptolemy] examined all the ancient reckonings of [the early astronomers] — of Hipparchus (אבר"כוס [Hipparchus]) [?], of Ptolemy [himself], and others — and found, by [careful] examination [comparing] their data, that in every hundred years [the sphere] shifts one and a half degrees [1½°]; according to which reckoning the sphere of the signs would complete its rotation in **24,000 years**. With this reckoning almost all the sages, the ancients and the later ones, agreed and held fast, down to this day.

And behold, Rambam (הרמב"ם [Maimonides]), of blessed memory, in [Hilchos Kiddush HaChodesh], chapter 3 (פרק ג [קידוש החודש] בה'), wrote that the rotation of the sphere of the signs is one degree for every seventy years, according to

which reckoning this sphere would complete its rotation in 25,200 years (כ"ה אלפים ומאתים שנה [25,200]). [Verification: 70 years/degree × 360 degrees = 25,200 years — arithmetic checks.] And this is a great approximation, close to the reckoning of Rambam, of blessed memory.

And I, the writer, heard from the mouth of the lawful [authority] — the renowned sage, the foremost astronomer of our generation, [Tycho Brahe — הי"כרא? = Brahe?] טי"חא [Tycho?] [?] — that he scrutinized all the reckonings of the ancients with great and ample scrutiny, and found that the rotation of the sphere of the signs [is] in every year, by a close approximation, twenty-one seconds [כ"א שניות = 21] [?]; according to which reckoning this would reach, per hundred years, [a value of] 35 minutes [פ"ה? / נ"ה? = 35? / 55] [?] [of arc], which is 1 degree 25 minutes [מעלה א' כ"ה דקין] [?] [per ?]; and according to this reckoning this sphere would rotate one [full] rotation in about 25,000 years ([25,000] כ"ה אלפי') [?], by a great approximation. And [there are] 411 years ([411] תי"א שנה) [?] difference, by a close approximation, [from] the reckoning of Rambam, of blessed memory.

You should know that I have found in the words of [R. Yitzchak] HaYisraeli (החכם הישראלי [the sage Yisraeli — author of *Yesod Olam*]) [identification disputed — flag] a matter both great and most wondrous, hard to picture. For in the sixth chapter [?] of the second treatise (מאמר שני), he wrote that, after the [aforementioned] sages Ptolemy and al-Battani, there arose the scholars of the Ishmaelites [Arabs] — such as Abraham al-Zarqali (אברהם הזרק"יל [al-Zarqali / Azarchel]) [?] and his colleague, who was in the city of Toledo (טוליט"לא [Toledo]) [?] — and [they held] that the sphere of the signs does not [perform] a complete [uniform] rotation around the whole life of the world; rather, only [that] for one [span] — a known, long time — the sphere of the signs shifts [a portion] toward the east, and on another occasion [for] another known, long time this sphere shifts [a portion] toward the west, [the constellations] rolling [back and forth]. He elaborated greatly on this there in his book, and concluded that this is a correct and well-founded matter; and these later [scholars] gave their reckoning [of it], and [held] that this sphere of the signs [moves] in a [trepidation]. And I, the writer, inquired about the aforementioned motion [from] the sage Julius [?] [יהכי"ם? יזולירו"ס? = Julius?] [?], the foremost of the sages dwelling before the Duke (דוכס) of Mark, [Margrave] of Brandenburg (מבראנדינבור"ג [Brandenburg]) [?], and he replied to me that some [account] of this motion is found in their language: the [Latins — מהטי"ם? = the Latins?] [?] call it [trepidation — טריפיציאני"ם = Latin: *trepidatio*, "trembling"] [?], that is, a motion of trembling and quaking (פי' תנועה של רתת ורעדה) in [the eighth sphere] [?]...; and in his [reckoning] it rotates in seven thousand years (בשבעת אלפים שנה [7,000]) [?] [the cycle of trepidation] —

[וקוועגונ"ג גי"זאיציט"ר = German: *Bewegung des Zitterns/Gezitter*, "motion of trembling"?] [?]. But this [trepidation] motion does not nullify the motion of al-Battani (אבצתיינו"ס [al-Battani]) mentioned above, for the motion of the sphere of the signs [remains] one and a half degrees in every hundred years, [each] in its [own] place. And at present I cannot speak [further] of it, for I have not [worked through] its constructions [demonstrations], until [the time] when I [shall] investigate it [more] fully.

> **Editor's note** The index (TOC) lists simanim 127–131 as distinct entries — 127: rising of the 12 constellations during the year (does not vary with the sphere's revolution); 128: rising-arcs (mitz'adei) not equal through the year for inhabitants of one clime; 129: the "swing" (mezon) of the sphere of the constellations; 130: why we cannot tell the stars have shifted over years; 131: on the host of the sixth sphere. On the heavily-degraded pp. 83–84 these simanim are collapsed/merged in the print and could not be unambiguously separated or numbered across four verification passes (the ר"x/רי"x and worn-rubric readings conflict). **By index-topic, the body below — the "host of heaven shifts over many years" precession/zenith material — corresponds to siman 131**, and the preceding precession-rate dispute (Ptolemy 36,000 / al-Battani 24,000 / Rambam 25,200 / Tycho / al-Zarqali trepidation) carries the 129–130 content. The first-pass "siman 127" label is retained here only as a positional marker; the true segmentation of 127–130 is a **higher-DPI rescan candidate** (see `.md`). A prior recovery (``) supplied topical reconstructions for 128–131 that the definitive reconciliation found did NOT match the source text — they were therefore NOT spliced, to avoid introducing unverified content.

Siman 127 (סימן קכ"ז) [by index-topic = siman 131, "on the host of the sixth sphere"] — That over the Span of Many Years the Positions of All the Host of Heaven Change for Us (שאחרי שנים רבות ישתנו לנו מצבי כל צבא השמים)

Know that, according to [what was said], the signs which are the figured forms (בעלי הצורות) — that is, the [constellations], the true [visible] signs that appear to our eyes in the eighth firmament — after many years [their position relative] to all the inhabitants of the world will change. Together with [their] sphere, with its rotation and with the rest of the spheres, [there is] a great and ample variation and difference over a long span of [time]. For some of the inhabitants of the

earth, [a given star] now [stands] opposite the axis (ציר) in the eighth firmament, [lying] above their horizon at present (as we mentioned above in siman 27) — yet after many years that same point will be beneath their horizon. And when [that happens], all twelve signs will then [appear] to us [shifted] — to us [it will be] as though they are all northerly, or [as though] the point [now at] the head of Cancer (סרטן) is [now] opposite their zenith, [whereas later] the head of Capricorn (גדי) [will be] opposite their head [zenith], and the figured-form [signs of] Aries (טלה) [and] Libra (מאזנים) will rise [respectively] in Tishrei and in Nisan. [?]

And in order to ease [the matter] for the students, to make them perceive this with a little contemplation and reflection, I shall offer a parable and say: that the people who are at present dwelling under the circle of Cancer (עגול סרטן [the Tropic of Cancer]), which is at 24° [latitude?] [?] from the equator — behold, according to what we explained above in siman 48 (מ"ח), the northern axis is raised above their horizon by 24°, just as [it is by] 24° [for them]. And we have already noted above in this section [?], with respect to the point in the sphere of the signs, that the axis-point of the ascension-sphere [pole of the ecliptic] [stands] at the point [I called]... [?] (which I called above, in the first section, in siman 27, the "axis-point at the zenith") — for [in their case] this [point], like the axis-point, by every rule is judged [the same] in [respect of] the axis-points of the upper sphere.

Therefore, according to Ptolemy's reckoning that the sphere of the signs rotates by about one degree every hundred years [recte: per the figures above], you may now know that when the [sphere of] the signs as a whole rolls about its two axes — which, according to this reckoning, is in **nine thousand years** [9,000] [?] — the [analogous] point marked in the sphere of the signs will have shifted [melted away] from its place. Just as in this [present time] it was higher above their horizon by 24°, [in nine thousand years] it will then tilt toward the east and become level with their horizon; and likewise the southern axis will tilt by 24° toward the west, which is also level with their horizon; and at this time the circle that is [the Tropic of] Cancer (סרטן) — opposite whose head [zenith] [it then stands] — the equator [equinoctial] will then be [there], and after [a further] **eighteen thousand years** ([18,000] י"ח אלפים שנה) [?] [in which] it [continues] to melt away [shift], according to this reckoning, the point will exchange its place once more [for one] better [more remote] in [respect of] the sun, in such fashion that at this time it is above the horizon by some 24°, [whereas later] it will be below the horizon by 24°; and the southern axis-point of the southern axis, which is now 24° above their horizon, will then become for them 24° beneath their horizon. [?]

In the time mentioned, for those people — when the circle [Tropic of] Cancer (סרטן) [stands] at [their zenith] — the circle [Tropic of] Capricorn (גדי) will then be opposite their head [zenith], and the figured-form sign Taurus (שור) [and the rest] will rise [shifted], with Libra and Gemini (מאזנים, גמיני) [rising] in Tishrei [respectively] [?]; and many other variations beyond number, which you will be able to see by direct perception, [by] placing the diameter upon the two axes of the signs at the horizon and rotating the sphere until the [analogous] point comes to be beneath the horizon by 24° — and [the result] will be: according to Ptolemy's reckoning [in] some [years], it will be after **nine thousand years** [9,000] according to al-Battani's reckoning. [?]

Section 5 (שער ה) — conclusion of siman 127 and closing remarks

[continuation of siman 127]

and after about 12,000 years the reckoning will follow al-Battani's calculation [אלבטיני = al-Battani], whereas according to al-Zarqali [כטלחיאז״ס — reading uncertain, likely al-Zarqali [?]] one complete reckoning takes 12,000 years [?]. [The numerals in this clause are degraded; the surrounding precession-cycle figures from siman 127 should be cross-checked against batch 21.]

In sum, from the matters already mentioned in chapter 11 [siman 11] of the first Section, where it was explained that all seven planets — together with the sphere of the fixed stars [גלגל המזלות, the sphere of the constellations] — are in confused [non-uniform] motion. Therefore, in the place where the sun draws nearest to us at the winter solstice [תקופת טבת], the daytime will be at its very shortest, shorter than on all other days of the year; and conversely, at the summer solstice [תקופת תמוז] the sun grows most distant from us, the daytime lengthens to its maximum, and the day becomes longer than on all other days of the year. So too the seasons themselves: the cold then intensifies for those people, and cold, heat, summer and winter would not keep to their fixed times. Yet this matter is not self-contradictory, for in the end all these phenomena will be found in every place and at every era. Understand this carefully, in accordance with what we explained above.

With the help of Him who built the rib into a woman [a play on Bereishis 2:22 — i.e. "with God's help"].

Some of the sages hold that the sphere of the constellations [גלגל המזלות] — the one discussed just here — at one time rotates its surface toward the east and at

another time rotates its surface toward the west, and that it does not make a complete revolution like the rest of the spheres in the whole span of the world's existence. According to this view, the variations [in the constellations' positions] discussed [in siman 127] will not occur within the host of the heavens. Yet — as we explained — even granting them this trembling, quavering motion (a motion that is not a complete revolution of the sphere of the constellations), it necessarily follows that most of the changes already mentioned will be found within the host of the heavens. In a place such as this, the ultimate truth of our words we do not know, nor can we render a definitive judgment on the matter, for our grasp is short, and like sheep we have strayed in this. And in my opinion, this too we may say regarding the seventh treatise [מאמר השביעי], as stated above in siman 25 [כסי' כ״ה] — that the matter is exceedingly difficult, and it is impossible for created beings to settle it with certainty over many years.

We have completed five Sections. [: השלמנו שערים חמשה]

Section 6 (השער הששי) — Section heading, p. 85

The Sixth Section [השער הששי].

In it is explained: the declination of the sun [נטיית השמש] from the equinoctial line [מקו השוה], and the circles it traverses [ומקפ"ב עגולי — the circles it goes around twice], together with the variations found in this regarding the lengthening and shortening of the days, and the wondrous variations found among the inhabitants of the earth in every place and at every time of year; also the precedence of the daylight hours for those in the east and their delay for those in the west, and for those in the north over those in the south; and other great and wondrous matters besides these.

The sun's "circuits" [גלילי השמש] — in the language of the gentile scholars called פאל״א [pal'a / parallels (Latin *parallela*)] [?] and "girdle-numbers" [מספרי הגליל] mentioned [in the figures above] [Greek/Latin term garbled in transmission — likely "parallels of latitude"; read with caution [?]] — these we shall now explain and make known to students, to clarify the nature and order in which these circuits are produced, beginning from the head of Capricorn [ראש מזל גדי], when the sun is then [at its lowest].

Siman 132 (סי' קל"ב)

In it we shall speak of the declination of the sun [נטיית השמש] from the equinoctial line — called in the language [of the gentile scholars] דיקלינ"ציאניס [declinationes,

"declinations"] — and of the circles it traverses twice in the year [ומקפ"ב עגולי שעושה השמש פעמים בשנה].

We have already clarified above, in chapter 24 [בסי' כ"ד] of the first Section, that every star — that is, each of the 24 [reading "כ"ד" [?] = "24"] — in its course makes, in the daily motion, in each day's revolution… [the text returns to:] every star, in its course, in each day's revolution by the daily motion, makes a revolving circle around one of the two poles of the world [מב' קוטבי העולם]; and the sun too, like each of them, makes one circle each day, from east [around the globe of the world].

Now know from here: had the sun always stood in one place, as do the stars of the eighth heaven [רקיע השמיני], then it would have appeared to us to revolve always upon a single circle. But since the sun, by its own [proper] willed motion [מהלכו הרצוני], travels along the whole circle of the constellations [עגיל כל המזלות] beneath the line of the poles [קו הקטרים, the colure/meridian of the poles] [?], moving from west to east once each year, reaching close to one degree per day — for this reason we do not see the sun rise each day in the place where it rose [the day before], but only about one mil [a unit] removed from it.

When we see it ascend [emerge] from a known southern point [מנקודה דרומית], it makes one circle, or one revolution, around [the globe]. On the second day we see it ascend from another point, close above the first point. And so its course continues each day: it changes its circuit day by day, leaping from circuit to circuit, day after day, in the manner described — yet appearing [continuous].

The circuits [גלילים, here = the day-circles] mentioned are called, in the astronomical [reckoning], "the two [extreme circuits]." [The text:] These are the two day-circuits [שני הגלילים] called by the astronomers… When [the sun] is there — at the head of Capricorn [ראש גדי] — it is at its greatest distance from the inhabited world [מן הישוב], that is, in the extremity of its remoteness. And when it has gone round half the circle of the constellations [חצי עגול המזלות], by way of [traveling] from Capricorn through to Cancer [מגדי דרך טלה עד סרטן] [note: the path Capricorn→Aries→Cancer], it is then at the extremity of its nearness [תכלית הקירוב].

The time of one revolution [סיבובה] in its course [its half-course from Capricorn to Cancer] is half a year, which is 182½ days and a little more [קפ"ב יום ומחצה ועוד מעט = 182½ days, half of 365]. Now by the daily motion, in this stated time, the sun makes 182½ circles and a little more. And by this same process the sun makes the second half-circle on its return from the sign of Cancer through Libra to

Capricorn [מסרטן דרך מאזנים עד גדי] — for in this course too it makes a second 182½ circles, similar to the first 182½ circles — so that the total number of its circuits is 182½ twice, and these are 365 circles [its yearly tally], close to a quarter more [i.e. 365¼] [: שמספר גליליה קפ"ה ומחצה פעמיים והם מספר יחי שנתה שהוא שס"ה עגולים וקרוב לרביעי]. And as the law is for the sun, so is the law for the moon, and likewise for the five planets [חמשה כוכבי לכת] and for the stars of the eighth sphere [כוכבי גלגל ת'], as will be explained later, with God's help.

Siman 133 (סימן קל"ג)

Prophesying and making known [נבא' ונודיע] regarding the sun's day-circuits — that most of them share with one another [are partnered, this with that].

Know that of the sun's circuits, no single circuit is exclusively for itself alone for one day; rather, most of the heads [beginnings] of the circuits are shared. The day-circuits that share with one another in their starting point [נקודת ראשם]…

on the heads [starting points] of these. The signs that share at their heads are the following [the partnered constellations, paired]:

- Aries [ט״לה] with Virgo [בנת״ולה]
- Taurus [שו״ר] with Leo [באר״יה]
- Gemini [תאום״ים] with Cancer [סרט״ן]
- Libra [מאזני"ם] with Pisces [דגי"ם] [reading: מאזנים↔דגים]
- Scorpio [עקר״ב] with Aquarius [ד״לי]
- Sagittarius [קש״ת] with Capricorn [גד״י]

That is to say: the circuit which the sun traces at the head of Aries [ראש מזל אריה — see note] is the very same circuit it traces at the head of Virgo [?]. [The text reads "ראש מזל אריה" here where the pairing-list gives Aries↔Virgo; "אריה" (Leo) appears to be a compositor slip for "טלה" (Aries) given the immediately preceding pairing list — flagged as a numbering/naming anomaly.] [Reason: years differ in their distance [from the solstice]; in the same place the equal distance [equal declination] of the straight line is the same.] And likewise the law for Cancer [סרטן] and the equinoctial line [המעגול שוה — the equator]; and so too the law for the rest [of the pairs].

These partnered signs [המזלות המשתתפים] — this partnership applies specifically at the heads [starting points] of the day-circuits, that is, only at the partnered day-circuits, meaning that they share completely. But the partnered signs mentioned: this Aries which shares its sign with another sign — that other is Virgo [reading per the pairing list; the printed text again shows a Leo/Aries confusion [?]].

These are: Gemini with Cancer [תאומים … סרטן]; Aries with Virgo [טלה … בתולה]; Taurus with Leo [שור … אריה]; Sagittarius with Capricorn [קש״ת … גדי] [?]; Scorpio with Pisces [עקרב … דגים] [the printed pairings here partly diverge from the first list — see anomaly note]; Libra [מאזנים]…

[The text continues:] The circuit which the sun makes when it is at the head of Gemini [ראש מזל תאומים] [?] — they have between them no gap at all; and the circuit it makes at the head [of the partner sign] — the sun, being two degrees from the head of Gemini, is in the [same] circuit; and at 29 degrees from the head [of one sign it equals the circuit at the corresponding point of the other], and so on for Cancer; and likewise [for all the partnered points] until they are equal. So too: for the thirty circuits of Gemini and Cancer — at all thirty degrees of each — the same matter holds exactly for Taurus and Leo, and so too for the rest of the signs mentioned as partnered. This entire partnership is only at the start of the circuits, as has been explained.

From now on, know this: the sun has 365 [reading "שהשס"ה" = 365, the day-circuits] circuits [יום, days] which the sun makes in the whole year by this reckoning. But this is not [exactly] so, for there are only 182½ circles [קפ"ב], except that they are doubled — that is, the sun goes round each circuit and each circle twice per year. Know also that, by this reckoning, when there will be two heads or two parts of the signs partnered together, then the days, and also the nights, of the two [partnered] times will be equal to one another in their measure, by the approximate reckoning, as will be explained shortly.

Siman 134 (סימן קל"ד)

Explaining that the sun's circuits are not complete circles [אינם עגולים שלמי':].

Know that all the sun's circuits mentioned are not complete circles, from point [back] to point [from point to the same point], for every circle grows distant from its beginning to its end. Diagonally [ובאלכסון] this is sometimes close to one degree of the 360 degrees of the sphere [קש"ס מעלות הגלגל = 360 degrees], and sometimes about half a degree — at times to add, at times to subtract. For instance, like this: when the sun rose upon our horizon, at the start [of the day] being at the head of Aries [בראש טלה], and it then revolved by means of the daily sphere [גלגל היומי] around the globe of the world in 24 [hours] [כ"ד], the sun would still be standing at the head of the sign Aries [ראש חול טלה] when [the time came] to rise upon the horizon the next morning. Then it would have completed one full circle — except that, because the sun is also being conducted along

[revolving with] the sphere of the constellations [גלגל המזלות], like one degree on the diagonal [כמו מעלה אחת באלכסון]. Therefore this circuit is not a full circle from end to end [מן קצה לקצה]; rather every circuit grows distant by the breadth of the diagonal on the side of the diagonal, by which the sun, in its course beneath the circle of the constellations, grows distant in one day by one degree from the equinoctial line — or draws near to it.

So picture for yourself the circuits mentioned as if they were a spiral [חוט = thread] wound about [a cylinder] — its windings close beside one another, near every [adjacent] circle — such that in all this winding no circle is complete from end to end; rather each circle grows distant a little from its beginning point.

[Rashi-script gloss, foot of column:] [Gloss: …regarding the sun's circuits… (text partly illegible)… the precision applies only at their beginning. ✻]

According to what we explained above — that the sun's circuits are not complete circles, but [each] withdraws from its end to its beginning — therefore know now that [the statement] "the sun's circuits are partnered" is correct only at their beginning, for immediately these two circuits separate and grow apart, one from the other, more and more remote with every passing hour. Because the circuit beginning at the head of a sign — say the head of Aries [ראש טלה], which is the sign partnered [with another] — proceeds; and after [the sun has gone] 54 minutes [נ"ד] [?] it inclines a little toward the northern side, so that when the sun completes its full circuit (since the sign inclines toward the diagonal), the end of the circuit will be found higher by more than one degree, from its beginning at the equinoctial line, toward the north. And the circuit beginning at the head of Libra [ראש מאזנים] — which is likewise exactly on the equinoctial line — immediately bends a little and turns, and after the order of 24 hours, when it completes its circuit, from that day the end of the circuit will be found more than one degree below the equinoctial line, toward the south. So you have it: between the ends of these two partnered circuits the difference is more than two degrees [יותר משני מעלות שלימי']. And the same reasoning holds for the others: between any two partnered circuits a difference will always be found — even between the circuits of Gemini and Leo [גלילי תאומים וארי' — see anomaly note] there will be 30 degrees [ל"ס מעלות = 30] [?] of difference — between the head of Gemini and the end of the first degree of Cancer, this beside that.

In sum, regarding the matters discussed, it will become clear to you — once you grasp the measure of the days — that the two equinoxes [תקיפות], that of Nisan and that of Tishrei [ניסן ותשרי], are not equal to one another. Rather, in precise

reckoning, a difference will be found between them, by which the one exceeds the other, as will be explained to you later in siman 140 [בסי' ק"מ] [?].

Know this: to recognize that the 182 [reading "שק"פ" = wrong; the figure is the 182½ circuits, see above] circles which the sun makes from the head of Capricorn [מראש גדי] to the head of Cancer [ראש סרטן] cross, meet, and intersect with the 182 circles which the sun makes from the head of Cancer [מראש סרטן] to the head of Capricorn [ראש גדי]. For instance: in this manner — the circuit which the sun makes from the head of the sign Aries [ראש מול טלה] inclines toward the north; the circuit which the sun makes after half a year, at the end of 29 degrees of the sign Virgo [כ"ט מעלה ממזל בתולה], inclines toward the south — so it necessarily meets and crosses the circuit of Aries. And so too for the others, two by two, and likewise for the rest.

Siman 135 (סימן קל"ה)

Explaining that the sun's circuits mentioned are not [all] close, nor [equally] equal and distant from one another, nor [equal in] their diagonal [אלכסונם].

Know that the sun's circuits mentioned are neither [uniformly] close nor distant from one another by one fixed measure; rather, each circle draws near and grows distant from its fellow according to the measure of the diagonal mentioned above in the fifth Section. So, for instance, at the place of Pisces and Aries [בי כמקום דגים וטלה], and likewise at the place of Virgo and Libra [ובתולה ומאזנים]...

there the circuits [גלילים] will be [most distant on] the diagonal [אלכסון], because they are Libra and Aries [reading uncertain; the printed sequence of sign-names here is garbled [?]]... and so too at the place of Capricorn and Cancer [גדי ... סרטן], the circuits will be [most] near and almost touching one another, being [close] together. The difference that is found among the circuits themselves arises from the diagonal, for every circuit that inclines from the equinoctial line — whether to the north or to the south — each one, by reason of its smallness [proximity], according to its nearness to one of the poles [הצירים], so likewise its fellow that inclines toward the [equinoctial] straight line.

Siman 136 (סימן קל"ו) [reading the body rubric "סי' קל"ו" — see report]

[On] the straight line that is [overhead] — [explaining the day-circuits above our horizon].

[The body opens:] ...the straight line [קו השוה / קו הישר] which is above us, for our horizon — and likewise the rest of the circuits, or the arc of the days [קשת הימים]

— which the sun makes by reason of the daily motion: all of them are, for us, the dwellers in the inhabited world, most of whom dwell in the northern climes [from the climes] above our horizon, inclining toward the southern side; and they are to us like an inclined wall. And the arc of the nights [קשת הלילות] that is below our horizon — all of them incline toward the north. Even the arc of the night of the winter solstice [ליל תקופת טבת], which is the arc closest to the circle of Capricorn [עגול גדי] — whose daytime arc is at the extremity of its remoteness from us toward the south — nonetheless, the [night] arc beneath our horizon inclines, in accordance with our standing-place toward the north, by the measure of the declination [שעור הנטיי']. According as a person's distance from the straight [equinoctial] line toward the north increases, so the declination increases for us — until, for those who dwell beneath the northern pole [ציר הצפוני], the straight line [קו הישר, the equator] becomes their horizon, [and the day-circuits] remain wound about them like a girdle [כאזור], the circuits coiling about the [celestial sphere]. All this you may see physically, in the [model] globe of wood [בכדור העץ].

How elegant are the words of the wise scholar [החכם] in his commentary [בעי בא"י, perhaps "בעל..." reading uncertain [?]] on the second [chapter] [מתאמי ב'] of [Tractate] Bava Basra [בבא בתרא], where he interpreted Chazal's dictum at the beginning of the chapter "כיצד" [the opening of a perek, R"P = ריש פירקא] [?] — concerning their teaching that [the sun] "goes by day toward the south and circles by night toward the north." [reference: Bava Basra 25a–b on the sun's daily path] For, according to what appears to us visually at the start of [the sun's] setting, Chazal's dictum corresponds to what is revealed to us before our eyes. For at all times the sun always emerges each day from the eastern horizon, makes one circuit, and sets in the western horizon; then it circles by night opposite that same circuit, from west toward east, from beneath the earth. Thus its path by night is like its path by day; only on the northern side it has no [perceptible] motion, nor any path between day and night, for it does not pass over a hidden circle [a colure] from one part of the world [to the other]. Therefore those who, on account of this, opened their mouths against the dictum of Chazal [ז"ל] — [their objection fails], for according to the true premise, [valid] for all the inhabitants of the earth in all the climes, the arc of the days [קשת הימים] is for them [inclined] toward the south, and the arc of the nights forever toward the north. Thus Chazal's words are correct in the most precise sense. And the resolution and fine explanation of the Maharshal [מהרש"ל = R. Shlomo Luria] [?] is fitting and proper. How sweet are his words to the palate! [cf. Tehillim 119:103]

[Note: the attribution "מהרש"ל / מהרס" is partly degraded; the cited authority on Bava Basra 25 may be the Maharsha (מהרש"א) rather than Maharshal — flagged [?].]

An incidental [interpretation] [אגב]: I saw fit to explain in this place a further matter, as a digression: [the verse] "and [the wind] goeth toward the south, and turneth about unto the north" [Koheles 1:6 — "הולך אל דרום וסובב אל צפון"] — its [plain] sense and its true meaning is that when the sun revolves through the northern signs [המזלות הצפוניים], it then draws near to the inhabited world, after circling toward the north. For in no instance does Scripture call any circuit "remote"; rather [in] every [such] revolving, the one that revolves draws near, the one [to] the other, as in "round about" [the verb root ס-ב-ב]. [Compare] "and they encompassed the city" [ויסבו את העיר] and "their borders" [וגבולותם] — and many like these. But when [the sun] revolves through the southern signs [המזלות הדרומיים], then it grows distant from the inhabited world; [therefore Scripture] said "goeth toward the south" [הולך אל דרום] — for we find "going" [הליכה] used for [motion that is] remote, by way of [the idiom] "a path of distance [going] afar" [כקו רחוק/במרחק].

Siman 137 (סימן קל"ז)

Explaining that for those who dwell beneath the equinoctial line [תחת קו השוה], the measure of the daytime and the measure of the night are equal — they are [each] twelve [hours] of the world.

All who dwell beneath the straight [equinoctial] line [קו הישר], such that its horizon [the equator coincides with their horizon and] bisects the line of the [celestial] equator [קו הישר], and likewise bisects the line of the signs [קו המזלות, the ecliptic] — each of these into two parts: the part above their horizon is called the arc of the day [קשת היום], and the part below their horizon is called the arc of the night [קשת הלילה].

From this it follows that the whole host of stars — and the sun too, one of them — when they all encircle the globe of the earth in the daily-motion revolution, will be found, for those dwelling beneath the straight line, to have their revolving above the horizon equal in time to the hidden [portion] beneath the horizon, throughout all the days of the world. From this it necessarily follows that the measure of the day and the measure of the night are forever equal for them — twelve hours each — in all the seasons of the year: cold and heat, summer and winter, neither one exceeding the other; the day never exceeds the night, nor the night the day, even in the days of the summer solstice [תקופת תמוז] and the winter

solstice [תקופת טבת] [the year's two solstices]. They have no variation whatever — no "precedence" for those of the east and "delay" for those of the west, and [for] those dwelling outside [off] the equinoctial line, whether toward the north or toward the south.

Now the day and the night [for those off the equator], indeed, are [variously] contained for them within twenty-four hours, just as for the dwellers on the straight line. But [there is a difference:] the one exceeds the other — sometimes the measure of the day exceeds that of the night, and sometimes the reverse. This variation comes from two causes. The first cause is the declination [נטיית] of the inhabitants of the earth from the straight line toward one side, away from one of the poles — so the days and nights lengthen or shorten for them accordingly. The second [cause] is that the length of day and night, for those dwelling beneath the [various] climes, is entirely in accordance with the seasons of the year, as will be explained in siman [later].

Siman 138 (סימן קל"ח)

Explaining that on the two days [שני ... שבימי] of the [equinoctial] turning-points [התקיפות], the daytime and the night are equal for the rest of the inhabitants of the earth too [לרוב שאר יושבי תבל].

There are two days found in the year — by the general principles [already stated] regarding the inhabitants — on which the daytime and night are found equal for all the inhabitants of the earth in every clime, just as [they are always equal] for the dwellers on the straight line. These are the days of the equinox of Nisan and the equinox of Tishrei [ימי תקופות ניסן ותקופות תשרי], the true [equinoxes], in which the sun enters the sign of Aries [טלה] and [Libra] [מאזנים]. The reason is that on these two days mentioned the sun revolves upon the straight line [the equator]. It has already been explained above, in Section 2, in siman 39 [שער השני סי' ל"ט], that the great circles passing through the center of the world always bisect one another [into two equal halves]. According to this, it necessarily follows that the straight line — by every manner in which it bisects the world into two equal halves — [does so] because both are great circles [העגולות הגדולות]. From this it likewise follows that just as there are six signs that rise for them by day, so there are six that set for them by night…

[continuation of siman 138]

[in the time] when most of them are above the earth, the sun being always opposite the earth; at the time their revolving is beneath the earth, as is the case for those dwelling beneath the straight line. By all these things, [it is] as plain as

can be that on these two days mentioned, the arc of the day equals the arc of the night in all the climes, [throughout] all the [seasons].

These two days mentioned are not found [equal] for those dwelling beneath… [the climes other than the equator] [?], nor is there found, in all the days of the year, any equality of day and night [for them] — nor even among two [different] climes will [equal days and nights] be found equal to one another, but in one of them the one [the day] exceeds the other. Indeed, even two consecutive days [שני ימים רצופים] will not be found equal to one another in their measure in any place, except when there are two partnered signs [שני מזלות משותפים], as explained above.

Siman 139 (סימן קל"ט)

Explaining that the measure of the daytime of the equinox of Nisan [תקופת ניסן] exceeds the measure of the daytime of the equinox of Tishrei [תקופת תשרי].

Although in all the [astronomical] books it is found that the measure of the two days at the true equinoxes of Nisan and Tishrei are equal to one another — because both of them encircle the circle of the equinoctial line [קו השוה] — nevertheless I say this: when we examine precisely the revolving of the two days of the two equinoxes, it is found that on the day of the equinox of Nisan [the daytime] exceeds the daytime of the days of the equinox of Tishrei by a small matter. This [is so] because, as already explained above in siman 135 [כשי' קל"ה], in the revolving of the two solstice-points [המזנות, reading "החזנות"], Aries [טלה] and Libra [מאזנים] — each of them, [moving] from the points of the straight line [נקודות היושר], grows distant after 24 hours by more than two degrees [יותר משני מעלות = <2°].

Therefore know: when the sun makes its night-circuit from the head of Aries [מראש טלה] in the time of 24 hours, in that same time the sun, by its own [proper] motion [במהלכה העצמית], moves to incline one degree [מעלה אחת] toward the north side. By this revolving of 24 hours [the daytime arc] is [affected so that] the arc of the day [קשת היום] lengthens for us over the arc of the night by a very small matter. And when the sun makes its [day-]circuit from the head of Libra [מראש מאזנים] in the time of 24 hours, in that same time it revolves by its own proper motion about one degree toward the southern side, so that during the revolving of those 24 hours the arc of the night [קשת הלילה] lengthens for us, and the daytime shortens for us, by this measure.

Siman 140 (סימן ק"מ)

In it I inform you that the day-circuits [are] not… [equal] in the measure of their length [אינם … שוים במדת אורכם].

We explained earlier in siman 400 [בסי' ת'] [reading "בסי' ת'" = siman 400; this exceeds the work's 305-siman count — flagged as a numbering impossible], and it will be explained further later in siman 184 [בסי' קפ"ד], that the measure of the time of the year, according to the view of the astronomers, is 5 hours, 55 minutes, of the 60 [minutes] in an hour, approximately [ה' שעות נ"ה דקין מששים בשעה — see note: this appears to be a measure tied to the daily surplus, not the full year]. [The "5h 55m" figure does not match a year-length; it likely refers to the diurnal excess in the natural-day computation that follows — flagged for review.]

Now, when we wish to know how many parts [חלקים] and seconds [ודק] the sun revolves on a natural day — that is, a [full] day and night [יום ולילה טבעי] together — divide the 360 degrees of the firmament [360° = ש"ס מעלות הרקיע] by the number of days of the sun [ימי החמה], and you will get a uniform motion equal to a day of 59 minutes [נ"ט דקין] [reading "59 = "נ"ט], 8 thirds [ת' שלישיות — reading "8 = "ח' שלישיות thirds] [?], approximately [the figure ≈ 59′8″ per day matches the known mean solar motion]. At first inspection it would seem that the [mean] motion of the equinoctial line [המהלך השוה] is for every day and night forever the same. But know that the matter is not so, for we have found a great difference and distinction between one natural day and another natural day, as already explained above in the fifth Section, in the siman dealing with the [non-uniform] motion of the sphere of the constellations [גלגל המזלות]. There [it was shown that] some of them are surveyed somewhat more, some somewhat less, briefly, for this reason [the daily mean differs]; by which [point] one needs no special study or [further] consideration to verify — [it is enough to recognize] that there is a difference between the [reckoning of] the natural day [and the equal day].

Siman 141 (סימן קמ"א)

[The body rubrics on p. 88 run: סימן קמ"א then סימן קמ"ב — see report. The right-hand column heads "קמא סימן" and "קפב סימן" (a compositor transposition of letters); content shows these are simanim 141 and 142.]

The measure of "the natural day [יום טבעי]" is not the same as the measure of "the natural day of the morrow," even for those dwelling beneath the straight circle [עגול הישר, the equator]. For when the sun is opposite [in] the signs Libra, Virgo, and Aquarius [מאזנים ובתולה ודלי? — reading "ובתולה ודגי" = and Pisces], Aries, and Pisces [טלה ודגי'] — because they incline toward the diagonal [אל אלכסון] — the

sun's ascent in them is swift [ממהרת עליה], just like the signs themselves [the rapidly-rising signs]; whereas the reverse holds in the signs Gemini, Cancer, Capricorn, and Sagittarius [תאומים וסרטן וגדי וקשת], as explained above.

Siman 142 (סימן קמ"ב)

Know that the difference mentioned, for those dwelling beneath the straight line [the equator], is a difference exceedingly small and fine — so much so that it is not recognizable nor sensed physically; only the intellect and the demonstration testify to it. But for those dwelling beneath the [northern] climes [תחת המעיות, "beneath the climes"], this difference is sensed even physically, as you will observe above. This [you may verify] in the Section that has passed [Section 5], in the table of the rising of the signs [בלוח עליית המזלות], (and their setting) for us, the inhabitants of Prague [יושבי פראג]. You will find: when you combine the times of the rising and setting of the sign Cancer [מזל סרטן], the sum of these two times is six hours and 14 minutes [6 = ששh שעות וי"ד דקי 14m] [?] — so you have, the difference between them is about half an hour [כמו חצי שעה].

You should further know that there is a second, secondary cause [for the difference], by which the natural days [היומים בטבעים] differ a little in their measure. This arises from the variation in the motion of the sun [חלוף מהלך החמה], which moves on its [eccentric] — [so that] for us it moves at varying [unequal] times [for an] equal motion, as will be explained later in the seventh Section [בשער השביעי], with God's help.

Siman 143 (סימן קמ"ג)

In it [are made known] the causes of the lengthening and shortening of the days for us, the dwellers of the north [יושבי צפון], in all the seasons of the year.

Know that those who dwell and incline from the straight line toward the north — their horizon, too, bisects all the circuits which the sun makes by reason of the daily motion into two parts: the arc of the day [קשת היום], which is the circle or the circuit above their horizon, and the arc of the night [קשת הלילה], which is the circle below their horizon — but not into equal parts. For as soon as the sun grows distant from the straight line toward the south, immediately the arc of the night exceeds, for us, the arc of the day.

From this it will become clear to you that all the circuits which the sun makes in the northern signs [המזלות הצפונים] — which are Aries, Taurus, Gemini, Cancer, Leo, Virgo [ת"ש … = the six northern signs, reading "ת"ש" for the

spring/summer signs] — the arc of the day exceeds, for us, the arc of the night. And all the circuits which the sun makes in the southern signs [המזלות הדרומים] — which are Libra, Scorpio, Sagittarius, Capricorn, Aquarius, Pisces [חע"ק וגד"י = the six southern signs] — the arc of the night forever exceeds, for us, the arc of the day.

By way of general rule, know: the lengthening and shortening of the days is for us from two causes. The first is that, in accordance with the nearness of the inhabited world to the northern pole [קוטב הצפוני], so the [winter] cold increases; the arc of the day [is shortened relative to] the arc of the night. The second is according to the seasons of the year, namely, in accordance with [how much] the sun draws near to us toward the north — then [the day] lengthens and increases for us so much; and so [too the verse]: "the day goes lengthening" — and this is when the sun draws near to us [in spring/summer]; the days go on lengthening, and the nights go on shortening, until [the sun] reaches the head of Cancer [ראש סרטן], which is the time of the true summer solstice [תקופת תמוז האמיתי]. For it [the sun] is then drawing nearest to us toward the north, and we then have the longest day in measure — and the [day] is at the extremity of its length, the night at the extremity of its shortness — because its daytime is, for us, the greatest of all the day-arcs, and its night-arc the smallest of all the night-arcs.

So you have it: for us, the dwellers of the city of Prague [יושבי עיר פראג], the circle of Cancer [העגול … סיטן = the circle of Cancer] is contained in its entirety [within view] — for a third [שליש] of the whole circle is hidden from us beneath our horizon always, while the [remaining] two thirds [שני שלישי] of it are always above our horizon. Therefore, by reason of the sun [traveling in Cancer], the night is for us short…

Section 6 (continued)

the night. If it should turn out that the sun's rising is delayed, the duration of daylight will not be diminished by the amount [the calculation might suggest]. [?] The setting-point of the heaven for us [in Prague] lies at 15° of [a sign reckoned] by the hours [?]; and at the rising-point one finds, in accordance with the hours [?]…

[This opening region of p. 89 is badly degraded; the right-hand column especially is broken up and several phrases are unrecoverable at this resolution. I transcribe what reads cleanly and flag the rest. — see batch report.]

[at] the summer solstice (תקופת תמוז), which is when the sun reaches the head of Cancer (סרטן), [the daylight is fifteen hours] [?] of the fifteen hours…and the sun reverses its course, [turning back] toward the night [side] [?]. From that point onward the days and nights begin to even out and grow shorter [?]. When the sun reaches the sign that lies at the very limit of the inhabited world's [southern reach] [?], the day will be at its shortest and the night at its longest — because the sun's day-arc is then the smallest of all the daylight arcs (קשת היום), and the day is short while the night-arc (קשת הלילה) is the longest of all night-arcs.

It has been explained and made clear to us, regarding the measure of all the days and nights, that the measure of our daylight in the northern signs is exactly equal to the measure of our nights when the sun is in the corresponding southern signs; and likewise the reverse — the measure of our nights in the southern signs equals the measure of our days when the sun is in the corresponding northern signs.

Thus when the sun is at the head of Cancer (סרטן) — that is, at the summer solstice (תקופת תמוז) — the measure of our daylight is fifteen hours, and so too the measure of the night [is fifteen hours] when the sun is at the head of [the opposite sign]. [?] And the measure of our daylight when the sun is at [the opposite sign] [is] likewise [?]. When the sun is at the winter solstice (תקופת טבת), at the head of Capricorn (גדי), our daylight measures [?]; and so too the night measures fifteen hours when the sun is at the head of Cancer [?].

[The text here is again degraded; the pairing of solstice day/night figures is partly recoverable but several numerals are unclear — flagged.]

By these you may reckon analogously for other [latitudes and] times. And know that everything we have stated concerning the matter of the lengthening and shortening of the days and nights applies to dwellers in the north. By contrast, what you will find regarding the various climates (אקלימים) — that sometimes [the night exceeds the day] [?] and sometimes the reverse — nonetheless in every case, what one measure of daylight loses, the corresponding [measure of] night makes up, so that the daylight and night together always complete the cycle of twenty-four hours; what one [period] subtracts, the other restores.

And now let us inform the reader of the things that occur for those who dwell from the seventh climate (אקלים) northward, toward the northern pole (ציר הצפון) of the world. For some of them it will be found that the sun remains above their horizon for one [continuous] day in the year; for some, the sun remains above their horizon for [several] days [?]; for some, two months; for some, three or four

months [?]; and for some, six months, during which time the sun remains above their horizon — and likewise, by the same token, the sun is hidden beneath their horizon [for the corresponding period], just as it is above their horizon [for the other half].

And now let me explain these matters to you in order.

Siman 142 [סימן קמ"ב]

That the measure of the days of [the month of] Tammuz is not equal [to the measure of the days of Teves], and likewise the nights of Tammuz are not equal to the nights of Teves.

[Heading degraded; reconstructed from content — the two columns of the heading interleave "the measure of the days of…" with "are not equal." The siman number reads קמ"ב = 142, consistent with the running count.]

Many of the world's inhabitants suppose that the measure of the daylight at the winter solstice (תקופת טבת) is equal to the measure of the night at the summer solstice (תקופת תמוז), and likewise that [the measure of the night at the winter solstice equals the measure of the day at the summer solstice]. [?] But the matter is not so. For when you find that at the winter solstice (תקופת טבת)…

[Right-hand reasoning on p. 89 is broken; the gist:] …[the moon] [?] draws near to us on the side toward the north [?]. We must therefore reckon the measure of [our] winter[-solstice day] precisely (מילא יותר שעות) [?] — just as the summer-solstice day will be explained further on in the eighth section, siman [קצ"ט?] [?] — so that according to this, by the reckoning in siman [203] ר"ג [?], at the head of the ninth section [?], and at the head of [the same?] section…

[This passage is heavily degraded; cross-references to later simanim are present but their exact numbers cannot be read with confidence]

[at] the winter solstice (תקופת טבת) the moon will [?] be a quarter-hour above [the horizon] for us [?] — that is, the time during which the sun [or moon] remains above the horizon for us. [?] We have already known the measure that holds for us, the dwellers of Prague, at the summer solstice (תקופת תמוז): sixteen hours, as will be explained further on in section [166 / קס"ו] [?].

Therefore the moon [?] will remain above our horizon for seventeen hours and a quarter [?]; and the moon withdraws [?]…[at] midnight, [as our heads point] [?] toward [the zenith] [?], more than five degrees from where the sun is [?]; whereas at the winter solstice (תקופת טבת), [the point] at midnight [is] more distant from

[our zenith] [?]. According to this, at midnight [the moon] will not remain above [the horizon] for us [?] equally; rather, for our horizon it will be like six hours and three-quarters of an hour, [reckoned] from the equal-hours (שעות הישרות) of the [degrees?] mentioned.

It appears to me, when we examine carefully — as is the case with the moon's sphere, which is always [in motion] [?] — that we, the dwellers of the north, find as follows: throughout the whole time that the sun is in the southern signs, our night-arcs on the northern side exceed our day-arcs on the side [toward the south?] [?]; and when the sun is in the northern signs, our day-arcs exceed our night-arcs on the [southern] side, as stated above.

Siman 143 [סימן קמ"ג]

An explanation, in brief, of the men for whom the daylight will be [twenty-four hours].

[Heading: בביאור בקיצור… מדת היומם עשרים וארבע שעות — "in brief, … the daylight measures twenty-four hours." Siman number reads קמ"ג = 143.]

Know that for the men who are inclined away from the equator (קו הישר) by 66°9′ [?] toward the north — they dwell beneath the northern circle (העגול הצפוני) [the Arctic Circle] — for them the sun will not set [at all] when it is at the summer solstice (תקופת תמוז); rather, the daylight will then be a full twenty-four hours.

The demonstration of this requires us to recall what has already been made clear above, in Section 2, siman [42] מ"ב [?]: that the northern circle (העגול הצפוני) [the Arctic Circle] is nothing other than the trace marked out by the circuit of the [pole of the] ecliptic-axis [?] (ציר המזלות) about the axis of the world (ציר העולם) — and there too, in siman [40] מ׳ [?], it was already explained to be 23°51′ small [degrees] [?]. [And it was made clear] that from the equator (קו הישר) to the head of Cancer (ראש סרטן) — that is, the sun's greatest declination (נטיית השמש הגדולה) — is likewise 23°51′; and it has already become known that from the equator to the axis [pole], which is the quarter of the circle, there are ninety degrees. Subtracting [23°51′] from this leaves 66°9′ [?].

And from the [northern] circle to the head of Cancer (מעגול סרטן עד הציר) — [?] it has also become known to us that the horizon of any man, up to the point directly opposite his zenith (נקודת קדקדו), spans ninety [degrees]; so that when we are distant from this by [66°9′] [?], for these men, who are at 23°51′ from the axis as stated above, the distance from the axis to their horizon is likewise 66°9′ [?].

And now, when all the aforementioned conditions are present together [?], at the moment the sun first moves [into] [?] the head of Cancer (ראש מזל סרטן) — that is, at the summer solstice (תקופת תמוז) — when the sun is then, according to its prior distance, at the head of the northern circle [?] 66°9′ [?], and at this distance there are from the northern axis (ציר הצפוני) to the horizon 9 degrees [?], so that the axis stands [exactly] above their horizon [?] — by this true [reasoning] [?], thus [it is established] that the sun will not set for them.

Section 6 (continued)

[Siman 143, continued]

the distance, according to which the sun does not set for them [?]. For at that day, when the sun is brought above the horizon [?], it remains above their horizon all day [?], as was already brought up above in this section. As stated in Section 2, siman [42] מ"ב [?], regarding all the stars that are near to the northern axis (ציר הצפוני): by the measure of the elevation of the axis above the horizon — at the point opposite the zenith [?] — they [the circumpolar stars] are always preserved for us above our horizon (above our zenith [?]) [the stars at the distance of] the equator (קו הישר) [from the pole], and they never set for us at all.

Behold, this has been clarified for you by the two foregoing demonstrations: that the sun will not set for the aforementioned men who are beneath their horizon [i.e., for whom the pole is at the zenith] [?]; and so for them the daylight, or the measure of the day, will be a full twenty-four hours.

Siman 144 [סימן קמ"ד]

I shall make known, in brief, the lands [for] which the measure of the day is one month, or two months and more, and likewise the measure of the night.

[Heading interleaves across columns: "I shall make known, in brief, … the lands … the measure of the day … one month or two months and more, and likewise the measure of the night." Siman number reads קמ"ד = 144.]

[Now consider those who dwell] still farther beyond the northern circle (מעגול הצפוני) toward the pole-axis (ציר העולם) of the world — those who dwell quite close to the northern axis. By this much, the head-points of the sign Cancer (מזל סרטן), [together] with the signs on its two sides [Gemini and Leo], are raised and ascend above the horizon and never set there at all. And throughout the whole time the sun travels in its annual course through the degrees of those signs, they

remain above the horizon for them, and for them it will be continuous day [?] with no night reckoned to them at all.

And if that portion [of the orbit] which forms one [continuous] day, together with the head of Cancer (ראש סרטן) on its two sides — the portion above the horizon that the sun [traverses] — should be the measure of [?] one month, then for them the day will be one month; if that portion be the size of two signs, the measure of their day will be two months.

To give an example of this for those distant from the equator (קו הישר) toward the north by some [?] degrees: those who dwell beyond the northern circle (מעגול הצפוני) toward the axis (ציר) of the world by about four degrees [as is roughly the case in certain lands known to us, such as the land of Angel (מדינת אנגל) [?]] — for them the signs Cancer (סרטן), Gemini (תאומים), and Leo (אריה) [?] will always remain above their horizon, and the three signs opposite them — which are Capricorn (גדי), [Sagittarius] [?], and Aquarius (דלי) [?] [the arc Sagittarius–Capricorn–Aquarius] — will always be hidden beneath their horizon. Six [other] signs remain, which rise and set for them always, as we explained above in siman קכ"ה [125]. Therefore, throughout the whole time the sun is in the three signs Gemini (תאומים), Cancer (סרטן), and Leo (אריה), there will be continuous daytime for its inhabitants, since this is a span of three months; and conversely, when the sun is in the signs Sagittarius, Capricorn (גדי), [and] Aquarius (דלי) — the [opposite] arc [?] — they will have a span of [twilight or] night of three months.

And I saw fit to set down in my book a deed that happened in this place, about three years ago, in the great city of Amsterdam, in the land of Holland [Netherlands]: that many men gathered together — among them great and learned scholars — and they took it upon themselves to set out and explore the northern sea, to learn about the islands and dwellers of the northern world. They prepared for themselves a great and mighty ship, and gave themselves still more provisions and gold and silver. And they set out from the great city of Amsterdam and sailed the sea, and they journeyed with their vessels and traveled and found certain islands which are at the far edge of the world, at the western [?] [region], ninety degrees [?], and the breadth [latitude] of which is 74 degrees from the equator (מקו השוה). And there the sun set upon them beneath their horizon, and they could no longer [raise it above their horizon] [?].

[The deed described is the Dutch expedition to Novaya Zemlya — Willem Barentsz, 1596–97 — whose crew wintered on the island and recorded the polar night. "About three years ago" relative to the writing of *Nechmad ve-Na'im*.]

there [the men were forced] to stay many days, and they sat [stranded] and could not depart [or come out] [?]. In that place the sun did not rise above the horizon for a period of three months. The reason that in that land [the body of the sun] is forever hidden from its inhabitants beneath their horizon [for that time] is: half the sign Scorpio (עקרב), all of the signs Sagittarius (קשת) and Capricorn (גדי), and half the sign Aquarius (דלי) — for these the sun's path lay beneath their horizon, which is the three months during which all this you may see by means of the celestial globe (כלי הכדור).

And you should also know that although the sun did not rise above their horizon for the period of those three months [?], they nonetheless sensed and saw, for most of those days, the diffused light [twilight] (האור הנאצל) that came about at that time by means of the rotation of the daily sphere (גלגל היומי) in its revolution — that is, when the sun was in the south [?]; for then it did not withdraw beneath their horizon by more than about eight degrees, and so it gave them light by day even though they did not see the sun's body itself — just as we, in our own country, see the daylight half an hour or an hour before the sun's rising above our horizon.

Siman 145 [סימן קמ"ה]

[On the lands] in some of which the measure of the day is four months, and likewise the measure of the night.

[Heading: שבמקצת המקומות מדת היומם ארבע חדשים וכן מדת הלילה… Siman number reads קמ"ה = 145.]

From there [moving] still farther toward the northern axis (ציר הצפוני) — to reckon three more signs [?] whose [latitude] degrees are seventy [?] degrees from the equator (מקו השוה) [?] — there will be four signs, which are Gemini (שור→ תאומים) [?], Taurus (שור), Cancer (סרטן), [and] Leo (אריה) [?], that remain always above their horizon; and the four signs opposite them — which are Scorpio (עקרב), Sagittarius (קשת), Capricorn (גדי), [and] Aquarius (דלי) — are always hidden beneath their horizon. In such a manner that throughout the whole year they have four months [of day from] those [signs as well] [?] — four months [during] which the [remaining] four signs that rise and set for them give them continuous night [?].

[The arithmetic of "four months" against four signs, and the substitution of שור (Taurus) into a list that contextually should run Taurus–Gemini–Cancer–Leo, is internally rough here — flagged.]

[the signs] that rise for them in order and set in order are Aries (טלה) and Pisces (דגים) [?]; and the signs [Virgo] (בתולה) and Libra (מאזנים) rise for them and set in order [?]. All this is concealed, as is shown by the work of the [celestial] globe (מלאכת כדור), when you raise it [the globe so] that the northern axis (הציר הצפונית) is warmed [stands] above the horizon by 70 degrees [?].

And you, the reader, should know that we have in this matter a certain perplexity, and a great halachic question (שאלה גדולה בדין): namely, if it should come to pass that in one of these places mentioned a Jew (יהודי) should settle, or that Jews should travel there by ship — how, and for how long a span of time, would the Sabbath day (יום השבת) and the other festivals (מועדים) [?] be reckoned for them? It is not feasible to advise our people to rest [from labor] for a span of three or four months. It seems right to say that for the six days of their workdays they should reckon six revolutions of the daily sphere (גלגל היומי), [each] revolution being a day [?], and that the seventh revolution shall be the Sabbath. [So they would have a measure of] [?]…

Siman 146 [סימן קמ"ו]

[On those for whom] the measure of the day is six months, and likewise the measure of the night.

[Heading: שיש להם מדת היומם ששה חדשים וכן מדת הלילה…. The opening word reads שומי / "those dwelling beneath the northern pole." Siman number reads קמ"ו = 146.]

Those who dwell beneath the northern axis (ציר הצפוני) itself — that is, [a place] which is upon the axis itself [so that] its zenith-point faces directly opposite [the celestial pole] [?]. Here, indeed, after reflection and careful consideration, it follows [?]: the circle of the equator (קו הישר) will be their horizon, and the circuit of the belt of the signs (אזור המזלות) [the ecliptic] serves them as the [annual] circuit, just as it serves [in place of] the daily revolution [for others] [?].

It has already been explained that the equator (קו הישר) divides the line of the signs [the ecliptic] into two parts: [the half] from the head of Aries [?] — [the six signs] which are [Aries through Virgo] [?], that are inclined from there [?] toward the north of the equator (קו הישר); and the second half of the belt of the signs (אזור החלוק) [?] — the signs Libra through Pisces (מאזנים…דגים) [?] — that incline toward the [southern] side, [the southern half] [?].

Section 6 (continued)

[Siman 146, continued]

so that for them [those at the pole] the six signs from [Aries to Virgo] [?] will be above their horizon, always rising [?], for the whole half-year [from Nisan to Tishrei], while the [other six signs Libra–Pisces] [?] are hidden beneath their horizon from now [until then] [?]. And it is fitting, since throughout the time the sun is in the signs from Nisan to Tishrei (מניסן ועד תשרי) [the spring–summer half], the sun does not set [below] [?] beneath the aforementioned [equator-]horizon — because, as stated, all that half-year the sun [stands] above [their horizon]. [So] for them it will be continuous daytime [?].

And from the time the sun is in the signs [of the other half-year, Tishrei to Nisan] [?], it will be continuous night for them, because the sun is then always below their horizon [?]. According to this, throughout the whole year, for the place mentioned, it is so reckoned: by natural reckoning, for its inhabitants it is always [?] half a year of continuous daylight, and half a year of darkness and night — and all this is [matter] proven by intellect and by reasoning, the way of demonstrations.

Nonetheless, in truth, at the place mentioned no human settlement whatever is to be found; and assuredly no man or beast has ever passed through it, on account of the extreme severity of the cold (חוזק רוב הקרירות) there.

Siman 147 [סימן קמ"ז]

To inquire and to know, by means of the celestial globe (בכלי הכדור), the measure of the length of the days [?] [and] the [length of the] short days, for all the days of the year, in every place and at every time.

[Heading: לדרוש ולדעת בכלי הכדור מדת אורך הימים וקצרים כל ימות השנה בכל מקום ובכל זמן. Siman number reads 147 = קמ"ז.]

At the outset, you must first know the place [position] of the sun for that day, by the [reckoning] of the [celestial] globe set against the line of the signs (גלגל המזלות) according to the law I demonstrated to you above. Then I will explain to you that you are to raise the northern axis (ציר הצפוני) of the celestial globe above the horizon to the height of the axis [appropriate to] the place whose [day-length] you seek — that is, the elevation of the pole at the place for which you are inquiring [its latitude]. [Then turn the globe] and revolve it until the degree [of the ecliptic] at which the sun is reaches the eastern (מזרחי) horizon, where the

signs come to rest [rise] upon the horizon. Then look on the equator (בעגול הישר) [the celestial equator] at the degree which is then above that horizon, at the sun's place [?], and make a mark there with a pen [a first mark] [?]. After this, rotate the globe until the sun's place comes to the western (מערבי) horizon-line, and then look a second time at the equator (בעגול הישר), at the degree of the equator that is at the sun's place — which will be at the western (מערבי) horizon — and make there a second mark.

Then count the number of degrees between the two marks you have made, and for every 15 degrees [count] the completion of one hour; and the resulting number is none other than the count of [the hours of] the day's length (אורך היום).

Example. At the city of Prague, the axis rises above the horizon fifty degrees [Prague's latitude ≈ 50°N]. When the sun is at the true summer solstice (תקופת תמוז האמיתי), at the beginning of the sign Cancer (סרטן), rotate the globe until the beginning of this degree comes to rest at the eastern (מזרחי) horizon. While it rests at the eastern horizon, look at the degree [of the equator] then resting there and make a mark; then make, after it, [the first] mark. Rotate the beginning of the sign [from] the eastern (מזרחי) horizon to the western (מערבי) horizon, and there opposite it make on the equator (בקו הישר), at the degree then resting [there], [a mark]; and on the western (מערבי) horizon opposite it make a second mark. Then count the number of degrees between the two aforementioned marks, and here at the city of Prague you will find them to be 240 degrees. Divide them by 15 — by the degree-measure of [one] hour — and the measure of the day's length comes out to you as sixteen hours; and at Jerusalem (ובירושלים) [?] [you would proceed likewise], [where] the elevation of the axis above the horizon is 32 degrees [Jerusalem's latitude ≈ 32°N]. When you inquire its [day-length] by this rule, you will find the measure of [its] daylight there to be fourteen hours.

And when the sun is at the beginning of the sign Capricorn (גדי), proceed by this same practice, and the measure of its daylight here at Prague comes out to be eight hours; and at Jerusalem, by this rule, you will find the measure to be ten hours.

And I saw fit to give the students a general rule (כלל) in this matter, so they may have it [readily] in hand: if the first mark you made on the equator (בקו הישר) sets beneath the western (מערבי) horizon before the degree of [the sun's place in] the signs sets, then the sun is at that moment in a longer [day] than the equinoctial measure (מדת השוה) — that is, more than twelve hours — and this is the case when the sun is in the northern signs, which are Aries through Virgo (טלה…בתולה). The reverse holds when the sun is in the southern signs (הדרומיים).

Therefore know henceforth: when here at the city of Prague the sun sets [?], the first mark you made on the equator (בקו הישר) will still remain for you above the horizon, at the degrees of the sign in which the sun is, and it has not [yet] set; [continue] in the case mentioned until the equator (קו הישר) has turned through sixty degrees. From this you know that the measure of the day is more than the equinoctial day (יום השוה) by four hours — so the measure of its daylight is sixteen hours; and at Jerusalem in this case there remain thirty degrees, so the measure of its daylight is fourteen hours.

And when the sun is in the sign Capricorn (גדי), you find the matter reversed: here at the city of Prague, after the degree of the sign in which the sun is sets, there remain on the equator (קו הישר) [degrees corresponding to a daylight] less than the equinoctial daylight by four hours — so the measure of its daylight is eight hours; and at Jerusalem there remain [degrees such that the daylight] above the horizon is thirty degrees [?], its measure being ten hours. By that time [?] [proceed] likewise for the rest of the days of the year, for every place and position, according to the elevation of the axis [latitude] and according to the sun's true position relative to the sphere of the signs (גלגל המזלות).

The seasonal hours (השעות הזמניות) — which are always twelve by day and twelve by night — are reckoned in this way: take the [degrees] you reckoned above at the head [of the count] by the rule mentioned, [namely] how many degrees is the measure of that day already mentioned; I found it to be 240 degrees [for Prague at the summer solstice]. Divide the number of those 240 degrees by twelve, for the twelve seasonal hours of the day, and you will find that the measure of each [seasonal] hour [in summer] is twenty degrees — which is one hour and a quarter of the equal hours (שעות הישרות). And at the winter solstice (תקופת טבת), the measure of each hour will be ten degrees, [all] reckoned by [the degrees of] the equator (קו הישר). And at Jerusalem, likewise.

Siman 148 [סימן קמ"ח]

On the beginning of each day, and the moments of midday — a general rule.

[Heading: …בהתחלת כל יומם ועתי רגעים חצות יומם דרך כלל. Siman number reads קמ"ח = 148.]

By reason of the roundness of the earth (כדוריות הארץ), many differences and variations are found among the inhabitants of the world as to the beginning of each day, the beginning of each night, and likewise as to the moments of midday (רגעי חצות יומם): the easterners (מזרחיים) have priority over the westerners

(מערביים), and the southerners (דרומיים) over [or relative to] the northerners (צפוניים). These differences are found in four categories (מינים), which are these:

[1] Those who share a position on the equator (תחת קו הישר); [2] Those who share [a position] in the [?]…

Section 6 (continued)

[Siman 148, continued]

[The four categories of shared circumstance, completing the list begun on the prior page:]

[1] Those who share [a position] on the equator (תחת קו הישר), [in respect of day-length]; [2] those who share the length of the daylight (באורך הישׁ[ר?]) [?]; [3] [?]; [4] those who do **not** share [these]. As for those who do not share, we have not [yet] explained them [?]; we shall explain them in their proper order in due course, with God's help. [?]

Take note that some of these distinctions [?] — R. [?] of Israel [the author of the cited work] [?] reveals a handsbreadth of this and conceals two handsbreadths in the comment in [chapter] 15 [?] of his second treatise (ממאמר שני) [?]; for he did not speak of this matter as fully as needed. Therefore I do not pride myself on speaking of it [with full precision] [?], [but only] according to the sight of my eyes, as far as my understanding reaches — to the point where I will set it forth properly, that the matter may be expounded well.

[The phrase "שני [מאמר] מ…בפ' ט"ו הישראלי" appears to cite a work "of the Israelite/of Israel," chapter 15 of its second treatise. The reference is most plausibly to Isaac Israeli's *Yesod Olam* (R. Yitzchak Israeli, *Sefer Yesod Olam*) — flagged for confirmation. — see batch report.]

Siman 149 [סימן קמ"ט]

The law of priority and lag (דין הקדימה והאיחור) for those who dwell on the equator (תחת קו הישר).

[Heading: דין הקדימה והאיחור ליושבי תחת קו הישׁ[ר]. Siman number reads = קמ"ט 149.]

This matter we have already prefaced in our earlier words, and we touched on it above to some degree, in several places [?]. Nonetheless, since our intent is that

all four categories (בחינות) be found together in order, I saw fit to return to this law here, since this is its proper place.

Know that for those who dwell on the equator (קו הישר): at the beginning of daylight and night, and likewise at the moment of midday (רגע חצות יומם) and at the other parts of the day, the easterners (בני מזרח) have priority and the westerners (בני מערב) lag behind. The measure of the priority and the lag is in proportion to the distance between them: for every 15 degrees of distance, the easterners have priority over the westerners by one hour — in such a way that the difference between those who dwell at the eastern edge (קצה הקדם) and those who dwell at the navel of the earth (טבור הארץ) [?] [the central meridian]: this distance is, as it were, a quarter of the [celestial] globe, which is ninety degrees. According to this, the beginning of daylight for the dwellers at the navel of the earth (טבור הארץ) [is] at that very same moment [as] [?] [some other reference point], [while] for the dwellers at the eastern edge it is [already] midday; and night for the dwellers at the western edge (קצה המערב). And the distance between the dwellers at the eastern edge and the dwellers at the western edge — which is half the circumference, namely 180 degrees — yields a difference of 12 hours between them. It turns out that the beginning of [day] for the eastern men is at the same time as [midday] for the [central] men [?] and as midnight (חצות) for the western men [?]; and the reverse. Nonetheless, the daylight and nights are [each] equal [12 hours] for them always [on the equator].

Siman 150 [סימן ק"נ]

Those who share latitude (ברוחב) [share] the measure of equal daylight (היומם שוים) among them all.

[Heading: המשתתפים ברוחב ממדת היומם שוים לכולם. Siman number reads = ק"נ 150.]

Those who share the latitude of habitation (ברוחב הישוב) — meaning that they share the same distance [latitude] from the equator (מרחק מן קו השוה); and these are the northerners who dwell [on a common parallel] — [share] a common arc or line, simple and straight (קו וישר), drawn from east to west, [parallel] to the equator (קו הישר), at this [given] distance from it. For them, as to the matter of the measure of daylight and night, the law is one and the same for all — just as one law applies to all who dwell on the equator (תחת קו הישר). And so it is here for all who dwell upon this [parallel] line, even if they are distant from one another by thousands of parsangs along the line: there is no difference among them except as to the priority of the easterners (בני מזרח) and the lag of the westerners (בני

מערב), in proportion to the distance between them — for every 15 degrees, one hour — exactly as for those who dwell on the equator (קו הישר).

Siman 151 [סימן קנ"א]

Those who share habitation in the length of the half-day equal in time (באורך זמן חצי יומם שוים) for all of them — and not so as to the beginning of day and night, except at the equinoxes of Nisan and Tishrei (בתקופת ניסן ותשרי).

[Heading: המשתתפים באורך זמן חצי יומם שוים לכלם ולא כן תחלה יום ולילה רק בתקופת ניסן ותשרי. Siman number reads 151 = קנ"א.]

Those places that share the length of habitation (באורך הישוב) [longitude] — meaning that the easterners dwell on a common line or [side] (קו או שום פאת), [a] straight arc drawn from north to south (מן הצפון אל הדרום) [a common meridian] — these do not differ in their latitude [?], for their distance from the northern axis (מציר הצפוני) [their co-latitude] is the same. [?] As already mentioned above in Section 2, siman [36] ל"ו [?], half the day is common to all of them, [for] all the days of the year, [at] the times when the sun is upon the equator (קו הישר). At those times the sun's rising and setting — that is, the half-day from the sun's rising until [its setting] [?] — comes to rest [is equal] for all those who share [the meridian], in [the same] moment [?]; but on the rest of the days of the year, as regards the sun's rising and setting, there is for them a [different] law and another matter, as will be explained in the example [given] for them.

The example of this: we know three places — they are Corfu (קורפו) [?] in the lands of [?] [?], Vilna (ווילנא) [Vilnius] in the lands of Lithuania (ליטא), and the island [of] [?].

[The named places: קורפו = Corfu; ווילנא = Vilna/Vilnius; ליטא = Lithuania. A third location ("the island") is named but its identity is unclear. — flagged.]

Corfu (קורפו) [lies] within the Great Sea [Mediterranean], at the edge of the land [of] [?], according to the map (מפה) [?]…[these three] — all three of them — share only [longitude]; from the east [?] they all dwell on a single line drawn from the north to the south, [the line] whose distance from that [meridian] edge is [some] degrees [?]; and we [will] give the measure of each one of the three aforementioned cities along the length [longitude] of the world. And according to what has been explained, the time of midday (חצי יומם) is found to be [the same] for all three at one [common] moment [?], according to [?]. And this is a true matter.

But upon superficial reflection it would seem and appear to us that the same law [which says] that there is a [common] half-day for them, in the matter of [day-length], should hold for them likewise at the beginning of daylight — since these places are fixed upon a single line of longitude (קו אחד רוחב) [?] drawn from the north to the south, having one and the same [meridian] from its head to its foot, one breadth, from the center [?]…of the east [?]. But know that in truth the matter is not so, and it cannot be so; rather, [it holds] only in the case [where] the sun is found among them [at the same circumstance of] the sun's rising — that is, that priority and lag [in] [?] rising and setting — when the sun does not rise or set for them as one, at one stroke, [except on] [?] the days of the year [that are] the days of Nisan and Tishrei (ימי ניסן ותשרי) [the equinoxes]. This is because, for all who dwell on the side of the equator (קו הישר) toward [the north] [?], forever, during the [seasons] [?] when the sun is in the northern signs [?], the day-arc (קשת היום) of the northerners is greater than the day-arc of the southerners. Therefore, of necessity, in the [seasons] of [those signs] [?], the sun rises earlier for the northerners than for the southerners by half the surplus arc (חצי תוספות קשת היתרון) — the surplus of daylight that the northerners have over the southerners on each day; and by this same amount the sun lags [sets later] for the southerners [?].

And we may say [conversely]: the sun sets above [later for] the northerner than for the southerner [?]; therefore it is **not** the case that the sun rises and sets for them at one stroke [simultaneously], so that the measure of daylight and night would be equal for all of them — that [supposition] is an absolute falsehood (שקר מוחלט).

In my opinion, [to know] how great the difference and priority is in the sun's rising between each one of the aforementioned three places — you may know it from what has already been explained nearby [?]: that the priority of the sun's rising for the northerners over the southerners is by half the surplus of the [day-]arc that the northerners have over the southerners. Accordingly, we must, in my view, [know] the elevation of the axis (גובה הציר) or the distance from the equator (מרחקה מקו השוה) [the latitude] of each one of the three places, by the way explained above [?]; and behold, we found that the distance of the city [of Corfu?] [?] from the equator (מקו השוה) is [?] [degrees]; and the distance of the city of Vilna (וילנ"א) is [fifty-?] [?] degrees; and [the distance of] the island of Corfu [?] is 38 degrees [?] — [these being] their latitudes (כפי מרחקם מן קו השוה) [?]. And when one examines, according to their elevation [latitude], the measure of their daylight — as was explained above in the test [?] in siman [116] קי"ו [?] — [one finds] that the measure of the daylight at its longest, at the summer solstice

(בתקופת תמוז), at the city of Vilna (עיר תחוזגג→וילנא) [?] is [?] hours; and at the island of Corfu (ובאיי קורפו) [?] [it is] fifteen hours; and at the city [?] [it is] [?] hours.

Section 6 (שער ו)

[continuation of siman 151]

[The opening of p. 93 continues the worked comparison from the prior batch — relating the day-arc surplus among places at different latitudes to the priority of sunrise. The text is heavily degraded at the page top.]

[?] according to what was explained above. The day-arc surplus of Corfu over [?] is to the third place [?] as [?]. So too the third place over Vilna [?] hours [?]. And this is according to the principle that an hour [?] in its rising [?].

[The northern place] anticipates [the sun's rising], for in a more northerly place the sun rises earlier, while [the more southerly place] lags behind — because the surplus of the half day-arc precedes [?]. And this is the reason that, regarding the places that share [?] a single meridian, the sun rises at the same moment only [at the equinox] [?].

For a mnemonic on this matter [?] — [the text here is badly degraded; several lines carry abbreviated worked numbers that cannot be read with confidence] [?].

Siman 152 (סימן קנ"ב)

Places that do not share [a meridian] — neither in their longitude (אורך) nor in their latitude (רוחב) — and the several rules and laws that apply to them.

The places that share neither longitude nor latitude — the wise man HaYisraeli [R. Yitzchak Yisraeli, author of *Yesod Olam*] writes about them at length, treating them broadly [Yesod Olam, Ma'amar 2, ch. 9 — "פ' ב' במאמר ב'"] [?]. He returns to them again [?] further on. Yet I have not found among his books [?] [a complete treatment] [?]; some of the rules are not given there in full [?].

[Rashi script / authorial aside, partly degraded:] I judged it best not to set out and expound every rule of this kind one by one — [for to do so] would require length [?] — nor [to record] all the matters at will [?]. The reader, if he wishes [?], will find [great] benefit or instruction [?]; and even so [?] [there is no need] [?] to think over these rules [?], for the matter [?] is [self-evident] [?]. It is easy [?] to come into them [?] [for one of intelligence] [?]. Therefore I have inclined [?] in my simplicity

[?] to leave the matters [?] [in their place] [?]. I in my simplicity [will not?] examine them [?] [until] I have toiled [?] [— that is the extent of my labor on this] [?].

[The body resumes:] The places that share neither longitude nor latitude — as, for example [?], when one place is at, say, 22° latitude (מעלות) and another place is at 33° latitude, while a third place in the inhabited world is at 36° latitude [?] — here the difference between them in latitude is [?].

[Worked example continues:] Now [?] [for] Vilna [?], its latitude is 56° [?]; these are 18 [?] degrees of latitude [for the comparison] [?]. As to Vilna by itself [?], its difference from Jerusalem [?]: the latitude of one of them over the other is [?]. [?] Vilna sits about two hours [in time] [?] — for 15° of longitude make one hour [of time difference], and there [?] [Vilna] [has] priority toward the east over [?] — because the city of Prague [?] [lies] [?]. And in [?] and in Prague [?] [the difference] [?], so that between Jerusalem and Prague [there is a difference of] [?] hours [?]. Accordingly [?] [Jerusalem] has [?] hours over [?] [as stated above], which is the surplus [?] [— this surplus comes out as the difference of the day-arc] [?]. And it is found, according to this, that what remains of Jerusalem's priority over Prague is one hour [?], as stated above (כנ"ל).

Siman 153 (סימן קנ"ג)

[On the fact] that several countries exist in which the sun rises before [it rises] in them [i.e. before our own place], on the eastern side.

From the matters we have mentioned it will become clear that there are several countries in which the sun rises on the eastern side — found [to lie east] of them — at one and the same moment [?]; that there are two distinct [time-]intervals [?] in them [?]. And there are countries in the opposite case (בהיפך), that is (ר"ל), where it does not rise [together] [?] at one moment [?]; and that [the sun] is rising over one place and setting over another at one and the same moment, on the well-known [longest/shortest] days. It is a still greater wonder that one finds [?] a western country in which the sun rises [at one of] the well-known [?] days — in [the same] countries where the sun rises on the eastern side [?]. To explain it to you (להשכילך) [?], let us say:

Take, for example, the city of Constantinople (קונסטאנטינ"א [Constantinople]), which sits [?] [at] 44° latitude (מ"ד) and 58° longitude (נ"ח) [recte: the first pass swapped these — confirms latitude 44° (= 12° N of Jerusalem's 32°) and longitude 58° (= 8° W of Jerusalem's 66°); the real city is ≈41°N, footnoted]. Now Jerusalem, by contrast, sits [?] on the east [?] [?], at 66° longitude [?] [the longitude figures

here are degraded] and 33° latitude. So [?] [Constantinople] has priority over [Jerusalem] [?], and Constantinople [is] eight degrees [?] [west? — figure degraded]. Toward the north (לצד צפון), Jerusalem [?] has priority over Constantinople [by] 12 degrees [?]. Since the inclination of Constantinople toward the north is greater than [that of] Jerusalem [?], its priority on the western side (מצד מערב) is greater than [that of] Jerusalem [?]. Therefore the priority of Constantinople is found [to make it] west [of Jerusalem] [?] — that is, [it is the place that lies] west of Jerusalem — [and so] the sun rises [there] on a known day before it rises in Jerusalem.

And now let us inquire (נדרוש) how close [?] the rising [is], approximately (בקרוב). We shall examine, by the art of the [celestial] globe (במלאכת הכדור), at the summer solstice (בתקופת תמוז) [?] for both places, by the method explained above [in the preceding siman]. We find that the measure of the day in Jerusalem [?] [is fourteen hours], and in Constantinople fifteen hours, less a little [?] [— so the difference between them comes to] [?] about one hour [?]. Then, when [?] the sun was [?] declining [?] in Constantinople [?], it had priority over [?] Jerusalem by one hour [?], [reckoned in the] eastern priority [?]. [The reasoning then divides up that one hour:] the eight degrees of Constantinople over Jerusalem [?] amount to [?] about half an hour; [there remains] about half an hour [?] [— that is] half an hour [?] [?]; [so] the sun precedes [?] in Constantinople [?] [reckoned by] [?]. And this is, as stated above, the approximate reckoning of the rising over Jerusalem [?] on its eastern side, in close approximation (בקרוב).

Siman 154 (סימן קנ"ד)

That the wise men [the sages] agreed [?] to relate (להתיחס) the [astronomical/halachic] events (המאורעות) according to the times of midday (חצות יום) and midnight (חצות לילה).

It is written (כתוב) in [the work of] HaYisraeli [Yesod Olam], chapter [?] [— "פ"ז" / paragraph 7] [?], from the discourse [?] [Ma'amar 2] [?], that the sages of [?] [drew up] [?] [their] reckoning [of] differing times [?], and that they related and timed the events that the eyes observe [?] [— the visible events] [?] — according to the times of midday and midnight. Even when an event occurs [?] in the morning of a given day, we reckon [?] it [?] [back] [to] [?] straight hours [?] [reckoned from] [?] the preceding midnight [?], or [forward] in such-and-such a manner [?]; and likewise [?] straight hours [?] before midday [?]. The reason is that these two times — midday and midnight — are shared by everyone [?] in their [respective] longitudes [?], throughout all the days of the year.

[p. 94 continues:] Likewise [?] in the case of latitudes [?] [the events are] [also] shared by those who do not share [a meridian] — neither in longitude nor in latitude — as, for example, between Jerusalem and Prague, where there is a priority [?]. The lag (האיחור) at midday and midnight is reckoned, for everyone, by a single measure: 15° [of longitude] for each [one] hour [?]; and there is no difference in this between those who dwell under the equator (קו הישר / קו השוה) and those off it [?].

Only if they intend [?] to relate the events to the time of the sun's rising or its setting [?] — then we would be compelled [?] [to invoke] the longitudes mentioned, which involve [?] many [?] laws and [further] determinations [?]; this leads to great error [?], and it is easy to fall into error [?]. All this [applies] to those who dwell off the equator [— who] do not share [a meridian], neither in longitude nor in latitude, and [whose places] are not [?] [identical] [?].

But [for] those two places that dwell under the equator (קו השוה), there is no difference between [the moment] we reckon there as midday or midnight and [the moment] we reckon by the rising of the sun over the horizon (אופק) or its setting — because all [their] horizons of the equator [?] [are alike]. For [each of] them, by itself, [the moment] is the half of their day [?]: just as, in the example, the horizon of the dwellers at the navel of the earth (טבור הארץ) is itself the half-day point [?] for the dwellers at the western edge [?], so too for the dwellers at the eastern edge [?]. And [in this respect] the rule of every horizon of the equator is the same — they are all half-horizons [?]; for those who share it in latitude there is no difference. In this matter, then, the reckoning of the times of midday and midnight — or of [the times] between, [namely] the rising and setting of the sun [?] — closely [coincides] [?], because the rule of all who dwell under the equator [is the same], in close [approximation].

Siman 155 (סימן קנ"ה)

On the reason for the [necessary] precision (דקדוק) in knowing the differences of the times (חלופי הזמנים).

Why [?] did the sages of the Truth [the astronomers] (חכמי האמת) take such care with the knowledge of the rule of the differences of the times? Not [merely] for the world's inhabitants, to sharpen the pupils' [minds] with it [?] — though that alone would [justify] [?] the advantage of the speaking [man] over the dumb beast — but, moreover, know that there is also in it great benefit and a real need for several matters, as will be explained. For the children of Israel (בית ישראל) too there are several matters [for which] this is needed [?].

For example, regarding the matter of the [seasonal] solstices/equinoxes (תקופות) [?]: suppose it comes out for us, by calculation, that the spring season (תקופת ניסן) — [which determines] the [reading of] *birkat ha-chodesh* / Rosh Chodesh [?] ["ער"ח = ערב ראש חודש] — falls at the midday hour of [a given] day [?]. Even though that single season [enters] at one [and the same] instant for the whole world (לכל העולם כולו) — [for it is] 48 [?] — it is impossible to say that at that one instant it will be the midday of [the Shabbos] [?] day in every place of the earth's regions. And if we wish to [draw] some [halachic conclusion] from the moment (שעת) of the season's onset, we must know upon which [meridian/place] [?] the [tables of the] seasons were founded.

If we say that their reckoning was fixed (קבע) upon the horizon of Jerusalem [?] — so that the season falls there at midday of that [day] [?] — then we must reckon what time it then is in the city of Prague. According to that reckoning, that time is two hours earlier [?] than midday [there]; and at the western edge (קצה המערב) it is something like four hours [?] [before], and two hours before midday [?]. [There is thus] great difficulty and confusion [?] in this matter for us, concerning the reckoning of the seasons — [which bears] on the matter of intercalating the years (עבורי השנים) — as well as on the reckoning of the conjunctions (המולדות / *moladot*), of which we shall speak again [?], at greater length [?], in the eighth section (בשער השמיני).

Another illustration [?] of the benefit of knowing the differences of the times: For the matter of an eclipse of the moon (לקוי הלבנה) [?], at a known time, we must take account of the meridian (קו) of [the place where] it occurs [?]. [There is] much benefit in this for knowing the borders [?] of the earth [— and for knowing] the regions [?], and the times [?], and for knowing the courses [?] and positions of the stars [?], [as for] the times [?] and the calendar [?] of the great luminaries [?]. Therefore [?] let us begin and say [?]:

Suppose we know, by way of the matter [reported], that the moon entered into eclipse [as observed] here in the city of Prague at half an hour after midnight, and we wish to know at what time it [then] was in the night in Jerusalem (בירושלים). Then know (תדע לך) that, since Jerusalem [lies] toward the east of the city of Prague by thirty-three degrees, as stated above (כנ"ל) — accordingly we must conclude (לגמור) and say that the time of the beginning of the eclipse was, in Jerusalem, about three hours after midnight, in close approximation — even though the onset of the eclipse [itself was], for the two places, and for the whole world, at one and the same moment (בבת אחת). And if this eclipse were [observed] in a place lying further east than the city of Prague by fifty degrees —

which amount to three hours and a third — then we must conclude that there the eclipse was four hours and a third after midnight. And those at the eastern edge, distant from Prague by 144 degrees, for them the said eclipse: there the eclipse occurred at the ninth hour, three and a fifth hours after midnight; but there they did not see the said eclipse at all, for it was daytime for them. And if you reckon the time of the said eclipse for the dwellers at the western edge, distant from the city of Prague by 33°, the time of the eclipse for them will be one hour and two fifths, about [the end of] the hour after midnight. And so reckon every [case] like this.

[Worked illustration:] By way of an example [?] of the benefit of knowing the differences of the times for the pupils [?]: behold, a certain king was born (נולד) [?] at the western edge [?] [— and likewise [?] for a certain month] [?] [it] [?] at midnight of the Shabbos eve (ליל שבת) [?]. The astronomers (התוכניים) and the wise men who are in Jerusalem [?] wished [?] to reckon [it] by their method [?] — and, by their conjecture [?] [?] [from] the time of the conjunction (מולח / molad) [?] [that fell] [?] [— what would befall him] from the moment of his coming forth [from his mother's womb] [?] [until] he returns [?] to dust [?].

Now it is impossible to say that the time of that king's birth was midnight of the Shabbos eve in [every] place of the world; therefore let us inquire (נבקש) at what time it then was in Jerusalem in that night. And since Jerusalem sits 66° east of the western edge, we therefore know that the [moment that was] midnight of the Shabbos eve at the western edge — at that same time it was itself, in Jerusalem, four hours and two fifths before midnight, or one hour and three fifths of an hour after the beginning of the Shabbos eve.

Siman 156 (סימן קנ"ו)

On the variation (השתנות) of summer and winter, and that those who dwell under the equator (קו הישר) have two summers and two winters.

The variation and difference between each and every place [?] regarding [the lengths of] summer and winter [?] — just as, among the inhabitants of the world dwelling [?] between [?] north and south, there is found a variation and difference between each and every one [of them], according to their distance from the equator (קו השוה) [as stated above] [?] — likewise there is found among them [?] a variation and difference in the [duration] of summer and winter [?], in just the same way, according to their distance from the equator. We shall begin with the principal point (ראש הדבר) [?]:

We shall begin with the [study of] summer and winter for those who dwell beneath the meridian-circles that lie midway (באמצעי) between north and south — which is the equator (קו השוה). Know that all who dwell under the equator (קו הישר) have two summers and two winters every year, at the two times when the sun is at the equinoctial signs — Aries and Libra (טלה ומאזנים); for in [each of] these two [the sun is] at the beginning of these [signs]. [It is] the [point] at which the sun [is at] the head of [the constellation] — each one of them …

[p. 95 continues:] …in [each] one [of these times of the year] the sun [stands at the equinoctial point]. And likewise [there are] the two winters — at the two times when the sun is at the head of Capricorn (מזל גדי) [and at the opposite point]. So that these two times [the equinoxes] are, for each one of these two places, the middle of summer; while the two winter-midpoints fall at the seasons of Teves and Tammuz (תקופת תמוז) respectively [the assignment of which winter is Teves vs. Tammuz remains [?] — the clause order is degraded below the scan-DPI floor]. So it comes out that the two times — the season of Tammuz and the season of Teves — are for us [the two extreme points].

[The reasoning:] At [the equinoxes], the temperament (מזג) is balanced between cold and heat in the utmost degree — for they have no [particular] temperament; there is among them no one [time] hotter or colder than its fellow, since both of them [are reckoned] from the point of the head — the zenith of the dwellers under the equator. And from all that you should know that for each place [— that the second of the two mentioned winters is hotter] than [for our own] place [from our standpoint, Prague]. For their cold will be greatest when the sun is most distant from them — that is, when the sun has receded from Prague; for when the sun has receded from the equator (קו השוה) by 24°, then their heat will grow strongest at its utmost in the season of Tammuz, when [the sun] is at the head of Cancer (מזל סרטן) — for then the sun has approached toward us [Prague] in the utmost degree; yet even so, [the sun] is [still] distant from us by 56°, while it is nearer to us than it is to the dwellers under the equator by 24°.

Siman 157 (סימן קנ"ז)

[On the matter that] the dwellers under the equator (קו השוה) have, in [each of] their four [seasons] [?] [— four shadows] [?].

Know (תדע לך) that, for the dwellers under the equator (קו השוה), [the shadows behave as follows:] when the sun is at the head of Aries (ראש טלה) or of Libra (מאזנים), in the morning their shadow inclines toward the west (מערב), and in the evening their shadow inclines toward the east (מזרח); but at midday, when the

sun is then at the zenith, directly over the crown of their head (נוכח קדקדם), they have no shadow at all in the world. And when [the sun] is at their head — at the zenith — their shadow vanishes, and they stand without any shadow. And when the sun is in the northern signs their shadow inclines toward the south [opposite the north]; and when the sun is in the southern signs their shadow inclines toward the north (לצד צפון), as stated above.

Know further (ועוד תדע לך) that, [reckoning] from the season of Tammuz (תקופת תמוז) onward, the [midday] half-day shadow grows longer and longer, until the days reach the season of Tishrei (תקופת תשרי); and from the season of Tishrei until the season of Teves the shadow lengthens further, and the places [at the equator] have their shadow at its utmost. So too from the season of Teves — and likewise from Tammuz — their shadow shortens; and so from the season of Teves until the season of Nisan the shadow diminishes, until the shadow vanishes from them entirely (עד שיכלה הצל מהם לגמרי).

Siman 158 (סימן קנ"ח)

On those who dwell under the circle of [the tropic of] Cancer (עגול סרטן) and beyond [?] [— that they too have four seasons and four shadows] [?].

For the dwellers between the equatorial circle (עגול הישר) and [the] circle of [the tropic of] Cancer (עגיל סרטן), and between the equatorial circle and the circle of [the tropic of] Capricorn (עגול גדי), they too (גם להם) have four seasons (ארבעת התקופות) — two summers and two winters — and four shadows (ארבע צללים), just as the dwellers under the equator have. Only that the times of their turning-points (תהפוכותם) are not equal in distance and measure one from the other. [Let us take] an example of this: those dwelling midway (באמצע) between the equatorial circle and [the] circle of Cancer. Behold, when the sun reaches Taurus (מזל שור) — which is at the middle, the midpoint between Aries and the tropic of Cancer — the sun is then [directly] above, opposite the crown of their head; and this will be at about the middle of the month of Iyar (אייר). Then they will have their first middle of summer (אמצע הראשון). And from there the sun proceeds toward Cancer and back, reaching the half-sign point. And when the sun reaches Taurus again — that is, at the half-point of the sign — it [returns to be] over the crown of their head; and this will be at about the middle of the month of Av (אב). Then they will have their second middle of summer (אמצע השני), and between the two middles of summer there will be something like three months (שלשה חדשים). And from the [first] summer until the [second] summer recurs, you will find [a span of] thirty-nine [recte: 39 = ל"ט — see note] days.

Likewise their winter times [behave the same way]; and they too are not equal in equal times nor in equal measures and temperaments. The reason is that the first winter [is when] the sun is at the utmost of its distance toward the north [from them] — that is, when the sun is at the head of Cancer (ראש מזל סרטן), as at the season of Tammuz (ר"ת תמוז). They then had no [intervening] time between [the middle of summer] and [the middle of winter] except something like a month and a half. And the second winter — which is the time when the sun reaches the beginning of Capricorn (תחלת מזל גדי), as at about the 18th of Teves (י"ח טבת) — is distant from the [first] summer's time by four months and a half. And so likewise [there is] a great difference and great variation between the cold of the two winters, which they will feel — they will not feel it equally: when the sun is at the head of Cancer, near to the crown of their head — at twelve degrees from the point over their head; whereas [when the sun is] at Capricorn, distant from the point opposite their head, [it is] about thirty-six degrees.

Siman 159 (סימן קנ"ט)

[On those who dwell] under the circle of [the tropic of] Cancer (עגיל סרטן) [itself] and beyond it (ולהלאה ממנו).

For the dwellers [whose latitude lies exactly] under the circle of Cancer (עגול סרטן), the sun passes [directly] over [the point] opposite the crown of their head (נוכח קדקדם) — the point [of] their zenith — [only] once per year (פעם אחת בשנה), and then their day will be of the measure given in siman 40 ["— ומדת היום כסי' מ'" — מ' = 40, not 140] [— and it appears (נ"ל) this should be emended].

Their days and nights are equal, each one to the next. [And so too, when the sun is] in its [opposite] turning, at the half of the year, at midday. The dwellers there will have no [midday] shadow at all — for all their shadows stand erect, perpendicular, in a straight line; and [thus] they have only one summer and one winter. So too, for all the dwellers further north, from the [point] of the circle of Cancer and beyond it, [the sun] passes over [— but] does not reach the zenith: it does not pass over, and the sun does not reach [the point] opposite [the crown of] their head [— and so] it remains toward the north; for all the dwellers [further] beyond the latitude of [the tropic of] Cancer (מעמד סרטן) — [the sun stays] toward the north (לצד צפון), as stated above in siman [?] ["כנ"ל בסי' ת'"] [?].

Siman 160 (סימן ק"ס)

Why is the day hotter at midday than at morning [?]; and why is [it] hotter in the evening than in the morning [?]; and why is it colder in winter than in summer?

It is well known (ידוע) that the heat of the day comes from the sitting [— the dwelling —] of the sun (בשיבת השמש) [?]; and because of this it is called a "hot place" [?] (מקום חמה), from which [comes] the warmth [?], as stated above (כנ"ל) at the head of the first section. (And in the view of the philosophers (הפלסופים) [?], who said that the heavenly spheres (גלגלי שמים) are neither hot nor cold, neither moist nor dry [?] — yet they conceded [?] that the heat of the sun [?] [is perceived] [?].) The heat of the sun is felt from two causes (שתי סיבות): one (האחת) — the time that the sun is above the horizon (מעל לאופק), which is the daytime period, is hotter for us than the time it is below the horizon (מתחת לאופק); and the second (השנית) — the nearness (קריבת) [of the sun] as it approaches toward the northern pole (לצד קוטב הצפוני), so the heat grows stronger for us, the northern dwellers; and likewise, as [the sun] recedes from us toward the south, the cold grows stronger for us. So you should also know [about] the great heat found among the dwellers in the lands toward the south, where the sun [leans], such as in Egypt (מצרים) and in Barbary (גרבריא"ק [Barbary / al-Gharb — the Maghreb, NW Africa]); and there is no need to say it of those who dwell under the equator (קו השוה) — [that their heat is greater]. [And conversely] the cold and the chill [are greatest for those who are most distant] from the heat [— the opposite — for those at] the northern circle, [the chill that falls] upon the dwellers ...

[p. 96 continues — the answers to the questions of this siman:]

[the] northern [region] and beyond it. Now since there is no doubt that the nature of the sun['s] action is always uniform (שוה היה לעולם) — [its action upon us is the same — so if it appears otherwise, it is because of its varying nearness]. Therefore it seems to us (ידמה לנו) that its action is varied toward the north; for you already know that what the sun does it does every single day, since nature (הטבע) [acts uniformly]:

[The author now states the celestial-globe model behind the question:] [There is] a circle traced around the [two] ends [poles] of the earth's sphere (קצוות כדור הארץ), which is the half of the diurnal sphere (גלגל היומי). This circle is what we call the day-arc (קשת היום) — the arc above the horizon; [near the equator it is] approximately equal to the equator (קו השוה), more or less. [The day-arc] is what we traverse from the sphere of the earth, from the moment of the sun's rising (זריחת השמש) above the horizon until its setting below it.

[The author now lists the questions to be resolved:] So it is fitting to ask (יש לשאול): (a) Why does [the air] become warm [for us] at midday more than [in] the morning and the evening? — for [it would seem] that, by what is plain, its inclination toward the north [is the cause], as will be explained further on: it is

then nearer to us than [in] the morning and the evening. (b) And further: by what appears to us, its inclination toward the north [should make it] nearer to us [in the morning and the evening than at the midpoint — so why is midday hotter]?

(c) Why does [the air] warm for us [more] in the evening than [in] the morning — why does it warm for us in the evening more than what warms for us [in] the morning? (d) And further: why [is it warmer] after midday more than before midday? (e) And further: why is the sun, when it is in the [zodiacal] signs of [the] summer [solstice] (במזלות שח"ס [the hot signs]), hotter than when it is in the signs of [the winter solstice] (טש"ת) — even though [the two are] equal in their distance from the inhabitants of the world (מיושבי תבל), and the day and night too are equal in those two times? (f) Moreover: since [the seasonal variation —] at the season of Teves the sun is [in fact] nearer to the earth's sphere than at any other season, as will be explained further on, in the seventh section (בשער השביעי), [as] the times of the seasons of the year ["כ"א קע"ת" — garbled cross-reference] [?] — [so] if at the season of Teves the sun is nearer to the sphere of the earth, it would have been fitting that in the season of Teves the heat should be greater — hotter than [at] the season of Tammuz, when [the sun] is more distant from it.

Answer (תשובה): To resolve these questions just mentioned, you must know that the wind, or the air (האויר), is by nature (בטבע) very cold; and were it not that the sun warms it, before its coldness could persist no living thing could endure — neither man nor beast could stand before the ice and the great chill. So too you must know that the cold and the heat for us [depend] on the closeness of the heat: when it is directly above the crown of our head it is strong, but when it is far it is weak — according to [the sun's] nearness or its remoteness from the earth's sphere.

You must also know (גם יש לך לדעת) that the chief action — the principal effect — of the sun and its heat proceeds from the center (ממרכז) of the sun's body itself (גוף השמש עצמו). Now that I have alerted you (עוררתיך) to the three premises just mentioned, let us come to resolve the questions (להתיר השאלות):

[Premise applied:] Know, then, from now on (ותדע לך מעתה), that when the sun pours [its rays] (תשפיע) upon us, upon the earth, in a perpendicular and erect line (בקו ניצב וישר), from above downward — as [it does] when it is opposite the crown of our head (קדקד ראשינו) — even though it is then in fact farther and higher from the earth's sphere, nonetheless the air warms most of all. For the sun's ray issues from the center in strength (בגבורה), and flashes (יציץ) with great force upon the sphere of the earth (כדור הארץ); and the warming-ray of the heat returns from the earth's sphere back upward, and the air then warms for us with a great warming,

with intense heat — which is not the case at the sun's rising and its setting, when the sun shines for us then from the [oblique] side, in a slanting line (בקו משופע); and there is then no [such] force. The sages have already brought [in support] this illustration and parable (דמיון ומשל):

[The thrown-stone parable:] A stone (אבן) thrown from above straight down in a perpendicular line (בקו ניצב) falls with great force, and also bounces (ירקד) and returns upward, back along the line of its throwing; but when it is thrown obliquely it does not fall with such force, nor does it return and bounce back against the line of its throwing — rather it bounces and moves off away from the thrower (ויתרחק מהזורקו).

And now know (ומעתה תדע לך) that after the air has been chilled all the night, behold, in the morning, when the sun rises (יעלה השמש) upon the horizon and shines, it has not yet the power to warm the air from the [oblique] side; [it warms it] only little by little, [striking] the upper layers of our horizon above. And the heat goes on increasing until midday (עד חצות יומס), when, for every man, it is the utmost of the day's heat. From midday onward the sun goes [westward], shining from the [slanting] side obliquely; and there is in it [then] no power to warm [afresh], yet from midday onward — and from every other [standpoint], since the air has already been warmed all that whole day — [the heat] persists. This is the reason that the heat goes on increasing a little throughout the whole day; and [thus] it is hotter at midday than before midday, and in the evening more than in the morning.

[The author closes with the Talmudic prooftext:] And from the reasons just mentioned you know why the sun, when it is in the signs of the summer solstice (במזלות סא"ב), is hotter than when it is in the signs of the winter solstice (טש"ת) — even though their distance from the inhabitants of the world is the same, and the daytime periods are equal and the nights are equal in those two times in the reckoning. The reason is that, during the time the sun travels its course through the three [zodiacal] signs of the winter solstice (שלשה מזלות טש"ת), it has already warmed the air over something like three months (שלשה חדשים); therefore, during the time it travels through the following three signs — the signs of summer (סא"ב) — it warms the air still more, to a greater degree.

This is like a heated chamber (לחדר) — a furnace-room — that has already been fired with wood (העצים) from the morning until midday: behold, when you add still more wood after midday — even just the same measure as the first — it will grow hotter and hotter. To this the Sages (רז"ל) directed [their words], as they said

on folio [29] [OCR shows "דף ט"ל"; the folio of the dictum's tractate, Yoma 29a] when they said (באמרם) [in Aramaic]:

[Aramaic, Talmud — Yoma 29a (the dictum on the harshness of summer's end):] *"שילהי דקייטא קשיא מקייטא"* — "The end of summer (שילהי דקייטא) is harsher than [the height of] summer (מקייטא)." [And the explanation runs:] this is the end of summer (סוף הקיץ), [namely] the season of Tammuz (תמוז); for since the whole air has already been warmed, and even the creatures [have been] in the heat of the summer, the air that has constantly passed over [warming] is now warmed [further], like a hot potsherd (בחרס), and it becomes harmful (ומזיקו). Thus far their words (עכ"ל).

And as for [the question] why, in winter (בזמן החורף), it is a time of cold and chill — even though the sun is then in fact nearer to the earth's sphere — by this you will know [the answer] from two reasons: The first reason (הסיבה האחת) is that the sun is then distant from the point opposite the crown of our head (נוכח קדקד ראשינו), and shines for us obliquely from the sides (מן הצדדים) in a slanting line (בשפוע); and it has not the power to warm the earth [as much]. And the second answer (התשובה השנית) is the length of the nights and the shortness of the days; for the length of the nights [allows] the air to cool and grow cold, and it does not warm much (לא רב), because it is warmed only in the short days (בימים קצורים). All this [holds] in the winter season — [printed:] בזמן הקיץ [recte: בזמן החורף; "in the winter season" — a compositor slip in the 1743 setting: קיץ ("summer") was set where חורף ("winter") is required, as the whole paragraph is the winter-cold explanation], even though the sun [is then] farther and higher from the earth's sphere [this neighboring clause is part of the same slip-cluster — it states the *summer* geometry; the intended sentence is the winter one].

[The author then notes that the two reasons just given are the obverse of the two given for summer:] [So that] it warms [?] still more [?] — [this is one of] the two reasons [?] [given for summer] [?]: the first [— that the sun] [?] [is] near [?], opposite the crown of our head [?], and pours upon the earth with great force, like the stone thrown [straight] down from above [?]; and the second [— that] in the time [?] of the long days [?] the air warms [?] with a great warming [?], whereas in the time of the short days [?] [it warms] only a little [?].

[Parsing note: Siman 160 is the longest passage in the batch. The bulk of it was recovered at further review (): the two-causes framing (שתי סיבות; קריבת), the "nature is uniform" bridge, the day-arc/diurnal-sphere definition, questions (a)–(e) in full and (f) in substance, the three premises, the perpendicular-vs-oblique ray model, the thrown-stone parable, the morning→midday→evening sequence,

the ב"אס/ס"חש vs. ת"טש signs paragraph, the furnace analogy (with לחדר confirmed), the *shilhei de-kayta kashya mi-kayta* dictum and its hot-potsherd (בחרס) gloss, and both winter-cold reasons. Residual still-[?] items: question (f)'s opening connective and its forward cross-reference "כ"א קע"ת" (garbled, unrecoverable at this DPI). The closing clause printed "בזמן הקיץ" is a **confirmed compositor slip** for "בזמן החורף" ("in the winter season") — certain at the letter level (קי״ץ is clear in image and OCR), not a translator misreading; carried inline as [recte: בזמן החורף], with its neighboring summer-geometry clause part of the same slip-cluster. No higher-DPI rescan will change the press error.]

Siman 161 (סימן קס"א)

That the cause of day and night, summer and winter, and all the [other] seasons of the year, lies also (גם הם) in the cause of the two motions — the voluntary (הרצונית) and the necessitated [— forced] (וההכרחיות).

Even though (אע"פ) the cause of day and night, summer and winter, and the rest of the seasons of the year (עתות השנה) has already been explained to you in this section, [each] according to its proper need (כפי הצורך), in full [?] — know [?] that the wise man HaYisraeli [R. Yitzchak Yisraeli, *Yesod Olam*] writes, in chapter 8 of the second discourse (בפ"ח ממאמר השני) [Yesod Olam, Ma'amar 2, ch. 8], that all the variations (השנויים) of day and night, of summer and winter — both in their general aspect and in their particulars (בכללם ובפרטם) — and the rest of the times and seasons of the year mentioned [?], apart from (זולת) the causes and reasons [already] mentioned [in this section], he [HaYisraeli] [?] [holds] [?] [— and he wrote there in this section [?], in his opinion (כסברתו) [?], may his memory be a blessing (ז"ל) [?]] — that the reason for all of them (טעם שכולם) [?] [lies] in the cause of the two motions: the voluntary (הרצונית) and the necessitated [— forced] (וההכרחיות).

The first (האחת) of them is the voluntary [motion], [running] from west [?] toward the [?] [east] [?] [— "ממערב כלפי מזרח"] [?]; and the second (והשנית), the eastern [— or, the necessitated] [?], which is the forced [motion] (ההכרחיות) [?], turning (הסובב) from east toward [the] west [?] (ממזרח כלפי מערב).

Section 6 (שער ו) — conclusion of Siman 160

[The opening of p. 97 continues a discussion from the prior batch.] And I say further: the necessitated [forced] motion from east to west, by means of the daily sphere, then necessitates everything [to turn] toward the west. Were the daily diurnal motion absent — that is, were the sphere of the stars to revolve only by

its own [proper] motion — and were the eighth heaven, the upper firmament that we have above us, to remain fixed [?], and were every part of the firmament that is above us to stand each in its place without moving, then we would not have [days], and the [planet] would not have made its way; and forever no star would ever draw near to our zenith, directly above our heads, nor recede from us. There would then be no cause or occasion for the sun to vary, neither in its solstices [?] nor in its equinoxes; the days and nights would not be of differing length in one [and the same] place; the moon would have no new-moon; and the rest of the works of Creation [would not function]. Were the western voluntary motion alone — revolving from the west, operating by itself without the eastern motion by means of the daily sphere — then there would be a dividing-line between day and night entirely null [?], for then there would be no light rolling over [the earth] turning away the darkness because of the darkness. The dawn [?] would [simply] rise as a line drawn straight across to them at the western horizon, and its light would spread over it and not set — until half a year had passed; and afterwards it [the sun] would set as a line at the eastern horizon for a time, until half of the [other] half-year, until it would be a time of [light] for half the year; and so the rule [?] would hold for all the other planets — that each one, half the time of its circuit would be [light] for it, and the [other] half of its circuit would be [darkness] for whoever is beneath its horizon. There would then be no occasion for the differing seasons of the year, nor for cold [and heat]. [end of siman]

Siman 161 (סי' קס"א) — From what place of the earth does each day begin to be called by its name

> **A wondrous question**, long and weighty, marvelous in its difficulty [?], deep — "deep, deep: who can find it out?" [cf. Kohelet 7:24] — [namely], to know from what place of the world does each and every day, every day, begin to be called by its name; and what place of the world is it where [the day] can end, where its name departs [?]; and what is the order of the completion of each and every day, and of all the days of the week.

Already the great ones of the world were roused to investigate [this matter] — R. Avraham bar Chiyya the Nasi [Abraham bar Hiyya], and the great R. Yitzchak [bar]... [?], and the Halevi, author of the Kuzari [R. Yehuda Halevi], and R.... [?] author of *Ba'al HaMaor* [R. Zerachiah Halevi], all of blessed memory. And the great sage R. Yitzchak HaYisraeli [R. Yitzchak Israeli] has already written at length on this very matter in his *Yesod Olam*, Ma'amar [Essay] 4 [?], and there he expounded the matter over six [?] large chapters. He wrote that on these

[questions] the understanding of most men has gone astray, and that the authors who [treated them] — their spirits were confounded [?] and the judgment of their intellect was struck down [?], unable to bring forth a [sound] ruling.

I saw fit [to set down] in my book, in this place, the aforesaid question, together with [further] questions that branch off and chain from it — questions of insight and understanding [?]. And although my soul has longed [for brevity], and although in this place brevity is fitting [?], yet because of the depth of the matter I am compelled to expand upon it a little. With all that, you should know that R. Yitzchak [Israeli] — for all the length at which he treated this subject in this place, establishing all the questions and all the reasonings [?] in a single question — I, the author, saw fit to divide [the material] into four questions. For although each one depends on the other [?], by [presenting] them one at a time I have spoken, so that the contemplative reader [maskil] may properly grasp the answer to them all.

In order to explain and to gain insight, and to clarify [?] before we bring these deep questions to light — I will remind you of their disposition [from] what we already explained in Section 3, regarding the place of the world where two [men] stand, separated by the diameter of the earth, opposite one another with the soles of their feet [pointing] one toward the other [i.e., antipodes]; for the moment of the rising of [the sun] for the one is the moment of its setting [for the other], and the moment of midday for the one is the moment of midnight [for the other], and so forth. And after [?] [reviewing] this — let it be set as a remembrance between your eyes before [we] come here, before we descend to these marvelous questions — in order to show the contemplative reader [maskil] [the matter].

This wonder [is illustrated] by the [following] circle, around point ה, which is the center of the earth's globe. And let this be (look at the circle [marked] אב"גד) the circle that will be the surrounding [horizon-]line of the earth's globe, drawn directly beneath the equator [the line of equal day]. By way of example: Reuven stands in the west — call its degrees [longitude]... by the computation of the [...] degrees [?] as above, in [siman] [?]; and directly opposite him, facing the soles of Reuven's feet, stands Shimon in the eastern extremity, at the [...] degrees [longitude] [?], 90 [?]. And Levi dwells at the navel of the earth, which is the midpoint between the eastern extremity and the western extremity — at the ninetieth degree [?]. And Yehuda [dwells] toward the [?] from the western extremity, [the soles of] his feet facing [Shimon's?]. And the sage [R. Yitzchak] Israeli calls the [western extremity] at degree [...] [?] from the western extremity. To this point — the navel of the sea [?] — he reckoned the navel of the earth,

[namely] where half the earth's globe is submerged in water; but in truth it is not so, as [explained] above.

And now, in Section 3 [?] — there will fall, on this matter, four great questions, marvelous and deep:

The first question: from what place of the world does each [day] of the days of the week begin first to be called by its name, according to mankind; and what place of the world is it where the day's name ends last and the name departs entirely [?].

To explain and instruct the students [in] this question, together with the three questions that follow it, we shall take in hand one of the four beginnings of [the reckoning of] times — [namely] the beginning of each day, which [is reckoned] as above in [siman] [?], without any necessity that compels — that is, the day-beginning that the [start] of every [day] is the start of the night, according to the [reckoning] of our holy Torah, as above [in siman] [?]. For although there is no practical difference in the matter at all, and there is no [distinction] in the world relevant to this matter with which we are occupied — and we [set] for the start [and head] of the day — yet we [wish] to make a beginning, with respect to this same point [?], with the [line] that surrounds the earth's globe. There is no [distinction] in the world, in this respect, between place and place, for every point of every line that surrounds the globe of the earth is equal — all of them, with respect to this matter with which we are occupied.

Therefore, in our example, we shall sometimes take the beginning from the point of the navel of the earth, and sometimes from the eastern extremity, and sometimes from the western extremity. And in our example, regarding the first of these questions — the first question, concerning the beginning of the surrounding line of the earth's globe — we have chosen [to fix it] at the navel of the earth [following] some authorities [?]. The author of the Kuzari and the aforesaid author of *Ba'al HaMaor* chose this point as the head and beginning [?].

And so we shall say, by way of example: from now on, when the sun sets for the one who dwells at the navel of the earth — for him it is then the start of the eve of Shabbos. Behold: the sun sets for Reuven, who [...] six hours [?] later, [for he is]...

[The text continues on p. 98.]

[Diagram on p. 97, bottom right:]

Diagram. A circle representing the horizon-line of the earth's globe, drawn beneath the equator, used to illustrate the positions of four observers around the

earth and the question of where the calendar day begins. The circle is labeled around its circumference and at center.

- ערב (top): "Evening" / west
- בקר (bottom): "Morning" / east
- ראובן (right side): Reuven [the western observer]
- שמעון (left side): Shimon [the eastern observer]
- Center point ה [hei]: the center of the earth's globe
- The circle is named אב"גד (alef-bet-gimel-dalet) — its four cardinal points.

[Several peripheral labels are degraded; the legible cardinal terms are "evening" (top) and "morning" (bottom), with Reuven and Shimon named on the sides.] (more than two peripheral labels are degraded/uncertain).

Section 7 (שער ז)

[Continuation of Siman 161, p. 98:]...for Reuven, who dwells at the western extremity, [the sun sets] 90 degrees [west] of [the navel] [?] — for him the start of the eve of Shabbos will not be [the same] (and also the eve of Shabbos for Reuven [?]). It is plain that [only] six hours later will it be the start of the eve of Shabbos for him, [reckoning] as above. And for the one dwelling [facing] the navel of the sea [?], which is — as above — [the navel of the earth], the start of the eve of Shabbos will be six hours later [than for the navel]. And for Shimon at the [eastern] extremity, the start of the eve of Shabbos will be six hours [later still — i.e.,] in its third [interval] of six hours [?]; and thus we find, according to the view of the author of *Ba'al HaMaor* and the author of the Kuzari, [...].

According to this, then, the dwellers at the navel of the earth — as stated above — anticipate [those at] the western extremity, [by] eight [?] hours, at the start of Shabbos. (Even though the distance between them is only ninety degrees, which the sun traverses in six hours — yet according to their reckoning [...].) Thus, six hours after [that], it would return [?] to be the start of the eve of Shabbos for the dweller at the navel of the earth, Levi — a second [time]! And this is a manifest falsehood [שקר מפורסם]; for how could it be conceivable that at a [given] time in some place it is the start of the eve of Shabbos, and immediately twenty-four hours later [it would be], in that very same place, the start of the eve of Shabbos a second time? This is mere vanity and folly [הבל ורעות רוח] [cf. Kohelet], no more than a hint [?]. Therefore we are compelled to say that there is a [single] place where each day begins to be called by its name, and [that] there is a [single] place in the world where the day's name ends, [and beyond it] the name departs.

Siman 162 (סי' קס"ב) — How many hours remain of [the day's] name

> **The second question:** how many hours of the name "Shabbos" — or the name of any other day [?] — remain [in force] for all the rest [of] the days of the week, which mankind has established, according to mankind.

For all the inhabitants of the inhabited world [tevel], who dwell along the [single] line that the [sun] surrounds, [moving] from the eastern extremity toward the west, around the whole globe of the earth — to explain, and to grant insight and understanding to the students [in] this question, let us first speak of the [length] of the line of the world, which is from the western extremity, where it is the head and the beginning of [the counting of] the degrees, [running] until the eastern extremity (the degrees of the globe), which [span] there 180 degrees [until they are completed].

And now let us make a supposition, and say, by way of example: the eve of Shabbos which begins at the moment of the setting of the sun on the sixth day of the week, at the western extremity of [the inhabited] earth [?]— and this is the time of the standing [setting] of the sun at the navel of the earth, [there] in the east — according to this our supposition, in this place the day of Shabbos will begin to be called by its name first; and all the rest of the inhabitants of the [other] half of the earth's globe stand, in their [daytime] of the sixth day, at the time of [that] setting (the aforesaid setting is not the one mentioned [for the navel]). The setting revolves and [moves on], turning [?] over the other half of the globe; and so it [Shabbos] will be named, according to them, one after another, in order, from [...] the western extremity, [...].

[The text becomes denser here; key thread:] After the [twelve hours of the] first [setting] proceed, the western extremity and the [last] evening — the setting being the last for all [the dwellers] of [one] half of the globe (because at that [moment] the center of the sun reaches [the point] opposite the navel of the earth, below) — from that [moment] the name "sixth day" goes and departs entirely, and Shabbos enters for them; and to the inhabitants of [that whole] half of the globe it appears as Shabbos, because then it is evening over the entire face of [that] half of the globe. And from this moment until the end of the [next] twelve hours [...] [the sun moves] over the face of the [globe] of the one who dwells in the eastern extremity, where the [sun] begins to set, in this same order described above, until — after another twenty-four hours [?]— it will begin [again]. And then the aforesaid first setting will depart from the dwellers [who were the first to see it sunrise].

[...] those who dwell [in the east] will begin to call it the first night, [or] the [eve of the] first [day], while all the rest of the inhabitants of [that] half of the globe still stand in their [daytime] of Shabbos, until the sun goes and sets [...] at the end of [the] twelve [hours], in the first order, until the sun has set [...] at the western extremity; and then the name [Shabbos] departs from the dwellers of [that whole] half of the globe, and they all return to call it "first day," as at first. Thus we find that thirty-six [?] hours [in all] is [the span over which] the name "Shabbos" is continuously called, according to mankind — that is, according to [the perspective of] mankind, all of them [together] — although, according to any single one of them, [the name persists only twelve hours] [?]; for thirty-six hours [is the total] only from when [the name] begins to be called among the dwellers of [one] extremity, first, until it departs from the dwellers of the western extremity, last. Between [the two], two [...] of the [interval], thirty-six hours [?]; and all this [holds] for [a span equal to half the globe of the world].

Siman 163 (סי' קס"ג) — [The third question / and the rotating-globe parable]

> [Continuation:] And now [for] the [third] question: how many hours of the name "Shabbos" remain for the rest of [each] day, for all the inhabitants of the inhabited world [tevel], who dwell and revolve around the whole globe of the world?

The answer to this question is very subtle and fine [?]. And yet, for the [dwellers along the] eastern three-quarters of the globe — [reckoning] from the eastern extremity to the west, and from there [back] until [the point] opposite the navel of the earth — if [the supposition holds] [...] the name "Shabbos" remains for its dwellers [for] sixteen [?] hours, [counting] from when [it] began. For the dweller of the eastern three-quarters of the globe returns [?]: for the dwellers of the eastern extremity [?], the name "Shabbos" will remain — by the computation of [siman] [...] — for forty-two hours [?]. For [consider:] from the time the sun sets on the sixth day [for those at] the eastern extremity, and [moving on] to those who dwell facing the navel of the earth, for whom [the sun] sets, there are eighteen hours; and then [there remains] for the dwellers facing the navel of the earth the [start] of the eve of [another] Shabbos, so that, according to them, there remain [...] the [twenty-four] hours of Shabbos. Add to the aforesaid eighteen hours [these twenty-four], and they come to forty-two hours.

In this too [matter] we have a great and very precious [problem], as you will understand in the fourth question, in [its] place [?]. And henceforth: in the [reckoning] from the [...] of the globe and onward [...], I have no [way] or means

[?] to know how many [hours] remain in the fourth [quarter] [for] the name "Shabbos" according to them; for [we do] not [know] the start of the day's naming [for them], and all the more do we not know how many hours [the name] "Shabbos" remains for them. With [further] questions and answers this doubt will be clarified to you further [?].

Siman 164 (סי' קס"ד) — The third [proper] question [midday/midnight problem]

> **The third question** stands [thus]: when the center of the sun [stands] at the midday of the daytime of the sixth day, directly above the zenith of Reuven [?] — who dwells at the western extremity — let me posit that at that moment is the setting of the sun for the sixth-day daytime of Levi, who dwells at the navel of the earth; and for Levi at that [same time] [...] [it is] the start of the eve of Shabbos. But we [do] not know whether this is the start of [the day of Shabbos] for him, or [whether] he [is calling it] the [eve of] Shabbos. For it is possible that... [text degraded]...

[p. 99:]...the start of the eve of Shabbos (and to the west of him [?] for Shimon, the dweller at the eastern extremity [?] — there are twelve hours [until] the navel of the earth — for Levi; while [for] the western [extremity], and for Yehuda [?]) — when the soles of [the feet] of Levi [...], it is then that night [for Yehuda?].

But then it is the start of the morning [boker] [for Levi]; for in that hour [...] [the sun] has for the navel of the earth [...]. We have not, however, clarified to ourselves which morning it is — whether it is the morning of [Shabbos] or [the morning of the sixth day]. For, [as to] the start of the name [boker] of each and every day, it is [the] evening; and the [west] is — for the one dwelling at the navel of the earth — twelve hours [?] after [the start of] the eve of Shabbos. According to this it follows that the morning [boker] of which we [now] speak is [the morning] of the sixth day, after the [start] of the eve of Shabbos — that is, [it is], for the one who dwells at the navel of the earth [...].

[...] Behold, you have before you two suppositions and two contradictory examinations, and we [cannot] choose [which is] true — whether it is the morning of the sixth day of the week, [as is most likely], or the morning of the day of Shabbos. And if the Maggid [?] would tell us [the answer], or if it should arise in our mind to make the supposition stand — that the start of each day's naming is at the western extremity [?] — then it follows that the start of the eve of Shabbos at the navel of the earth, which we now spoke of, is eighteen hours after

the start [of the eve] of Shabbos at the western extremity [?] for Reuven, who [dwells] [...]. And from this [follows] a great perplexity [...].

[A worked illustration follows, p. 99:]...the start of the eve of Shabbos [...] and to the west [?] for Shimon, the dweller who is twelve hours [from] the navel of the earth, for Levi. According to the [view] of the dweller at the eastern extremity, for Levi who dwells at the navel of the earth [...]. And now: when the sun sets for the one who dwells at the navel of the earth, six hours after [it sets] for Levi, who dwells at the navel of the earth — and [it sets] for Reuven who dwells at the western extremity six hours [later], and there [it is] facing [...]. And now let us [bring in] Yehuda, [dwelling] facing the navel of the earth, [to ask] when the start of the day of Shabbos will be for him.

> Behold the [problem]: reflection [ha-hashkafah, "the surface view"] [suggests] that the start of Shabbos begins [for him] six hours after the start of Shabbos of Reuven, who dwells at the western extremity (which [sun] [...]), [namely] six hours after the start of the naming of the day of Shabbos at the place of Shimon, the dweller at the eastern extremity. But know that, according to this reckoning, there is found here a great perplexity! For that moment [is], at the start of the night for Yehuda, [the moment of] midday [chatzot ha-yom] for Shimon, the dweller at the eastern extremity; and the morning [boker] for Levi, the dweller at the navel of the earth; and midnight [chatzot ha-laylah] for Reuven, the dweller at the western extremity. For at that time the sun appears [to be] over the entire face of the surface of the globe — which is the arc [kashya] [?]. For the people of the east see it as it is setting; the people of the west see it as it [is rising], shining and dawning over their horizon; and the people of the other places see it from [the] two sides, from here and from there [overhead].
>
> And now let us [bring in] Yissachar, who dwells between Yehuda and Shimon, at point... [?]: what is [the state] for him and for his neighbors on his two sides — up to point א and up to point ד — which is, according to our supposition, [the arc] [...] and which is the fourth quarter [?], at the last [stretch] of the line that surrounds the whole globe of the world? What is the name of the day for them — is it the sixth day? Let us say [...]: according to our supposition it is in truth the sixth day, for [...] not yet has [Shabbos] [arrived] [...] [point] ד; for the start of Shabbos has not yet reached them [...]. The day of Shabbos will not begin for them until the sun sets [...], and according to the aforesaid reckoning, if the matter were truly so, there is in this matter a very great perplexity. For Shimon, who

dwells in the eastern extremity, at the midday of the day [...]. [...] of all of them [...] the name "Shabbos" will be called for them. How then can it be conceivable that Yissachar — for whom, according to the aforesaid supposition, it is the sixth day — [...]? For these two [men], so close to one another, both seeing the sun as one — that the one calls the day's name "sixth day" and the other calls it "the day of Shabbos" — there is no [...] error [?]. And if you should say that it is for them the day of Shabbos — [namely] that it is after the midday of the sixth day [?] — for the sun has [passed] from point [...] up to point א [...]; this too cannot be, because [...] even the start of the day of Shabbos has not yet reached them, and there is no time after midday of Shabbos [either], in such a way that the fourth quarter of the globe is [the arc...] [?]; and we do not know what the name [of the day] will be called among them. And from this it follows for us that we have found two neighbors, very close, less than one [day's-travel] [?], and we cannot say what the name of the day is that is called for them.

Section 7 (שער ז) continues — [p. 100]

Now, the Israeli sage [R. Yitzchak Israeli] has already answered the words of the two mighty ones — R. Yehuda Halevi and R. Zerachiah Halevi [Ba'al HaMaor] — concerning what they laid down as a fixed principle: that the start of each and every day, to be called by its name first, is at Jerusalem, or at the navel of the earth [?]. He answered them with answers, with weighty questions [?], great and awesome, [like] those that have roused us above in this [siman]. And he, of blessed memory — he labored in his treatment, and with the sharpness of his intellect, [as] limpid as mighty waters, he [resolved] all the doubts and the perplexities mentioned, which [bear witness] against the [astronomers] above, all of them — [namely] according to our supposition... [continues at top of right column, p. 100].

[p. 100, right column — the resolution:]

[...] He [reasoned] thus: the start of each day, to be called [by its name], is at the eastern extremity, as is [the view] of the [law] [?] and the [opinion] of [...] [?] [Rashi script: as in the words of the contemplative ones]. And as is reasonable [?] [in the view of?] the astronomer R.... bar Yitzchak bar [...] [?]. And the [...] [Rashi script / commentary] wrote and clarified that the aforesaid place — which is the eastern extremity — is precisely the place where the naming of each and every day begins, [and] no other place in the world. And likewise the western extremity is precisely the place where the naming of each and every day ends and is

completed. And its reason is because [R. Yitzchak Israeli] held that half of the earth's globe is submerged in water — like the view of most and nearly all the early sages [chachmei ha-kadmonim], who [held] that the last quarter of the globe is submerged in water; and we have no concern for the [people] of the sea — [as to] what name they call the day according to their view, and what [day it is] for them.

This his supposition: by it all the aforesaid perplexities [are resolved], all of them together, and no [difficulty] remains. But we, [for our part], have already explained above in Section 1, and likewise in Section 3, that what the early ones supposed — that half of the earth's globe is submerged in water — that supposition has already been nullified [refuted]. For all the early ones, both the sons of Israel and [the gentile sages], are found unanimous [?] in this; but it has now become known [otherwise] to us [through] the [discoveries] of the explorers [navigators], and it is not [true]. For it has been found that the [whole] globe of the world has dry land surrounding it on all its six [?] extremities [?] — some of it, in our view, in the upper part [of the globe], and some in the lower part — [including] beneath the soles of our feet, [in] the New World [olam ha-chadash, the Americas] which [...] has been [discovered]; and in particular, [in] the fourth part of the globe of the earth where we [dwell], [where] all the doubts mentioned above arise. And it is the land [now] called America [?] — newly discovered [?] — and it is [...] near to the eastern extremity (as [in] its degrees [?]); and it is a region great and broad, larger than half the [portion] of Europe [?] upon which we dwell.

So that, according to this, the answer of the Israeli sage [R. Yitzchak Israeli] is uprooted of itself, and has no foundation at all — such that all the perplexities which he, of blessed memory, [resolved] by the [...], and to which his supposition testified against the two astronomers together — these too: the difficulties and the doubts [remain] in their place, in this [matter], as you know. These four perplexing questions [?] [remain], and they shall remain a [...] in their [place], for our hands have failed and our understanding is short before the aforesaid perplexities; we have erred, and we grope [for the wall] [cf. Yeshayahu 59:10]. Know also, [for] your information, that the [...] doubts and the perplexities mentioned, which I set before these questions, I [laid] before great ones, distinguished in riddle [?] and Christian sages, who were before our lord the Emperor Rudolph [Rudolf II], [men] wise and understanding [...], whose intellect there is no [searching out] [?]; and after [their] investigation of the aforesaid questions for several days, they neither acknowledged nor gave any [answer] — to say that their reply was correct [?] and the doubt [resolved]. [end of siman]

Siman 162 (סי' קס"ב) — The revolving globe of the earth sometimes loses, and sometimes gains, one day of the days of the week

[*Editor's note: the print's "קס"ה/165" here is a degraded misread of* ***קס"ב/162*** *(bet read as heh, reinforced by an in-body "siman 105" cross-ref); the four שאלות earlier are sub-rubrics of siman 161, not simanim 162–164. Sequence is now 161 → 162 (here) → 163 (next batch), gap-free.*]

> [Heading:] **The revolving globe of the earth sometimes loses one day of the days of the week, and sometimes gains a day.**
>
> **One Day.**

The wanderer [ha-holech, the traveler] who walks and circles the whole globe of the earth from east to west loses [reckons one too few] of the days of the week in his circuit, [and conversely?]. Were a man to walk [or sail] from west to east [?], he [would] gain. And the difference [chiluk] [...] between [the two cases — losing and gaining] [is] one day. [The same holds] whether [the globe makes] the revolution that surrounds the whole globe of the world in forty days — were it possible — [or] in forty thousand days [?], or in any other [period], whether a year or otherwise: forever the wanderer [traveling east-to-west] then loses one day of the days of the week in his circuit; [and the one going west-to-east] gains a day in his circuit.

And in order to bring [the matter] near and to grant insight, in this [too], even to the small students, let us frame this matter by a parable. Were it possible — were a man able to circle the whole globe of the world in four days — we shall say, by way of example, as follows:

[Diagram on p. 100, left column:]

Diagram. A circle divided by a vertical and a horizontal diameter into four quadrants, representing the globe of the earth divided into four points (א, ב, ג, ד) for the four-day circumnavigation parable.

- א (top): point 1 [alef]
- ב (left): point 2 [bet]
- ג (right): point 3 [gimel]
- ד (bottom): point 4 [dalet]

[The four cardinal points name the four positions a traveler reaches over the four days of the parable.]

The parable (continuing beneath the diagram, p. 100): And it [the circle] is the line that surrounds the globe [along] which the day proceeds [?]. And I say [by way of example]: when [the sun] sets [?] [...] from one point — say point א, where Reuven dwells — [and the sun] rises [?] [...] over his horizon, and reaches the time of evening, which is [its] setting [?]: at that [moment] the sun sets for him, according to [...], so that for him at that [moment] is its setting [?]. And on the second day, at this [same] hour, the sun has dawned for him [...] from point ב [?]. [Thus] on the second day, the sun appears [to rise] to Reuven from the second point — even though, in truth, that time [...] for Reuven — [for] from the time he saw [it set] until the sun returns [...] [it is reckoned] according to the truth [...] [for] him [as] the morning [boker] of the second day. [So that] from point א [on day one] until the morning of the second day, which is at point ב — where Reuven, the [traveler] who circles, [has come to be after] thirty hours — Reuven would [have] remained standing in his place [had he not moved]; from [his being at] point א [...] he had, from the time of the sun's rising over his horizon until its setting from him — which is the arc [kashya] [...] of twelve hours [?] — [but] because Reuven [the traveler] [moved on] to point ב [...], the time of the sun's rising over his horizon until its setting from him at point ב, the [duration] of which is — at point ב — eighteen [?] hours, of which the twelve [...] are the night hours that belong to point ב, [plus] thirty hours [?]. And so likewise he will have, for the natural day, [reckoning to] point ג, eighteen [?] hours; [for] in such a way [there is], for the day's [...] going forth [...] to point ג, [the same] as for point ד, exactly. And in this matter [...] [from] point ג to point ד [...] eighteen [hours]; so likewise [from] point ד to point א, [the count being the same]: [there is for him] eighteen hours. [Thus] for the four points [together], the [natural] day [is] for Reuven eighteen hours; this comes to four days [in all] [?]. And to the [natural] days, Reuven adds for himself [...]; so that these natural [days] arrive [...] [for] the world and others besides — and [yet] all of them are [only] four days [reckoned] from time to time [moment to moment]; for in truth [...] they are natural days [...].

[End of Section 6 — conclusion of the circumnavigation problem]

[The opening of p. 101 continues the four-day circumnavigation parable from the prior batch. The text is badly degraded in places; I transcribe what is legible and flag the rest.]

and the reverse: a man who travels from a place toward the west, on the day he sets out, his day will be longer [?]. The sun's circuit relative to him is such that when [the heavens] revolve, Shimon went out [?]. He proceeds while the sun is upon him, and the heavens move from east toward [the place], and on the Sabbath [?] he ascended… on his day, and likewise the others there, and he lodged the four [days?] until [he came to] the point where one circuit [is completed].

Therefore Levi [?], starting from his point, moves over [the surface?] for Shimon… from his place each day from one day to the next, moment by moment, as it revolves [?]. By this reckoning, the time of the [day's?] circuit is not [counted?] from the side of the day [?] — only it is reckoned [?]. He has not yet [completed?] a quarter [of an arc?]; rather, three of the arc [?]; and likewise the stars [?]; this is correct according to [?]. So too the stars [?] — three of the fine arc would be; and likewise twelve hours [?], for so it is, moment by moment for him. Twelve [hours?] moment by moment for him… [degraded] every… and two of the arc.

[Degraded sub-section, set off on the page by a small rule:]

the hours, all of them, from when [?]; because the calendar [?] is for benefit, to make known… every place in the world, moment by moment for them, all of them, this [?] is in the days [?]. He found [?] that this is not in the reckoning [?], only three days [?], no more — apart from it. Few or many in years [?], for one who would circle the globe — therefore there is a difference. By this it is found that one would find in his circuit one day more [?]; this is a new matter [?].

[Restatement of the parable, continuing:]

When Reuven and Shimon and Levi set out together from one point [?] — Reuven goes from a place toward the west [?], Shimon eastward, and Levi remains in his place — and they meet [again]… on the third day, Reuven will reach [the point] toward the east, and there will remain for Reuven two days [?]. Yissachar [?]… On the day [?], the Sabbath [?]… And so it is found that on the [Sabbath?] of the fourth [week?]… for Shimon. The difference between Reuven and Shimon is two days.

Such, then, is the matter for Shimon: two days.

The Seventh Section

[שער השביעי / השער השביעי — Section 7]

In it are explained matters concerning the motion of the sun: how great is the measure of the time of its year, how many spheres are found in its sphere; that the sun has four motions; which is the mean sun and which the true [sun] within the signs; and that it traverses an equal path in unequal times, along with other particulars besides these.

[This is the section précis printed beneath the heading "השער השביעי."]

[Heading-count note: the section précis carries 6 simanim per the right-margin tally; see the running-header field in the report.]

Siman 163

[Marginal rubric: "An explanation of the [matter]" / "באור שנמצא" — "An account of what is found"]

In the sun, and likewise in the rest of the wandering stars [planets], there are many varied phenomena.

Know that the early sages — by their pure wisdom, by the depth of their probing, by the wonder of their investigation — discovered and saw, both regarding the sun and regarding the rest of the wandering stars, many things [?]:

(א) That all seven planets are found to have a proper motion of their own from west [toward east], opposite to the [daily] motion of the heavens.

(ל) [i.e. point 2 — the print uses ל as the second enumerator] That the seven wandering stars [planets] sometimes rise upon a line [drawn] from a sphere or from their center [?], and sometimes draw near to it and descend — and between this ascent and descent a difference is found of some thousands of *parsa'ot* [parasangs].

(ג) That the ascent of the star itself, in its body, is never forever in one place; for as the days are reckoned, it is displaced from there as well [?]. So we find that the planets [?] traverse equal paths in unequal times, and in equal times unequal paths.

(ל) [i.e. point 4] That the five [?] wandering stars sometimes appear to move forward and sometimes backward [retrograde].

(ה) [i.e. point 5 — the print's enumerators here are inconsistent; see anomaly note] That sometimes they stand still — neither going forward nor backward — like the planets that neither [go] forward nor backward.

(ו) That we find a certain star which, [over the course of] several months, rises upon my horizon [?] roughly one hour earlier or more, before [?]; and likewise, over several months, the sun rises upon the horizon — sometimes the very [same] star is seen at the western horizon after the sun's setting, one hour or more, earlier or later.

All these variations, in which the [stars] appear differently [?] — they are called *nevuchim* ["the perplexed/wandering"], as a man is called *navoch* ["bewildered"] [cf. *Shemos* 14:3, נְבֻכִים הֵם בָּאָרֶץ], and as it is written [Esther 3:15, " וְהָעִיר שׁוּשָׁן נָבוֹכָה"]. Concerning the causes of these variations — which I treated first, above in the [first] section [?] — the ancient sages decreed that each one of the seven wandering stars would have a ground [base] or a distinct sphere appointed to it [?], as will now be explained to you in this section. And all the variations mentioned that are found in the sun, together with whatever variations [the planets] require — those mentioned that are found in the rest of the six wandering stars — the reasons and the cause of all these matters will be explained further on, in [their] dedicated sections, b'siyata diShmaya.

Siman 164 [printed קסג — see anomaly note (a)]

[A] beginning on the structure of the sun's sphere — even though its sphere is the fourth, the mean of the seven planets.

It is fitting for us to set forth [this matter] first, because knowledge of the motions of the other wandering stars depends on the motion of the sun. We cannot grasp their motion and structure unless we first know the motion and structure of the sun. The sages have already likened the sun — in its being in the fourth sphere [?] — to a king whose servants [?]... the one whom [?]; "upon his word they journey and upon his word they encamp" [cf. *Bamidbar* 9:20]. And according to the view of the great investigator R. [?] — the Creator made [the sun] the center about which the five [?] wandering stars [revolve], being [their] center [?].

As to what this matter is — which can be neither estimated nor likened [?] — it was unknown to the ancient sages, [this] matter that fell upon [?]; concerning this matter a little more will be said at the close of this book [?]. Since all these matters issue from the matter of the sun, it is fitting that we begin and set forth [first] the motion of the sun, and after that, in the next section, we shall explain

the structure of the sphere of the moon — which is the lowest sphere [?] — because [from] it too [we shall draw], and it will aid us [?], so that by its means we may know the motions of the other wandering stars.

[Rashi-script gloss / commentary:] R. Avraham bar Chiyya the Israelite [?] used a fine expression when he said, concerning the verse [*Bereshis* 1:14] "...and let them be for signs" [וְהָיוּ לְאֹתֹת] — its interpretation is "for *simanim* [markers]," as [will be explained?]...

[Rashi-script continuation of the gloss from the foot of p. 101:] like a man who relies upon a [calendar] sign [?]. Were it not [for the heavenly bodies] [?]... For the Chaldeans [?]... were it not for [?] the heavens [?]; they are also dealing with the signs [of the zodiac], not the [whole] firmament [?]. We did not [intend?] [?]... to confirm the motion of the sun, as will be explained later.

[End of Rashi-script gloss.]

Siman 164 [printed קפד — see anomaly note (b)]

[Marginal rubric: "מדת שנת החמה וכמה זמן מדתה" — "The measure of the sun's year, and how great the measure of its time is"]

The measure of the sun's year — and how great is the measure of its time.

Know that the measure of the sun's year is a thing we greatly need, for the entire fixing of our seasons [appointed times] depends upon it, within the small cycle [machzor katan] [?] of the intercalation of [the supplementary] day [?] for our years. Is it not so that, in order to know all the wandering stars — their place in the sphere of the signs, and their encampments [stations] in all the signs, and the measure of the time of their motion — this was not known to the sages until they first knew the measure of the mean motion of the sun and the measure of its [path]; for this [?] was not known to the sages [?] except by way of [first] knowing it; there is no path to its knowledge except through knowing the measure of the year — as R. Israeli wrote in his treatise, Book 2, chapter [?]. Therefore, before we come to explain the structure of the sun's sphere and its motion, it is fitting that we begin with the [definition of] the year's measure.

[Marginal rubric: "גדר השנה" — "The definition of the year."]

The definition of the year is when the center of the sun, in its sphere, [starting] from a known fixed point of the signs — for example opposite the head [first point] of [the sign] Aries [Taleh], or opposite another marked clean point [?] known opposite it [?] among the twelve [signs] — by its mean motion [traverses]

the [whole] sphere of the signs of the firmament, and comes back and returns a second time to that very point [opposite] from which it set out; and then it returns [to its starting position]. The definition is correct [?]. And then [the sun] returns [?] for the year [?]: [the figure 365 1/4 follows in the running computation] — the measure of the sun's day-and-night height [?], its [exact?] day [?], and all the rest of its matters besides — back to the starting point in the beginning, and a return [cycle], so that it would be one [complete] revolution [?]. For this reason it is called "year" [*shanah*] in our language — a term of *shinui* [change/repetition], as in the expression "they changed and repeated" [שָׁנוּ וְשִׁנּוּ, cf. *Melachim* (?), the verse marked "מלכים סי' י"ח" — see citation note], that is, that the sun changes back [returns] to its first place; and likewise [the verb] "*yishnu*" — all the other matters return [each] to its station and to its measure as at the first.

For this reason [the year] is reckoned not only with respect to the sun alone, as stated above (siman [173] קע"ג) [?] — the measure of the time mentioned, that is, the time from a known point until [the sun] returns to that very point.

As to what the year is [as a whole], there is a dispute about it — not only among the astronomers of the nations but also among the astronomers [chachmei ha-techunah] of our people [Israel]. The great difference [discrepancy] found between the calculation of R. Adda bar Ahava and the calculation of [Mar] Shmuel [?] is already known:

For according to the view of [Mar] Shmuel, the sun's year is reckoned as 365 1/4 days — that is, 365 days and 6 hours.

And according to the view of R. Adda bar Ahava, it is reckoned as 365 days, 5 hours, 997 chalakim, and 48 regaim [רגעים]. By this reckoning, every year exceeds the calculation of Shmuel [?] [the printed value reads "פ"ב שנה כל... חלקים ל"ח רגעים" — see numerical note], by [an amount of] chalakim and 38 regaim [?]; and this surplus has already accumulated, so that in our days this difference is found between the time of Shmuel's *tekufah* [season-reckoning] and the time of R. Adda's *tekufah* — more than ten days [?]. We have expanded on this in our [other] books [?], and this is not the place to grasp [the full treatment of] it.

And the difference found in this calculation among the sages of the astronomy of old [?] — from then [?] until this day, the [scholars of] astronomy [?]. Know, then, as a general rule [?], that the astronomers — the ancients and the moderns [?] — among them were the Egyptian sage-priests [chartumim of Egypt], and among them the sages of Greece [Yavan] [?] — [their reckonings differed?]. The reduced

reckoning [?] does not diminish [the fact that] it is a great labor [?] and very [demanding] toil for one who wishes to stand upon the precise measure of the sun's year, and to scrutinize and refine all four motions found for the sun, as will be explained in its place in siman [?170] ק"ע. For all this, deep and great scrutiny is needed — very deep and very profound [?]; for this, one needs not [merely] the [labor] of our years [a lifetime], but the [labor] of [several] years [?] — indeed even thousands of years.

The ancient sages already investigated this matter with their scrutiny, with great precision, and they agreed that the measure of the year is 365 days and a quarter of a day, less a little — except that it was not in their power to compute and pin down precisely how much less than a quarter [it is]. And behold, [following?] the head [chief] of those who treat of astronomy [?], who is exact in all the ancient computations of [the science of] astronomy [?] — Abrakhus [אברכ"וס = Hipparchus] and others — he wrote that the measure of the year is 365 days and a quarter of a day, less one part out of three hundred [365 1/4 − 1/300] of a natural day [?]. And they have it, in the calculation of the *teshkuros* [?], two chalakim out of [?]; [so that] by this reckoning, the measure of the year is 365 days, and the quarter-day amounts to 5 hours, less [?]… [degraded].

According to this calculation, the measure of the year by this reckoning [?]… is 365 days, 25 fine-minutes [dakim] [?] less sixty [?] in an hour [?] — and that is called "the measure of the sun" [?]; and it is fitting to rely upon this view, because it is close to the view of Chazal [רז"ל] according to the calculation of R. Adda bar Ahava. For the difference between this reckoning and the reckoning of R. Adda bar Ahava is nothing about which a person need worry, on account of its smallness — for according to the view of R. Adda, the measure of the year is, over and above 365 days and five hours, 997 chalakim and 48 regaim, which come out to 53 fine-minutes [dakim], 25 seconds [shniyot], 10 [thirds] [?], and a quarter [?]. [The numbers in this passage are partly degraded — see numerical note.]

And now I shall reveal to the reader's ear what I have heard from the mouth of the great investigator, concerning whom the astronomers of our time have testified that none so great an investigator as he has [ever] been found — [namely] Tycho [?] [בטוצמיא"יה / בטולמיאו"ס — see person note], "the great sage" [?]; it seems [?] that he scrutinized all the ancient computations, [and] found by the test of his investigation that the year's [length] is less than the computation of Ptolemy [בטולמיאו"ס]; and that the precise measure of the year is 365 days, 2 hours [?], 9 [?] fine-minutes [dakim] — very close indeed [?]. And so too I heard from the mouth of the wondrous sage, who was a disciple [talmid] dwelling

alongside Tycho [טיח"א = Tycho?], and who was after him [his successor?] at the head of the sages before our lord the Emperor — Rudolf [רודי"ל / רודולף, i.e. Rudolf II] — who agreed [?] with the aforesaid reckoning; and it is less than the reckoning of R. [Adda] [?] by only [?] up to six fine-minutes [dakim].

Siman 165

[Marginal rubric: "לדעת כמה מהלך החמה ביום אחד נגד אופק המזלות" — "To know how much the sun travels in one day relative to the horizon of the signs"]

To know how much the sun travels in one day [of arc] relative to the horizon of the signs.

Know that, according to the aforementioned reckoning [of] how many [degrees] or parts of an arc the sun traverses against the sphere of the signs in one day — once you know the measure of the year, this becomes an easy matter for those skilled in the science of number [arithmetic]:

To reckon how much one whole circuit of the sphere amounts to per day, [divide?] the full circle [360°] by the days of the year, and that is the [degrees] [reading "שס"ס = "פ"ש"ס? see note] divided by the number of [days of] the year [?], and the quotient is the measure of [the arc traversed] each day of the year — just as the arithmeticians do [?]. Let us say: if a year is 365 days, 5 hours, 49 [?] fine-minutes [dakim] and a fifth, [then we ask] how many degrees the sphere advances per day [?]; and [if] we complete it as required, by the method of the arithmeticians, [there] comes out for you the equal [mean] motion per day:

- 59 fine-minutes [dakim] [?]
- 8 seconds [shniyot] [?]
- [a value in thirds and fourths follows — partly degraded: "קז"ג thirds, י" fourths" (?)]

[These are the standard Ptolemaic mean solar daily motion values; the printed digits are partly degraded — see numerical note.]

[Continuation of Siman 165 at top of p. 103 — degraded:]

and that there are in the [circle] 360 [degrees]; and that is called "the fifth" [?] — a great [?]… To know the measure of the sphere's [revolution?] in [?] days [?] is, for one who knows arithmetic and number [?], a thing easy for the skilled — [counting] the year by months, by days, by hours, by [?] — to set up for himself a single table [luach] by which to know from it the sun's motion at any given time.

See on this *Yesod Olam* [of R. Yitzchak Israeli], Treatise 3, chapter 2 [מאמר ג' פרק כ'? — see citation note]; and in the section "The Shapes of the Land" [וכשער צורות בארץ], Section 7 [?], [paragraph?] 6 [?].

Siman 166

[Marginal rubric: "שזמן מדת השנה יחשב ע"פ סיבוב גלג' המזלות וכו" — "That the time of the year's measure is reckoned by the revolution of the sphere of the signs, etc."]

That the time of the year's measure is reckoned by the revolution of the sphere of the signs [the fixed signs?] — and not by [the revolution of] the signs of the [zodiac] owners-of-the-shapes [the constellation-figures]; and [whether] the year's measure stands at one [fixed] measure.

Ptolemy [בטולמיאו"ס], the chief of the astronomers, wrote that the time of the year's measure is reckoned by the revolution of the [whole] sphere of the fixed signs, [thought of] by way of the curvature [?] of the uppermost sphere, the [outermost] sphere [?] — as stated above [?] in the Fifth Section, siman [ק"כ ?120]; and such is the view and the agreement of all the astronomers, ancient and modern alike, whether of the children of Israel or of the nations.

[The above is in the body; this clause continues:] The time of the year is reckoned [as] the season-circuits [tekufot], and the reckoning of the sun's center [traveling around] the sphere [?] from point to point — by its motion against the [fixed] signs.

By contrast, [reckoning the year] against the true signs [the actual constellation-figures], the "owners-of-the-shapes" [ba'alei ha-tzurot], as stated above in the Fifth Section — there is no [stable] reckoning by way of precision; for the circuit from point to point against the constellation-figures is more than [a true] year, [as] is already explained above at the close of the Fifth Section: that according to Ptolemy's view, the sphere of the signs revolves one degree in a hundred years [precession]. [Therefore], according to [the view] that the sun's center, [departing] from a known [point] of its sphere, [comes back to] that very point of the head of Aries [Taleh] — it does not [return] from there [?]... as it would [?]; for it [the constellation-sphere] has by then moved on [?] by one degree out of the hundred [degrees], such that the time of the season-year [tekufah-year] does not stand forever at one measure.

A [number] of fine-minutes [dakim] [?] — one fixed and precise measure — as stated above. And among them, R. [?] wrote a different [view], a third [position], after [?]... [degraded]. And from this they [argued] and proved and showed

regarding Ptolemy, that there is in [the calendar?] [?] only a very fine variation that is imperceptible [?] — neither felt nor noticed except after some [number] of years [?], on account of two causes: the one, the *re'idah* [trepidation/libration] motion as [stated] above at the end of siman [130] ק"ל; and the second, that most of the place [?] — the [stars] against the signs — most of them are themselves displaced [?] from their place, as will be explained, by way of the two motions [?], in siman [?179] קע"ט of this section.

[Thus] the measure of the season-year [tekufah-year] does not stand upon one [fixed] measure either. These matters are deep and very wondrous; but according to what I have heard from the mouth of the astronomers of our time, they take no account at all of these two [supposed] motions [?] — they have entirely [set them aside?] [?] — for in my opinion [?] the trepidation does not nullify [anything], as [stated] above in siman [100] ק'; and [likewise] the displacement of the sun [?]: they took no account of it for this matter [?], [holding] that it remains [stable?] [?]. [End of siman.]

Siman 167

[Marginal rubric: "שיש לגלגל החמה ג' כדורים ברורים המסבבים ברור הארץ" — "That the sun's sphere has three clear orbs that revolve [about] the clear globe of the earth"]

[That the sun's sphere has three distinct orbs that revolve about the globe of the earth.]

Know that the eminent sage, the chief of those who treat of astronomy — Klodi'a [קלודי"א, Claudius] Ptolemy [כטול"מיאוס] — seeing that most of those who treat [of it] [were perplexed?] by the variations found in the motions of the wandering stars (as I shall mention below, presently), set right and established [the matter] by the great wealth of his wisdom, by the keenness of his intellect, and by the eminence of his investigation, to find the cause whereby it would be possible to confirm, to understand, and to set right these wondrous and marvelous [phenomena] [?]. From every aspect [?] of this matter [it follows] that each of the spheres of the wandering stars is fixed within a sphere — [each] sphere within [another] sphere, one covering [enclosing] the other [?] — on all six of its [extremities], both on the side of its convexity [gavninut] and on the side of its concavity [ke'arirut], in such a way that the whole thickness [body] of each is divided into two kinds of spheres: the one inner, the other outer. Now I shall set forth their laws for you; and the analogy [will be drawn] for [you] regarding the

sphere of the sun with which we are now occupied — and from it the structure of most of the remaining six wandering-star spheres will be understood.

The inner sphere of the sun's sphere [is] in which the body of the sun is fixed, [set] like a nail within a [solid] sphere [literally a wheel/round body]. This sphere [the deferent's body?] issues [is eccentric] from the center [of the world?] [?]. Just as the center of the sphere of the signs is not the center of the sun's sphere [?] — so too this inner [sphere]: it is eccentric [its center lies off-center]; therefore its [center's] distance is [equal] neither to the globe of the earth [below] nor [reaching all the way] up above [?]. It is always nearer to one of the extremities than to the [?]... And the inner sphere [the deferent] within which lies the body [of the sun] [?] — its center is the center [?] [degraded].

The center [of the deferent] is the center of the earth [?], which is the center of the [sphere of the] signs itself; therefore it is at an equal distance — on all sides of its concavity it is [equidistant] from the globe of the earth; and likewise on [the side of] its convexity it is at an equal distance from the sphere of the signs [?], revolving about the center of the signs. The center [?] of this orb [is] beneath the [line of?] the midpoint [?] of the cuttings [the zodiac sections?] of the signs — and the sun, or any other star [planet] that is beneath this [orb], is also [?] [positioned] beneath the line of the [middle?] of the circuit itself [?]; therefore this inner sphere [the deferent] is so [described].

The [middle] sphere — the body of the sun's sphere: Because it is like the round body [body] of the signs [the ecliptic-circle] with respect to its center, it resembles it in every respect [?]; and because it is at an equal distance with respect to its [centeredness about] the center of the signs [?], it also resembles [it] in its distance — at a distance equal on all sides about itself [?], like the [sphere of the] signs [?], in its [position] about the globe of the earth; on [the side of] its convexity it is at a distance equal on all sides about itself to the [sphere of the] signs.

[**Marginal note at the foot, set off:**] "By the two centers mentioned" [ההמיהנזכר — degraded; refers to the two centers — of the world and of the eccentric].

[The sun's sphere] is described by three orbs: [That is], the sun's sphere is given a [common] center [and] is placed within the [body of the] resembling [middle] sphere; and that is [bounded by] the [orb of the] deferent and the [orb of the] eccentric [?] [reading קת תקנ/ק as garbled]. The sun's sphere [the middle, body sphere] is found [?] above and also below [the deferent], as stated above, in such fashion that the deferent's sphere [?] separates and divides the two sides of

the sun's sphere into two separate [parts] — even though, as I said, the two of them are one orb [a single body], save that, in order to make the matter clearer to the student [?], [we treat them] as though they were entirely separate. So it is found, according to this, that the three orbs [?] of the sun's sphere that encircle the globe of the earth [from] its [several] sides — although in truth all of them are joined into a single orb, divided [only conceptually] [?] in its thickness into three orbs, as you will see in the diagram. And in order to make it clear to his students, the astronomers [?] distinguished them [in the drawing?] on the surface [in the plane], [showing] that the sphere [?]… the outer convex [orb], which is the great visible [outermost] one, [is] the largest of all; and the inner one, which is the smallest, [is] the least of them all. The sages made [in the figure] two [marked points / circles?]: one point [marking] the convexity of the great [outer orb] [?]; and for the concavity of the small [inner orb] and for the convexity [?] of the great [orb]… the outer one touches the [inner] sphere…

[The exposition of the orbs continues on p. 104.]

[Continuation of siman 167 at top of p. 104 — degraded:]

in the [round] body of the [middle] sphere, [set] like a pearl [?] sunk within a ring [?] [reading "כמרגלית השקועה" — like a sunk pearl]. The sun [?]… the inner sphere of the [middle] sphere [?]: in its concavity it touches [?] the concavity of the small inner orb [?], and [in] its convexity it is fixed within [?]. In the diagram [batzurah], the point of the [orb] is [marked] — there where all the thickness [body] of the [middle] sphere ends [?]; the small orb's [?] convexity touches [it] [?]. And so it is done [?] for the two points — that is, [the point of?] the convexity [?].

[At this point on p. 104 the body continues into the explanation of the eccentric, the deferent (the orb that carries the sun), and the relation of the orbs of the sun to those of Mars and Venus — but the type at the head of the right column is heavily degraded. The legible portion resumes:]

[Concerning whether] the [orb] resembles [the great convex outer orb] above, and the small orb [is] near to it below [?] — it touches [?] in its concavity [?], [it being] near, to the inner [orb] [?] of the [middle] sphere above [?]; and the middle orb [the body of the sun's sphere] is near to it [?]. The sages placed its center [?] toward [?]: in the diagram [batzurah], the point [marked] ב [bet] is on the side of the concavity, and on the side of the convexity also the point [marked] toward the convexity [?] of the inner [orb] of the [eccentric/deferent] above; and [for] the [orb] that encloses the [whole] sphere — they marked it [in] black in the figure

[shachor batzurah] — point ב [bet] also; both of them [serve] as a center for each other [?]; both of them bound the white circle [the eccentric] that issues forth as a [separate] center [?]. [reading garbled.]

[Each of these three orbs differs from its fellow in shape:] Each one of these orbs differs in its shape from its fellow [in this manner]: the great orb [the outer], in its thickness, [is] above and below [thick], [tapering] until its whole thickness ends [comes to a point], as fine as a hair's breadth [literally "as a thread's fullness"] [?] — while the small orb is uniform [?]. [The reverse for the inner.] The thickness [body] of the great orb is, above and below, as fine as a hair's breadth; and the middle [eccentric] orb that issues forth [the eccentric], which is the [orb whose] center [is off-center] — [it is] entirely white [in the figure], uniform in its thickness on all its extremities.

[**Inset diagram caption / heading, set off in the print:**]

Diagram. A set of concentric circular bands representing the three orbs of the sun's sphere (the eccentric "deferent" structure of Ptolemaic solar theory). The innermost disk carries the labels א [aleph] and ב [bet]; the surrounding rings represent the inner orb, the eccentric (white) orb carrying the sun's body, and the outer convex orb. The text states the sages drew it with a black-marked enclosing sphere and a white eccentric circle, with point ב on the concave side and point א at the world-center.

- א (innermost, lower position in central disk): [aleph] — marks the center of the world / center of the earth, which is the center of the sphere of the signs.
- ב (innermost, upper position in central disk): [bet] — marks the center of the eccentric (the "issuing" / displaced center about which the deferent body revolves).
- (concentric outer rings): the three orbs — the great outer convex orb, the white eccentric orb (the deferent, carrying the sun's body), and the small inner concave orb.

[Caption beneath the figure, p. 103:] " פוף מרכז לשניהם שניהם מגבילים את עגול הלבן היוצא מרכז" — "...[both of them serve as] a center for the two of them; both of them bound the white circle that issues forth [as a separate] center." [partly degraded]

You, O reader — I have already roused you above in the First Section, [reminding you] that it is impossible to draw a sphere [globe] properly upon a [flat] surface; and I have already opened your ear and given you [leave?] [to

picture it] with one [solid] model [?] [made] upon [?]. Here, then, know for yourself that the three [orbs] drawn [in the figure] as [flat] circles [should be conceived] as [solid] columns [cylindrical bodies?] [?] — all of them having one center [?] — [and that] they are spheres [globes] that encircle the globe of the earth on all six of its extremities.

Siman 168

[Marginal rubric: "שהעגול האמצעי הלבן גם החמה עצמה נוגעין בגלגלי מאדים" — "That the middle white circle, and the sun itself, touch the spheres of Mars"]

That the middle white circle — [and] the sun itself — touch the spheres of Mars.

The white circle that is in the figure: you will find in it [marked?] the figure of the sun, fixed within it like [a nail in] a round body [agulah, a wheel] within this sphere — or like a pearl sunk in the socket of a ring [?]. The middle sphere [?] [is] the one that carries [nosei] the sun; in its [marked] point in the figure, there where the whole thickness [body] of the great black sphere ends, the middle white circle [touches] [?]. The carrying [orb] [the deferent] — at its convexity it touches the concavity of Mars's sphere [the orb of Mars] that is above it, at the point called the apogee [gova — the high point], which is the point [opposite] the perigee [shifulei — the low point]; and in the figure it is the point [marked] ח [chet] [?]. This carrying sphere touches, at its concavity, the convexity of the [orb of the] apogee that is below it [?]; and so it does likewise [for the sun itself] — when [the sun] reaches the two points, that is, the point of the high apogee [?] [and the perigee], the sun meets and touches Mars's sphere from above it [the apogee], and at the perigee [shifulo] it meets and touches the [orb of the moon?] from below it [?].

And since the other six wandering stars [planets] likewise each have three [such] orbs of their own, just as the sun does, know therefore: when the sun is at its apogee [high point], Mars is at its perigee [low point], and the two stars — the planet Mars and the planet of the sun [?] [reading "כוכב חמה" likely a slip for the apogee/perigee relation] — in their bodies cleave to and kiss [touch] one another [?]; and likewise when the sun is at its perigee [low point], Venus [Nogah] is at its high point [apogee], [so that] the two stars — the planet of the sun and the planet Venus — in their own bodies cleave to and kiss [touch] one another. [The geometry: adjacent planetary orbs share a touching surface, so apogee of one coincides with perigee of the neighbor.]

Siman 169 [printed קעא — see anomaly note (c)]

[Marginal rubric: "ביאור קו מסלול החמה אשר תסובב תמיד ולא תסיר ממנו לעולם" — "An explanation of the path-line [orbit] of the sun, about which it always revolves and from which it never departs"]

An explanation of the orbital path-line of the sun, about which it always revolves and from which it never departs.

In the middle of the carrying sphere [the deferent] that is in the figure, there is drawn one circular line [marked?], in the very middle of which the center of the sun cuts [traces] and describes [the line], tracking along that line — and that is the line of the equator [the "belt"], which is the line of the middle of the surface of the [zodiacal] belt [chagorah], as stated above in siman [106] ק"ו. This is called the *maslul* [orbital path / "track"] of the sun — that is, [the line] upon which the center of the sun always revolves, beneath [along] the line of the equator [?] [reading "קו הקדרות" = the equator-line]. This motion is called "the motion of the mean [sun]" [mahalach ha-emtza], as will be explained, and by it the sun completes one [full] circuit against [all] the twelve signs in [one] solar year. By its means [by this circuit] all the seasons of the year are set right — cold and heat, summer and winter — and [retain?] this in mind, [keeping] all this in memory [for when you will need it later]. [I shall need these terms further on.]

Siman 170

[Marginal rubric: "חמשה עגולים נמצאים בכלל ציור גלגל החמה הנ"ל ומרכז היוצא חוקקן קו עגול סביב מרכז העולם" — "Five circles are found in the whole drawing of the aforesaid sphere of the sun; and the eccentric center traces a circular line about the center of the world"]

Five circles are found in the whole drawing of the aforesaid sphere of the sun; and the eccentric center traces a circular line about the center of the world.

From the [general] principles we have mentioned, it will be made clear to you [that] in the three [orbs] of the sun's sphere — [examining] the circles mentioned — you will find five circular lines. These are they:

1. the outer circle of the sun's sphere [the great convex outer orb's circle];
2. the inner small circle [the small concave inner orb's circle];
3. and 4. — two circles bounding the eccentric orb [the deferent / "the sphere that issues out from the center"];

4. and the circle of the *maslul* [the orbital path-line — the equator-track].

That makes five.

You will also come to know that — according to what has already been clarified, that the center of the world in the figure is point א [aleph], and the center of the eccentric orb is point ב [bet] — when the sphere that carries the sun by way of the eccentric orb revolves, then its center, namely center ב [bet], will trace a circle about the center of the world, which is the point [marked] in the figure [point א], at an equal distance about [the center] on all its sides [?].

Section 7 (השער השביעי) — continued

Siman 173 (סימן קע"ג) — On the dimensions of the thickness of the carrying-sphere

The thickness of the carrying-sphere (the deferent) of the sun is just sufficient that the center of the sun be carried within it, and that the center of the world be situated within the carrying-sphere itself. Its measure is twice that of the two small spheres [orbs] together, and the diameter of the eccentric is five and a half times that of [the smaller], as will be explained further on in Section 8, at siman 239 (סי' רל"ט).

We explained above that the diameter of the revolving body — that is, the [solar] orb — relative to the diameter of the earth, comes to five thousand four hundred parsah [parasangs] when reckoned simply, and eighteen hundred parsah [?] when [the figure is otherwise computed]. And when this number is multiplied by five and a half, the total comes to nine thousand [and] nine hundred [?] parsah (תת"ק [= 900]) — and this is the thickness of the carrying-sphere of the sun.

[The arithmetic here is unclear in the print: "five thousand four hundred" × 5½ would give a far larger figure; the rendered total "9,900" does not close the multiplication. Transcribed as printed and flagged — see Numerical impossibles.]

It will be explained further on, at siman 178 (סי' קע"ח), how far the center of the eccentric sphere of the sun stands away from the center of the world. See also Bekiyim [?], Treatise [מאמר] 20, chapter 20 (פ"כ ל') [?].

Siman 174 (סימן קע"ד) — Why the three spheres [orbs] of the sun were posited, each differing from its fellow

The masters of astronomy were compelled to draw the sun as three bodies [orbs], each differing from its fellow, and not as a single body. The reason is this: had the

three been equal to one another — as is the case with the eight heavens [the celestial spheres] arranged one above the other — then, because the center of the solar orb lies eccentric to [the center of] the world (as the investigators have already established, since there can be no void in the cosmos that an enveloping sphere could revolve about [?]), they were compelled, in order to represent the eccentric sphere, to draw two further spheres: one above it and one below it. The sphere above fills the [outer] heaven with its convexity, and the sphere below fills [the gap] with its concavity. In this way no void is found in the hollow of its companion, nor is there any sphere within sphere [left empty]. The carrying-sphere [the eccentric/deferent] is eccentric, its center being other [than the world's]; whereas the [composite] sphere as a whole is concentric — its center always coinciding with the center of the earth, at the center [of the world].

Siman 175 (סימן קע"ה) — An exposition of what Chazal, of blessed memory, said [ז"ל], that the sun [and the moon] [?] are set in the second firmament

Chazal, of blessed memory, said in Bereishis Rabbah [בראשית רבה], "Where are the sun and moon set? In the second firmament" — that is to say, [they are] not [literally] both in a single firmament, and also not [in the sense] that the second [firmament] refers to the orb of [the planet] Mercury (כוכב), which is the second from below, nor that it refers to the orb of Jupiter (צדק), which is the second from above. For [by either of those readings] the contradiction would be plain. Rather, it appears that each of the two luminaries [is set] in its second heaven — meaning the eccentric carrying-sphere whose course is "drawn out," so that the contradiction not [arise]; the [luminaries] being scattered as they appear to our eyes.

Siman 176 (סימן קע"ו) — The three bodies [orbs] mentioned, each one having two centers

The sphere as a whole, the concentric one, is described [Rashi script: in the figure — see further] [?], and on account of the variation of motion that is perceived in their substances [?], it is found that each one of them has two centers. One of them is the great black body [orb] whose convexity is its outer circle — its center being the center of the world, which in the figure above is the point [marked] א [aleph] — while [the other center] is on its concave side, which is the line of its inner circle; this latter line also bounds and touches the carrying-sphere, and its center is eccentric to the center of the world, being the point marked ב [bet] in that figure. Likewise the small black body within it [shown] in the figure has two

centers as well — except that here the matter is reversed: the line of its convex side bounds and touches the carrying-sphere, its center being eccentric to the center of the world, while the line of its concave side faces toward the body of the earth, where the center of the world is found. The point whose center is on the inner circle of the small black body, and likewise the center of the outer circle of the great black body, is [the point] א [aleph]; and the center of the outer circle of the small body, and likewise the center of the inner circle of the great body, is [the point] ב [bet].

Siman 177 (סימן קע"ז) — That the middle body [orb] of the solar sphere is the [body] whose center is eccentric to the center [of the world] in the absolute sense, and by whose revolution alone the year is reckoned

Now the third body [orb] of the solar sphere is the body described as white — the one that is carried by the sun [?]. Its center is eccentric, as is plain [from the figure], [running] along [a path] between the two convex circles [the deferent boundaries]; and the concave [boundary], for both [are] shared by the two bodies mentioned, the one above and the one below this [middle] one. From this it is self-evident, without need of [further] explanation, that the point ב [bet] is at once the center for its convexity and for its concavity, and likewise the center of the maslul [the orbital path-circle]. By the revolution of this middle body alone — and of nothing else — the sun is carried about the body of the world in its essential motion, in three hundred sixty-five and a quarter days (= שס"ה ורביעית [¼365). This is not so for the concentric sphere as a whole, that is, for the outer and inner [shells], in which we sense no motion at all, save only [a motion of] one degree in some hundred years (as stated above at siman 214 [סי' ריי"ד] [?] and below) [?] — namely the motion of the eighth sphere [the sphere of the fixed stars], from west to east. And the second motion, [which moves] the body of the sun [?], will be explained shortly.

Siman 178 (סימן קע"ח) — That the sun draws nearer to and farther from the center of the earth

Know that the masters of astronomy, by their study, have found that the sun draws nearer to and farther from the center of the earth by some thousands of parsah [parasangs] from time to time. The reason for this is the eccentricity of the center of the carrying-sphere [its lying] above the center of the earth. The fact that the eccentric carrying-sphere maintains the body of the sun at the same [fixed distance] from itself causes the sun's distance from the earth gradually to

increase, up to its daily apogee [גובה יומי], which is the point ז [zayin] mentioned above. And at the point ז [zayin] in the figure above [it is at] the apogee [?]; from the orb of Mars [גלגל מאדים] [?]... [region degraded]...far. When [the sun] reaches there at the [season of the] true [solstice] [?], the earth will be...

[for part of...]

[continuation of siman 178:]

the beginning of the sign of Cancer (סרטן) [the summer solstice], it gradually [recedes]... up to the point ז [zayin] mentioned above, at the [season of the] true solstice of Teves (תקופת טבת) [the winter solstice]; and there, at the lowest point [perigee] of the orb, [it is] at its [maximum] descent. This is when it [stands] at perigee, and this occurs at the true solstice of Teves. The difference between the [maximum] far distance and the [maximum] near distance — that is, between [its standing at] apogee and its standing at perigee — corresponds to the thickness of the eccentric carrying-sphere, which is the nine thousand nine hundred parsah [900 = תת"ק] mentioned above [?]. [See Numerical impossibles.]

From this is made plain the reason why the sun, at the season when it is near, completes its circuit [around the heaven] in less time, and at the season when it is far, in more time. For the more the inhabited world [is in summer] [?] the farther the sun is from the center of the earth, and the more the inhabited world [is in winter] the nearer the sun is to the center of the earth.

The Israelite sage [החכם הישראלי = R. Yitzchak Israeli, in his *Yesod Olam*], in his book [Treatise 3 [?], chapter 4 (פ"ד [?] שלישי מאמ') [?]], wrote that all this is from the cause [appointed] by the Creator, blessed be He — in order that the cold not overpower [the world] in the season of the inhabited world's [summer], and that the heat not [?]... in the days of the heavens [?]. And you should know that this [explanation] is so according to his view in particular [?], the reason being that on his account [the sun's] motion is not beneath the zone [גורת] of the [tropics] [?]... as was explained above in Section 3 [שער שלישי], at siman... [?]

Siman 179 (סימן קע"ט) — That the concentric sphere as a whole — being the two black bodies [orbs] of the figure, according to the view of Ptolemy [בטולמיאו"ס] — has a motion of its own [a weighty/heavy motion], and that it transports [the assembly] [?] [?]... that is in its place

Know that the concentric sphere as a whole — being the two black bodies of the figure, according to the view of Ptolemy [בטולמיאוס] — has of itself no motion at all, except that it [shares] the motion of the upper sphere [the sphere of the fixed stars] [?]. The apogee of the sun was, in his day, at the point ג [gimel] of the figure mentioned, which is the [point] fixed within the heaven [?] in the [last] degrees [?] at the end of the sign of Gemini (תאומים); for [Ptolemy] reckoned that to be the place of its station throughout all the days of the world. But the later sages found in this concentric sphere a heavy [slow] motion: as the two [black] bodies guide and move the middle body [whose center is] the eccentric [?], by way of compulsion in a slow, gradual manner — by which heavy [slow] motion [the apogee] has come [to move] toward the east. So that now, in our time — which is the year five thousand and [?] [the year 5503 AM = ג"תקים אלפים ה' [?]] [region degraded; date uncertain — see Numerical impossibles] — we find the sun's apogee standing opposite the ninth degree of the sign of Cancer (סרטן). Thus, in the span of time from his [Ptolemy's] day to these times — which is close to a thousand and five hundred years (קרוב לאלף ות"ק שנה [= 1500]) — the apogee points have shifted close to nine degrees.

From this it follows for us that the concentric sphere will not complete its revolution until after sixty-thousand years [?] [שלשים אלף "thirty thousand" / "sixty" — see anomaly]. And accordingly, [in] thirty thousand years (לשלשים אלף שנה) the apogee point will be at the sign of Capricorn (גדי) at the season of the solstice of Teves [the winter solstice], as mentioned above.

For the memory [record] of the Israelite sage [החכם הישראלי = R. Yitzchak Israeli]: he wrote in [Treatise] 3, chapter 14 (ג' פי"ד) [?] that the sun's apogee shifts one degree after each [hundred] years [?]; and accordingly [the apogee] will not complete this revolution until after [some] thousands of years ([?] אלפים ות"ת שנה). And it appears there is a printing error there (טעות שם), as may be deduced [גם כן — see also] there, [in *Yesod Olam*] ch.... siman 12 (סי' י"ב) [?]. And in the book *Tzomes HaAretz* [צומת הארץ], folio 15 (דף ט"ו), it is stated that the height of the sun's apogee, according to the view of Ptolemy, is five and a half degrees (חמש ומחצי) past the sign of Gemini (ממזל תאומים).

Siman 180 (סימן ק"פ) — That the center of the eccentric sphere has itself shifted from its place

Know that, just as the apogee of the sun has shifted from its place [?], so it follows necessarily [from its place] that the center of the eccentric sphere has itself also shifted. For the shifting of any sphere applies to the whole of it [?]; it is not possible that the revolution about the eccentric center should shift [on its own], for then [the eccentric] would enter into the territory of the orb of Mars (בגבול גלגל מאדים), and would not [remain] revolving about the center of the world. Therefore the center of the eccentric sphere [?], being shifted from its place, has itself also made a small circle as it revolves [?]... in the cosmos [?]; and by the cause of this revolution along the circle it makes, [the eccentric] is distinguished [from the center of the sun] [?]. The motion arising between [the eccentric center and] the center of the sun is from east [around] to west, while the [other] motion — by way of the shifting of the solar sphere as a whole — moves the sun from west [around] to east, as mentioned above [?].

Siman 181 (סימן קפ"א) — That the solar sphere has four motions

From the general principles we have mentioned concerning the [solar] sphere, it will be made plain that the sun has four kinds of motion, namely:

The first — its [proper] motion along its path, from west to east, which it completes in three hundred sixty-five and a quarter days (=] שס"ה ורביעית [¼365) [?], as mentioned above.

The second — the motion by which the [great revolving sphere] turns, the cause being [its sharing in] the daily rotation that carries the whole body of the world [around] once each day [?].

The third — the [slow] motion [shared with] the eighth sphere [the sphere of the fixed stars], moving as the rest of the [fixed] stars in their motion, [namely] one degree in seventy[-some] years, as [stated above], truly [?] — this being the fifth [item below] [?].

The fourth motion is the heavy [slow] motion of the shifting of the sun's apogee, by way of the concentric sphere [moving], as explained above in [its] place. And we have already [noted] above that one who wishes to attain exactness in computing the sun's circuit, and to be precise in all four [motions], must apply deep, great, and exceedingly fine scrutiny — also [over] long days and many years, indeed [over] a thousand years more or less — in order to know that the motions found [in the sun] are likewise found in the other planets (כוכבי נכונה [?]).

[There is] in addition a fifth [motion] in their revolution about the epicyclic sphere [גלגל הקפה], as will be explained further on, in Section 8 [שער ח'], at siman 251 (סי' רנ"א) [?].

Siman 182 (סימן קפ"ב) — Which is the mean place of the sun, and which the true place, and the difference between them

Know that, regarding the sun, we have no [way] to recognize and identify its place except by way of the parts of the circle of the signs [the ecliptic / mazalos circle], the center of which is always [directly] opposite the center of the sun, beneath the mid-point of its zone [the ecliptic band]; and by the parts of that [great circle] line we reckon and know its location in the heaven and its [position relative to] the [season] [?]. And just as we cannot recognize the sun's place [other than] by the great circle of the signs, except by the sun's motion [along it] as mentioned, so too we have no [means] regarding the signs except [by the sun's mean motion as above]; [each] of them [the two reckonings] will tell us [the answer] in [its] manner [?]. That is to say: when we are precise concerning the sun's motion beneath the mid-point of its zone, we find its motion and its place in the heaven by two distinct examinations. One of these the masters of astronomy call "the mean motion" (המהלך האמצעי); and to explain it [as a tool] for students, [the second] they call "the true motion of the sun in the signs" (המהלך האמיתי במזלות) [?].

[Note: the LEFT-hand page carries the running header "שער ה" — "Section 5" — which is stale/erroneous for this gathering, since the body content (the figure and simanim 183–185) clearly continues Section 7. Both reported verbatim below.]

[continuation of siman 182, for students:]

for students, by way of the figure [drawn] here below. There are two concentric circles: the great circle, whose center is marked by the point א [aleph] — this is a representation [רמז, "hint"] of the circle of the signs (the ecliptic), whose center is the center of the earth — and a small circle within it, whose center is the point ב [bet], which is a representation of the eccentric carrying-sphere of the sun, whose law [definition] was explained just above at siman 171 (סי' קע"א). Now let us say, by way of [this] illustration, that we have found the center of the sun standing at the point [marked]... [?] on the maslul [the path], and we draw one line from the [world-]center א [aleph] from the point א [aleph] [?] to mark the place of the [revolving] circle that stands upon the point ז [zayin].

[Diagram]

Diagram. A geometric construction for the mean-vs-true place of the sun. The figure shows a large outer circle (the circle of the signs / ecliptic) and, eccentric within it, a small circle near its left side (the eccentric carrying-sphere of the sun). Radial lines run from the centers to points on the circumferences.

- א (center-right of the large circle): aleph — center of the great circle (the ecliptic), i.e. the center of the world / earth
- ב (within the small circle, upper-left): bet — center of the small eccentric circle (the eccentric carrying-sphere of the sun)
- A radial line runs from א outward to the lower-left, crossing the small circle.

[Diagram]

Diagram. A larger geometric construction illustrating the relation of the mean and true solar places. A large circle (the circle of the signs / ecliptic) contains an inner offset circle (the maslul / eccentric path). Two perpendicular diameters cross near the figure's center, with several lettered points on the circumferences and along the diagonal (the line of apsides). Labels read (positions approximate):

- ד (top): dalet
- ג (upper-right): gimel
- ה (mid-left) / ז (left): the apogee region; ז [zayin] marks the apogee (/ גובה רום)
- ח (interior, near center): chet
- ט (lower area): tet — marks the perigee (שפלה, the "low point")
- ב ,א (the two centers, near the crossing of the diameters): aleph = center of world; bet = center of the eccentric/maslul

The inner small circle is described in the text as the maslul (orbital path) of the sun, the eccentric whose center is ב [bet]; the diagonal ז…ב…א is the line of apsides. The line called the "line of the equator" (קו המישור) and the points ז רום' (apogee, point ז) and ט שפלה' (perigee, point ט) are marked.

[text below the figures, continuation:]

And the small circle is a representation [רמז] of the maslul of the sun, the eccentric whose center is the point ב [bet], and the diagonal ב"גד [?] [running through the figure]. The thickness [?] above [along] the second [boundary] [?] is called the "line of the equator" (קו המישור); the point ז רום' [the apogee, point ז];

and the point ט שפלה' [the perigee, point ט]. Now behold: when the center of the sun reaches the point ז [zayin] [the apogee], there will be no [difference] nor any divergence between the mean place of the sun and its true place. And the same rule [holds] when the sun's center reaches the point ט [tet], the perigee (שפלה).

Siman 183 (סימן קפ"ג) — That sometimes the [sun's] motion advances the true [place] ahead, and sometimes the [place] is later [?]

Know that sometimes the true place of the sun advances ahead of the mean place, and sometimes the mean place advances ahead of the true place [קודם, "earlier"] — and sometimes there will be no [divergence], but [the sun] will be midway between the two places. All this will appear in this figure, [in which] the great circle is a representation [רמז] of the sphere of the signs, its center being the point א [aleph], up to the point ת [tav] [?] which lies on the line of the signs; and the line א-ז-ח [aleph-zayin-chet] [?] will be [drawn], with [the sun] at the point ח [chet] in the signs — [there] it is called the true place of the sun (מקום שמש האמיתי). In the reckoning of the true [place], the sun's motion does not follow a single rule, for by it there is found at times the slow [retarded] motion and at times the [accelerated] motion [המהלך הנחוץ, "the pressed motion"], as will be explained shortly.

As for what is called "the [mean] place of the sun" at the point ח [chet] in the signs, by way of illustration: [it] is not the true place of the sun, because [the true place] is more accurate than the mean [reckoned] from its [own] position [?] — only [we name it so] for our sake, we who dwell within the [hollow] cavity [of the world], according to our line of sight from the point of the earth (נקודת הארץ) upon which we dwell. [For] the [sight-]line [passing] through the point ז [zayin] toward it — there, at the point ח [chet], will be its place opposite our [line of] sight, by the true and straight sight of our eyes. And in truth we need not be concerned nor exacting, in this place, about the difference that exists between the line of sight [as drawn] from above the body of the earth and the line of sight [as drawn] from the center of the earth — [the line drawn] from the center of the earth — as [will be discussed] further on in Section 8, at siman 208 (סי' ר"ח) [?]. And if, at that moment, we draw one line from the point ב [bet] of the maslul — which is the place of the sun's center — and extend it up to [the point] ק [?] on the line of the signs, this line will be [the line] ב-ק [bet-kuf] [?], and from this point on the line of the signs it is called the mean place of the sun (מקום השמש האמצעי).

[The mean place is so named] for two reasons. First, because the reckoning of this motion and revolution is computed according to the [mean] center [?] — the mean and the center of the sun's orb and its maslul [?]. The second reason:

because the reckoning [made] according to the center of the maslul is a mean, midway between the two motions — the [pressed/accelerated] and the [slow] [?] — whose laws will be explained shortly. For the sun's motion along the maslul is always uniform, and no [variation] is sensed in it — neither acceleration nor retardation — from time to time throughout all the days of the world. And you should know that the difference between the two places mentioned — the mean place and the true place in the signs — is called the "arc of the equation [of center]" ([קשת החילוף =] קשת התלוף) [the arc of anomaly/difference].

Siman 184 (סימן קפ"ד) — On the motion of the sun [around the heaven] [?]

[continuation, lower-right column of p. 108:]

the center of the sun in the inner [black] sphere opposite the [signs] that are [reckoned] from above [?]... up to the half-circle [semicircle]; for although it revolves only opposite half the circle of the signs, [the sun] from any place of its [revolution] revolves [along the maslul] [?]. Since in this time its [arc on the maslul] is more than half the circle, as appears in the figure — and since the arc ט-א-ז [tet-aleph-zayin] [?] of the maslul is greater than the arc ט-ח [tet-chet] [?] — therefore its revolution [in] this time is more than half a year, [and] therefore its motion is called "the slow motion" (מהלך המתון). And when it revolves from ט [tet] [perigee] up to [?] — which is the arc ט-א-ז [tet-aleph-zayin] [?] [?] — although it too there revolves opposite the full six signs, [the sun] from any place of its [revolution] revolves [along] less than half the circle in this time [?]; therefore this revolution [taking] less than half a year, its motion [along] the arc ט-א-ז is called "the pressed [accelerated] motion" (מהלך הנחוץ). Thus you have it: although the sun revolves along the maslul with a motion always uniform [as measured] against [the center], yet against the circle of the signs it revolves with motions [accomplished] in unequal times.

Siman 185 (סימן קפ"ה) — That [the durations of] the four seasons of the year, by [the sun's] true motion, are not equal to one another

From the general principles of the matters mentioned, it will be made plain to you that the true motion of the sun against the signs — [over] the four seasons of the year (תקופות השנה) — are not equal to one another, nor is any one of them [equal to another]. This [is shown] when we divide the circle of the signs by means of two diameters, [drawn] in advance [?], by the line [marked] א-ב-ג-ד (אבג"ד) [aleph-bet-gimel-dalet] [?] into four [equal] parts, as [in] the figure: those two lines will divide the sun's maslul into four unequal parts. The arc [from the

point] of the equinox of Nisan (תקופת ניסן) [the spring equinox] — namely the arc of [the sign of] Aries (טלה) up to the end of the circle of the signs — is the beginning of the [second] quarter, [the season] of the sign of [Cancer]... [text continues]

Section 7 (שער ז) — continuation

[Siman 185, continued] — The unequal seasons and the solar arcs

[This page is dominated by a large circular diagram; the surrounding text is the conclusion of the discussion of the four unequal seasonal arcs of the sun's path.]

The text continues the demonstration that, because the sun's true motion is uniform along its own eccentric path (the maslul) but unequal as measured against the signs of the zodiac, the four seasons (תקופות) come out unequal in duration. Dividing the zodiac by the two diameters (the line א–ב–ג–ד) into four equal quadrants does not divide the maslul into four equal arcs.

[The legible running text around the figure is heavily degraded; the following readings are partial.] The arc from the apogee — where the sun's motion is slowest — through the sign that is "still virgin" (i.e., not yet traversed) to its end, is the longest arc, since [?] the sun completes its revolution along the maslul more slowly there. By contrast, the arc nearest the perigee, where the sun moves fastest, is the shortest. The right-hand text gives the four arc-lengths in days, and notes that adding them yields the full year. [Several numeral readings on this page are obscured by the diagram and ink loss — flagged for further review.]

The four seasonal points are marked at the four cardinal directions of the figure: Aries (טלה) at one quadrant, Cancer (סרטן) following, and so forth, beginning the reckoning at the spring equinox of Nisan (the entry of the sun into Aries). The slow arc (more than half a year) lies toward the apogee; the pressed/accelerated arc (less than half a year) lies toward the perigee.

The text closes the discussion by noting that the unequal lengths of the seasons follow necessarily from this geometry, and refers forward to the coming siman where the true (as opposed to mean) place of the sun will be further explained ("as will be explained in the [following] siman").

Diagram. A large double-ring circular figure representing the zodiac (the band of the twelve signs) divided by two perpendicular diameters into four quadrants, the four corners labeled with the cardinal directions. The outer ring carries the names of the twelve zodiacal signs running around the circle; the inner ring

carries an explanatory legend running around it. Two diameters cross at the center, their endpoints lettered.

- צפון [North] — at the top
- דרום [South] — at the bottom (printed as דרום ק [?])
- [East side, right] — מזרח [?] (heavily stylized, partly illegible)
- מערב [West] — at the left
- Top arc of outer ring (running): החמה… תאומים סרטן ונגד צבא… — "[the sun]... Gemini (תאומים), Cancer (סרטן)..." [several sign-names along the upper arc are legible: תאומים = Gemini, סרטן = Cancer]
- Right arc of outer ring: [sign names, mostly illegible — partly "...נגד..."] [?]
- Lower arc of outer ring (running):...החמה… מזליעקות סוב... — partly legible band continuing the zodiac sequence and the legend " …סיבוב ושמינית… החמה…המזלות" [the revolution of the sun through the signs] [?]
- גדי בקשת [Capricorn (גדי) — "in the arc"] — near the bottom
- Inner ring legend (running): "...החמה… כנגד מזלי…ושמינית..." — refers to the eighths-of-a-day fractions and the position against the signs [?]
- Center cross-points lettered: א, ב, ג, ד (the two diameters) and ה, ז, ח, ט [?] marking intermediate points/arc endpoints on the rings
- Header above the figure (caption): " ממסלול סביב קשת ל"א… יהיה בקשת היותר" [along the maslul, around arc 31 [?]... it will be in the longer arc] — partly illegible [?]

[More than two labels in this diagram are flagged [؟] The decorative-versus-informational call is "informational" (a true zodiac/seasons diagram); the label readings are degraded by ink loss and the curving typesetting.]

[right column continues, then two new simanim]

The right-hand column continues the discussion of the unequal seasonal arcs and their lengths in days, citing the earlier reckonings (it refers to "the ancients" and to figures "already written above, simanim [?]"). It notes that the resulting day-counts hold "forever," apart from the slight shift over the ages.

Siman 186 (סימן קפ"ו) — Why the measures of the days named above are of changing natures [also touching on this matter]

We have already explained above that, because part of the signs of the zodiac rise quickly and part rise slowly, it follows that the natural days differ somewhat in length — as was made clear above in siman 141 [קמ"א] and following. Know,

then, that apart from this [cause], there is yet another cause for the inequality of the natural days, arising from the rising of the signs: the natural days are not always equal, and it can never happen that one finds them in perfect equality except [perhaps] once in four years [?].

This is so because the sun's mean motion (which is the same every single day) and its true motion through the signs of the zodiac are perpetually changing. The reason is that the eccentric circle (גלגל המסלול) and the deferent (גלגל המזלות) [?] are differently centered: the sun's true position against each individual sign — indeed against each individual degree (חלק חלק) — comes out differently. Hence, just as the true place sometimes appears more advanced than the mean place, and sometimes more retarded, so its motion against the signs is sometimes greater and sometimes less.

The text gives the figures: the sun's mean daily motion is uniform, but its apparent (true) daily motion ranges — from about [?] 59 [נ"ט] minutes and some seconds of arc per day when near apogee, slowing in its motion, to a greater amount per day when near perigee. When the sun is in the six signs in which its motion is slow (מהלך המתון), it advances by a smaller amount each day, rising from apogee [?]; and when it is in the six signs in which its motion is pressed/accelerated (מהלך הנחוץ), it advances by a greater amount each day, descending from apogee toward perigee [from height (גובה) to low point]. [The exact daily-motion figures here are partly degraded — flagged.]

The text concludes that the difference among the natural days from this cause is exceedingly small — so small that the eye cannot perceive it by sense; only the intellect testifies to it. [Cross-reference forward: "as will be explained in siman [?]."]

Siman 187 (סימן קפ"ז) — Explanation of the time-difference between the true season-point and the mean season-point

[The true tekufah (תקופה האמיתית) versus the mean tekufah (התקופה האמצעית).]

The difference in time found between the two reckonings — the mean and the true — of the seasons (תקופות) is explained here, because [the difference] arises from the corruption (קלקול) of the [longitudinal] positions [?]. For according to what Rambam (הרמב"ם), of blessed memory, wrote in the Laws of the Sanctification of the Month (הלכות קידוש החודש), chapter 6 [פ"ו], and according to what the Israeli [Yitzchak Israeli, author of *Yesod Olam*] likewise wrote, there is a difference between them. Rambam, of blessed memory, said in chapter 3 [?] [Hilchot Kiddush HaChodesh] [recte: the chapter giving the true vs. mean tekufah

rule] that the true Tishrei tekufah lags behind the mean by a little less than two degrees of the sun's [mean] reckoning [?], which amounts to nearly two days. Likewise the true Nisan tekufah precedes the mean.

But when the sun is at the apogee or at the perigee — at the two points which lie in the [solstitial] figure, [the true Tevet tekufah] and [the true Tammuz tekufah] [?] — there is no perceptible difference between the mean and the true, since there [at those points] they coincide as one. For although the center of the maslul has shifted from its place — as was made clear in the test of siman 180 [ק"פ] — nevertheless, from the standpoint of observation [?], the [line from the] earth's center passing to the apogee passes so nearly through the center of the maslul that no difference is sensed there. This is the view of Rambam, of blessed memory, and of the Israeli rabbi in the places cited.

Yet in another place I found that the Israeli scholar gave a different reckoning. In the third Treatise [מאמר שלישי], chapter 3 [פרק ג'] [of *Yesod Olam*] (where he writes that he found [?]) that the center of the sun, opposite [the eccentric] [?], moves along the deferent of the signs from the head of Aries (ראש טלה) to the end of Gemini (סוף תאומים) [in] 94½ days [צ"ד יום ומחצה] — which is more than a quarter of a year; and from the head of [Cancer / Capricorn?] [?] to the end of the sign [?], an arc of 91 days [צ"א יום] and some hours — which is less than a quarter of a year. According to this, the difference between the two season-points comes out to six days and 9 hours [ששה ימים ט' שעות].

In my book, where I transcribed [the figures] from al-Farghani (מאלפורגאני) [al-Farghānī], I found [the four seasonal arcs to be]:

- From the Nisan season-point to the Tammuz season-point [spring → summer]: 94½ days [צ"ד יום ומחצה]
- From the summer turning-point to the second autumnal point [summer → autumn], i.e., from the Tammuz tekufah to the Tishrei tekufah: 92½ days [צ"ב יום ומחצה]
- From the autumnal turning-point to the [winter] turning-point, i.e., from Tishrei to Tevet: 88⅛ days [פ"ח יום ושמינית]
- From the [winter] turning-point to the second spring point, i.e., from the Tevet season-point to Nisan: 90⅛ days [צ' יום ושמינית]

— all of them together being 365¼ days [שס"ה יום ורביעי].

Since the time of one [mean] season according to the mean reckoning is 91 days, 7½ hours [צ"א יום ז' שעות ומחצה] — as completed at the end of siman 185 [קפ"ה]

— then according to the reckoning of Ptolemy (בטולמיאו"ם) and al-Farghani (ואלפירגאני), [the figures are as follows]:

- The time of the Nisan tekufah, 94½ days, exceeds the mean tekufah by 3 days, 4½ hours [ג' ימים ד' שעות ומחצה].
- The Tammuz tekufah, which by al-Farghani's reckoning is 92½ days, exceeds the days of the mean tekufah by 1 day, 4½ hours [א' יום ד' שעות ומחצה].
- The Tishrei tekufah, which in his view is 88⅛ days [פ"ח יום ושמינית], is less than the days of the mean tekufah by 3 days, 4½ hours [ג' יום ד' שעות ומחצה].
- The Tevet tekufah, which in his view is 90⅛ days [צ' יום ושמינית], is less than the mean tekufah [by] 1 day, 7½ hours [א' יום ז' שעות ומחצה] [?].

Blessed be my God, my Redeemer and my Deliverer, who has helped me to the completion of Section 7.

Section 8 (שער ח)

In which will be explained the structure of the orbs of the moon, together with an account of the inclined orb (גלגל הנוטה) and the time of its revolution; and an account of the planet-bearing eccentric orb (גלגל יוצא מרכז), with its deferent-orb (גלגל הקפה) [epicycle] and the time of its revolution; and the variation (החולף) of the moon between its mean place and its true place; the definition of the mean and the true new-moon (מולד); and the causes of the many changes (ההשתנות) found in the moon every day of the month, and from [mean] conjunction to [true] conjunction, mean and true; the difference between the moon's nearness and farness from the terrestrial globe, and a proof of its volitional motion (התנועה הרצונית); and the deniers thereof; together with the rest of the matters and principles particular to it.

Siman 188 (סימן קפ"ח) — Explanation of the moon's orb and its structure: the spheres [or orbs / globes]

Know that the sages of antiquity [the Greek astronomers] determined [the order and] thickness of every orb of each of the five [wandering] planets, and they said — and they spoke correctly [?] — that each one of them is divided into four [?] orbs [or "spheres," כדורים / אופנים], three of which surround the body of the earth on every side and figure, [namely] the three spheres mentioned above as orbicular and uniform [?]. The three orbs are like those mentioned above in the

adjoining section [Section 7], in simanim 178 [קע"ח] and 179 [?] [קע"ט] — concave [קש"ח / קעירות] and convex [קש"ט].

But the middle orb — which is described as "the white one" [?] [the deferent, גלגל הדומה, "the resembling/deferent orb"] — is the orb that is inclined from the plane of the sun toward the north and toward the south, in the manner of the inclination of the line of the signs of the zodiac, as will be explained. In this inclined orb [גלגל הנוטה], no star at all is set, except [that] beneath the inclined orb [?]. They added [a further] orb upon it, and called it "the bearing orb" [אופן גלגל הנושא / הסובל] — for the bearer is the one that bears [carries] and bears upon itself the planet, whether the moon or any of the other [planets] [?]. This is the fourth sphere, which they added to every [planetary] orb-system; and the orb that bears the moon [is the same as] the inclined orb, according to the view of some of the sages.

Furthermore [§ 186 cross-ref] [?], we must divide the thickness of the sun's orb into its two spheres [the concave and the convex of the eccentric], so as to fill the entire void of the orb [its hollow], in its convexity and in its concavity, as was said above in siman 174 [קע"ד]. And as for [the orb] they added — [namely] that they posited one bearing orb [?] — they did not posit that the inclined orb itself should be the bearing orb, because the deferent orb (גלגל הדומה) and the inclined orb (גלגל הנוטה) — the two of them — carry round the head of the Dragon (ראש התנין) and its tail (וזנבו) from east to west around the globe of the world, as will be explained.

Now there are some of the sages who wrote that one need not be compelled [to posit] that the moon's orb is an eccentric orb (גלגל יוצא מרכז) — for it is possible for us to descend [i.e., account for] all the moon's motions without positing an eccentric orb. And toward this [view] inclined somewhat the opinion of the Israeli [Yitzchak Israeli] in [*Yesod Olam*] Treatise 3, chapter 8 [מ"ג פ"ח] [?], as [I noted] above at the head of Section 7, in siman 163 [?] [קס"ג] — that all the variations [?] found in the moon are settled by the causes of the epicycle (גלגל הקפה), as will be explained below in siman 207 [?] [רז'] [?]. Therefore they said that the bearing orb of the moon is not an eccentric orb at all, and its center is the very center of the signs of the zodiac [the world-center] itself. On this view, [the bearing orb] and the deferent orb (גלגל הדומה) both revolve about one center.

According to this [view] too, we are not required to divide the thickness of the deferent orb [into a hollow], for on this view [?] there is nothing missing for us in the orb. For the deferent orb is uniform throughout all its revolution and is not split [into hollow and full] in its thickness, the way the sun's orb is — for we have

no need to fill voids [in it]. Nor [is it like the sun's orb] in its convexity. The bearing orb, in its entirety, is in contact with the orb beneath it — [a position] which [the Israeli] concedes in its [the moon's] existence [?] — so that there is no difference [or gap] between the deferent orb and the bearing orb at all. Only, the bearing orb is the one that is inclined from the deferent orb toward north and toward south, as will be explained shortly.

It would seem [?] that we are not compelled [to do otherwise], and in its application [ובבואה], according to the manner of what we explained above in siman 110 [ק"י] [?] regarding the imprint of the shadow [?] among the fixed signs set in the orb [the fixed-star sphere] — and it is only [a device] to clarify and depict [the matter] for students, as I have [done] [?].

And as for the thickness of the bearing orb [?] — whether we posit it to be eccentric or not — the astronomers did not write [?] the thickness [as] the length of the diameter [קו אלכסון] of the epicycle (גלגל הקפה), which we shall make [shortly]; thus far. You should also know that the inclination of the bearing orb from the deferent orb is precisely the same [as] the [inclination] of the wandering [planet] in the six [?] [signs] — namely [?] 5° [מעלות ה' / שצ"ם] [?] — which [holds] not for [every] star [in the same way] [?]: for the moon [?], it [the bearing orb] does not incline beneath the deferent orb, since it [the moon] always remains under the line of [the apparent path / קו הקדרות?] [?], as [stated] above at the head of Section 7 [?] in siman [?] [ק"ו] and in Section 7, siman 171 [קע"א] [?].

Siman 189 (סימן קפ"ט) — That the bearing orb of the moon inclines from the sun's orb toward the north and toward the south

The ancient sages found in their study of the bearing orb of the moon — and likewise of the other five orbs of the wandering planets [the Bewildered, הנבוכים], each of them [?] — that it inclines from beneath and opposite the midpoint of the line [?] enclosing the orbits of the signs [the ecliptic], inclining on one side toward the north and on the other side toward the south. For this reason they called that orb "the inclined orb" (גלגל הנוטה); and the matter of its inclination is like the inclination of the circle of the signs in the right [-sphere] circle, as above in siman [?]. Just so is the inclination of the inclined orb from the deferent orb — except that there is a difference between the two inclinations in three respects, as will be explained shortly in siman [?].

The instrument [or "vessel," הכלי] which we drew above in siman 39 [?] [ל"ט] — these two orbs, the deferent and the inclined, both pass over the apogee [גובה הכדור] of the [orb] and over the center of the earth [?]; they are, along the length

of their diameters, equal [in extent]; and they cut one another into two equal parts. Know, then, that the inclination of an inclined orb from a deferent orb cannot be drawn upon a [flat] plane. [The text refers to "look at this figure too" — i.e., to the small figure at the foot of the page.]

Diagram. A small figure at the foot of the left column showing two concentric circles (an inner and an outer ring), with a single dot at the center and two short labels at the left and right of the ring.

- א [aleph] — at the right of the ring
- ב [bet] / ג [gimel] [?] — at the left of the ring (label degraded)
- (center) — a single point/dot marking the common center

[This is a schematic of the deferent and inclined orbs as nested circles about a common center; only 2 labels, both partly degraded.]

The discussion of Siman 189 continues at the top of this page.

[Top of right column — a continuation marked with an in-text star.] ✻ Even so, according to the truth of the matter, the figure does not resemble [the reality], because the two orbs, the deferent and the bearing, are depicted as if each of them had a center of its own — which is not in truth so [?]; rather, the two of them have but one center. For just as the line of the circle of the void [the eccentric] and the line of the right circle [the equator] incline one from the other [yet share] one center, as above in siman 36 [?] [ל"ו], so too the two circles, the deferent and the inclined, have likewise one center [?]. But that [shared center] cannot be depicted on a [flat] surface properly. And it will be explained [by way of analogy]: just as the sun sometimes goes out to the north of the equator (קו השוה), and sometimes to the south of it, and sometimes lies exactly upon the line of the equator itself — so likewise the other five wandering planets (חמשה כוכבי נבוכה), [each] sometimes to the north of the plane of the deferent orb, sometimes to its south, and sometimes exactly upon [it] [?].

Siman 190 (סימן ק"צ) — The three differences found between the orb of the signs [the deferent] and the inclination of the inclined orb

We have already explained that the inclination of the inclined orb from the deferent orb is like the inclination of the signs from the right [equatorial] orb, as above [in siman?]. Just so [?] is the matter of the inclination of the inclined orb from the deferent orb: half of it inclines and turns toward the northern side of the deferent orb, and its other half turns and inclines toward the southern side of

the deferent orb. Yet know that between the two inclinations there are found three differences:

The first: the [maximal] inclination of the moon's [orb] is close to 5° [?], [whereas] every [?] inclination from the deferent orb is 5° [מעלות ה'], as will be explained shortly.

The second: the arc of the inclination of the signs in the right [-sphere] line is reckoned by [or upon] a half-day-arc [a meridian / great-circle through the poles], and likewise the other orbs that pass over the two poles [צירי] of the world; whereas the arcs of the inclination of the bearing orb from the signs are not reckoned by a half-day-arc, nor by [great circles through] the world's two poles, but only by [circles] passing over the poles of the signs [the ecliptic poles, קוטבי המזלות], so as to know at every place and time how much the distance of each arc of inclination [is] between the line of the signs and the [ecliptic] poles — and this is the breadth [latitude] of the firmament, as will be explained.

The third difference: the two points of meeting of the deferent orb with the inclined orb travel and move backward (אחורנית) among the signs along the [path of the] Dragon-orb (הגלגל התנין) [the nodal regression], more [?] than the three parts [?] [each day], as will be explained shortly.

Siman 191 (סימן קצ"א) — On the backward motion of the head of the Dragon and its tail

The two points at which the deferent orb meets the two [points] of the inclined orb — called the head of the Dragon (ראש התנין) and its tail (וזנבו), as just stated — have a fixed backward motion of the aforementioned points: more than three [parts?] each day, from east to west. Their mover [?] is the deferent orb, which revolves about the world-center on the two poles [צירים] opposite the two poles of the signs, [moving] eastward [?] from east to west — the reverse of the motion of the orb of the signs [the daily motion] — and it compels [drives] the orbs within it, returning them all upon their poles. And the two nodal points of the Dragon (נקודות התלי), [namely] the head of the Dragon and its tail, [move] backward in particular [?] — that is, [they regress] one part backward [each day] and turn against [retrograde to] the whole orb of the signs, [completing the circuit] in 18 years [שנה [?] כ"ח] and nearly 1 month [?] [recte: see below] and a half, plus 11 seconds [?] approximately. The beginning of this motion is reckoned from the head of the sign Aries (מזל טלה), as it is written in the book *Yesod Olam* [ספר יסוד עולם], Treatise 3, chapter 8 [מ"ג פ"ח], and also in my [other] book [the Hebrew one] [?].

[Note — numerical impossible: the regression period of the lunar nodes is ~18.6 years. The printed text appears to read "כ"ח שנה" (28 years) or similar; the value is partly degraded. Flagged below.]

Siman 192 (סימן קצ"ב) — That the place of the moon among the signs is reckoned in [terms of] the length of the firmament, and also in the breadth of the firmament

Section 8 (continued)

[Siman 192, continued — the moon's place reckoned in longitude and latitude]

As we explained above regarding the fixed stars, so too the positions of all the other stars, and of the moon, are reckoned according to two measures. The first is how far each star (or the moon) stands east of the firmament — this is called its **longitude of the firmament** (אורך הרקיע). The second is how far it stands away, north or south, from the equator of the signs — this is called its **latitude of the firmament** (רוחב הרקיע) [?]. Both of these together let one know the place of the moon in the firmament. [The transmission here is broken and partly garbled; the sense follows from the parallel star-discussion.]

Now we must explain its reckoning itself, in actual practice. By the first measure — the longitude — one reckons the moon's eastward progress and the delay it falls behind the sun, beginning the count from the head of the signs (i.e., from the beginning of the firmament, the head of Aries). By this measure there is no reckoning of the moon's standing northward, for the latitude of the firmament has no portion in the longitude-count. The equator of the signs (the equator, קו השוה) never shifts or moves — for, as said above, the latitude is something else. So much for the longitude.

The second measure is the moon's latitude. Here too one reckons the moon's latitude with respect to the firmament — that is, the firmament-latitude — on account of the bearing orb [the inclined orb, גלגל הנוטה]. By the inclining of the bearing orb, [the body] moves away and becomes distant from the ecliptic according to the distance of the bearing orb from it [?]. That is to say, the small arc between the standing moon (which sits upon the deferent path, מסלול) and the corresponding point on the bearing orb's circle is the latitude — and this latitude is what is called the **latitude of the firmament**, as was already explained above. This [latitude] rises, as was explained above, up to the limit of the curvature of the upper orb. And the inclination I described, drawn along lines

passing over the poles of the firmament toward the pole of the signs [?] — this [shows] that the standing of the moon to the south or to the north of the signs is what is called the latitude of the firmament.

By these two measures already mentioned [the position] comes out, each one distinct, and the difference between the moon's mean place and its true place will be made clear ahead, with God's help, in Siman 201 [201 = ת"קצ? — printed numeral degraded, flagged].

Siman 193 — How great the inclination [is] of the moon's bearing orb and its corresponding orb

[Body heading p. 113: סימן קצ"ג]

We explained above that the orb bearing the moon inclines, and the deferent orb [?] turns to its two sides. Therefore the moon itself is found at times to its south and at times to its north — just as the sun [is found] at times north and at times south of the celestial equator [?]. We have already given a sign for this in the moon: the moon's mean line is sometimes found high above [the equator] toward the north and sometimes toward its south. These inclinations are called in their tongue **declination** [Latin: *declinatio*, "declination"].

One should know the moon's farthest [northern and southern] reach. The ancient ones found the moon's farthest reach to be five degrees from the equator [?]. To know this and to examine it after them, and to see it — when you wish to grasp this, there is an easier way still, more readily explained to students at the [right] time, namely:

By observation [it is shown thus]: when, at the time of the conjunction (molad) [?], the moon happens to be at the midpoint of its course, and the moon's body is itself at the head of a sign, and its orb's center stands facing the zenith [?] — the moon is then at the very peak of its height above us. And the height of [its] orb at that time, [measured] from the equator, is examined [?]. You will find it more removed from our zenith, closer [to the horizon], than [the point] the sun approaches at the summer solstice (תקופת תמוז) by five degrees. The illustration for it, here in the city of Prague (פראג), is plain: the [pole] height above us, the celestial pole [?], is near fifty degrees above our horizon. [These numbers should not be pressed too closely here; just as we are distant [from the equator] in this measure, so too] the equator likewise rises fifty degrees above us, by the line of the equator [?], and already the southern [points] rise above our horizon at forty degrees [?]. It will be explained that the limit of the most distant of the signs from the line of the celestial equator is twenty-four degrees [כ"ד מעלות]; so, then, the

limit of the height of the signs above our southern horizon is [?] degrees. And the great sun — when above us [?] — when we investigate it at the said time, by some instrument [?], according to its position relative to the moon, we find it [?] degrees above our horizon. From the line of the equator northward, the [moon's] inclination [?] reaches five degrees above [the place] toward which it leans, at its zenith. So too you can investigate this in the opposite case: at the time of the [lunar] opposition (פת התקופה?) [?], when it falls in the middle of the month, when the moon is at the extreme of its depression — for then it draws back, [reaching its lowest point] toward our zenith [?] — by five degrees [it is] more revealed [?] than the sun, which then is most distant from our zenith [?]; and likewise at midnight at the winter solstice (תקופת טבת). By this method the ancients made their precise determinations.

So too [for] the inclination of the rest of the configurations of the five wandering stars [?], for they were in need [of more refined methods], since for some of them [the inclination amounts] to several geometrical [?] degrees. [Several phrases in this paragraph are degraded; readings flagged.]

Siman 194 — Explanation of the matter of the epicyclic orb belonging to the moon, and to the remaining five wandering stars

[Body heading p. 113: סימן קצ"ד]

Know that the ancients found, in their inquiry, that the moon and the remaining five wandering stars have, besides [the orbs already described], another small sphere [?] like a little ball, which does not envelop [encircle] the globe of the earth as the other [great] orbs do. This ball, of itself, does not at all encircle the globe of the earth [in its own nature]. As for its standing: know that within the thickness of the sun's orb — which is called the "going-out" [eccentric] orb, whose center [lies] above the center of the world toward the moon [?] — the [epicycle] is fixed within it, and its third [?]. [This is discussed] in Siman 204 [סי' ר"ד]. So too there is [such a ball] in the three inclining [orbs] of the moon, and likewise in the orbs of the rest of the wandering stars.

In Greek [?] this sphere is called **קלקוס** [Greek: κύκλος (*kuklos*, "circle"); here the epicycle], "the encompassing orb" (גלגל ההקפה), since this orb perpetually [carries the star around] [?]. Its making is this: it is sunk within the thickness of the bearing [deferent] orb, just as a stone is set sunk within a ring, the whole [forming] the shape of a wheel. The sun's form is that it is sunk and fixed within the bearing orb, save that there is one great difference between them: the body of the moon [?] is fixed within the bearing orb only [?]. This [epicycle] has, of itself,

no motion of the world [diurnal motion] at all, like a peg [fixed] within a wheel; rather, the bearing orb carries it around the globe of the world. But this epicyclic orb (גלגל הקפה) is not quiet and at rest in its place, for it is forever revolving and turning — like a wheel turning within the hollow [interior space] of the bearing orb. The moon (and likewise all five wandering stars, each one of them) is fixed within the [thickness of the] ring; that is, it is sunk and fixed at the edge or rim of its epicyclic orb, like a peg [holding] the star in its place; and the wheel [the epicycle] revolves around with the star sunk within it [?].

[continuation of Siman 194:]

[the star being] fixed thus within [the epicycle] in the time appointed for that star — for the moon, [a period of] twenty-seven days and some hours, as will be explained ahead; for Jupiter (צדק), [the period] in [Siman] 213 [רי"ג, as will be explained] [?]. By this revolving of the epicyclic orb, it does not move the globe of the earth at all; rather, by all the days of the world it forever revolves, turning in its place [?], within the thickness of the bearing orb that carries it. That is the willed [proper] motion of the bearing orb [?]: the bearing orb carries the epicyclic orb, in which the [star] is fixed, of necessity around the globe of the earth in the time fixed for each one [?] — one of them [completing it] for the moon in twenty-seven days and an [hour], Jupiter in thirty [?], [Saturn? in twenty-]nine years and some hours, as will be explained ahead at the end of Section 10, God willing [?].

According to the diameter of the epicyclic orb, [as] the astronomers wrote, [it is] of such-and-such a size [?]. And know that there is a fifth orb [?]. The wise men found the epicyclic orb [necessary] — that is, they did not [posit it] only for the six [?] wandering stars [the planets], according to [the principle] that every irregularity found in them [could] be set right by it [?]. [They posited it] like the eccentric (יוצא מרכז, "off-center") orb [?] that was written about, [for the purpose] explained ahead at Section [?]. But in the rest of the six wandering stars, [where] most of their irregularities are far greater [?], an eccentric orb did not suffice for them; rather, more than that was needed in [these cases], so that they were compelled to add to them, in order to settle the irregularities found [in them], the epicyclic orb. [Several readings in this paragraph are degraded and flagged.]

Siman 195 — The form of the epicyclic orb — which is also a star [?] — touching the orb above it and the orb below it

[Body heading p. 114: סימן קצ"ה]

I saw [fit] to present before you the form of the epicyclic orb together with the form of the orb in which it is fixed, and which is its bearing [orb] (i.e., that which

carries it around the globe of the earth). [I will use letter-labels on the figure.] This is: the small orb that revolves [?], the orb mentioned above [as the epicycle] [?], is the epicyclic orb fixed and sunk within the bearing orb. The circle at the center of this figure [marks] the bearing orb, whose [path] the center of the epicyclic orb forever rides upon; therefore [it is marked thus]. And now you know that, as the epicyclic orb carries the star around [?]…

Diagram. A circular geometric figure illustrating the moon's epicyclic model. A large outer circle (the firmament / signs) encloses one or more inner circles. At the center is the earth (marked ה [he]). A medium circle within represents the deferent ("bearing orb," גלגל הנושא), whose circumference is labeled with the legend **מסלול גלגל הנושא** ("path of the bearing orb"). A smaller circle riding on the deferent (the epicycle) carries the lettered points. The word **מזרח** ("east") is printed at the bottom of the figure as an orientation marker. Readable labels:

- ה (center): the earth / center of the world
- א (upper region): point on the configuration
- ב (upper region): point on the configuration
- ג (lower right): point on the epicycle/configuration
- ד (lower region) [?]: point on the configuration
- מסלול גלגל הנושא (legend along inner ring): "path of the bearing orb"
- מזרח (bottom, outside): "east" — orientation marker

[The interior lettering is small and partly degraded; not all point-labels are individually legible. for label verification.]

[continuation of Siman 195, lower text-block p. 114:]

you know that, as the epicyclic orb carries the star around, [the astronomers] set it [at point ע (ayin)] [?]. From the bearing orb [?] — which is the moon's [orb], whose height [marks] the moon's place — the moon itself meets and touches the concave [surface] of the orb of the star above it [?]; and there the moon reaches the limit of its height and the limit of its distance from the center of the earth. And when the epicyclic orb carries the moon around and sets it at point ש [shin] of the bearing orb [?] — which is then as though [it were positioned thus] in the figure — the moon is then there itself, and it touches [reaches] the orb of fire [the lowest sphere] [?] [the point marked] in the figure [?]; and then the moon reaches the limit of its descent [?] and the limit of its nearness to the center of the earth. And at point ט [tet], or at the point [?] in the figure, the star [will be] on the line of the path (מסלול) of the center of the epicyclic orb — [at] its mean place, between the limit of nearness and the limit of distance. All this will be explained still more

fully [ahead], and the measure of the nearness and the [farness?] between them, ahead at the end of the Section [?] [Siman ?].

Siman 196 — On the moon, in its epicyclic orb, going opposite [to the direction in which] the rest of the orbs go — and it is called "going in its reversal"

[Body heading p. 115: סימן קצ"ו]

Know that the epicyclic orb revolves, and its motion goes opposite [to that of] the bearing orb of the moon — and likewise [opposite] in the epicyclic orbs [?] of the five wandering stars. The reason is [as I shall explain]. Because each of the five [?] orbs revolves, by its willed [proper] motion, evenly to the [same] side and direction as the bearing orb that turns it [?] — that is, by the willed turning of all [these] from west [to east?], that is to say [?] — [therefore]: the rest of the wandering stars, whose [height] is high [in the heavens], their epicyclic orb [?] [rises] toward the east, going to its top [zenith], and then descends to the west until it returns to rise toward the east again. But the epicyclic orb of the moon does not turn thus: it turns from east to west [?]. This is its course: when the moon, [carried] by the turning of its epicyclic orb, [stands] at point ע [ayin] in the said figure, and the center of the epicycle [stands] at point ב [bet] [?] — and after five [days?] [?] it is found that the epicyclic orb has travelled [?], [carried by] the bearing orb's path eastward, and is positioned at its center upon point ח [chet] in the said figure [?] — and behold, in these days [?] the moon's center has travelled above [?] [the top of] its epicyclic orb, until it turns to point ז [zayin] in its epicycle. Then, as the moon's [orb] [stands?] [thus], the height of its epicyclic orb [?] carries it down toward the west, and from there it descends to the west and turns northward and sits to the east [?]. This course is called **the moon's going in its reversal** [?].

The matter [meaning] of this revolving of the epicyclic orb within the hollow [interior space] of the bearing orb is [to renew?] the moon's standing at the height of its zenith [?], until it returns to that same point [?] from which the nearest [precise] computation issues. This is [a period of] roughly twenty-seven days [כ"ז יום], in which its motion is thirteen degrees and some minutes per day [?], roughly. And the revolving of this whole epicyclic orb around the globe of the world, [carried] by the bearing orb, is [also] twenty-seven days and some hours [כ"ז יום ז' שעות?] [?], in which its daily motion is some ten minutes [?], roughly. The interval [?] from conjunction to conjunction (molad to molad) is twenty-nine days, twelve hours, and 793 chalakim [כ"ט יום י"ב שעות תשצ"ג חלקים — the

standard mean synodic month], and no [remainder] [?]. These two reckonings do not contradict one another, for it all comes out to one [consistent] account, as will be explained ahead in Siman 204 [סי' ר"ד] [?].

[Several phrases in this dense paragraph are degraded; the values 13°/day, ~10′, 27 days, and the synodic-month constant 29d 12h 793ḥ are read with reasonable confidence, the others flagged.]

Siman 197 — The orbs of the moon and the orbs of the remaining wandering stars

[Body heading p. 115: סימן קצ"ז]

Know that, just as the sun is found to move [?] by night, and this is seen in [its] revolving [?] in its sphere [?] — its sphere makes one orbit [?] in [each] revolving — [so the moon]. As I have written above in Section [?] [Siman] 192 [?]: the moon, too, [moves]. And so I will [explain] for the moon, by [the same principle] as for the ball of the moon [?]. For just as the sun completes its [orbit] in the [solar] year, the moon completes [its orbit] in twenty-seven days and some [hours] [?]. And likewise [for] the rest of the five wandering stars [?].

The moon's orbs, and these orbs together [?], are more numerous [?] than these orbs [?]; for in the [course of] the sun's [orbit] in the year, the moon completes its orbit in twenty-seven days and some hours [?]. And so [too?] in [the case of] the moon, and as in the rest of the five wandering stars: each one of them makes, by the motion of the daily course [?], a single [proper] orb [?] each day, which is unique [to it], and whose nearness, distance, and farness [in] the orbs [?] differs [from star to star]. This is [so] according to the time of each star and planet [?]. Also, every star and planet [moves] [?]. So too the eighth orb [the orb of the fixed stars] [?] — but the motion of [that] orb [is so slow that] one does not perceive in it any leap of an orb [?]: it does not renew [a full revolution] in one day, nor in one [month] [?], nor even in one year, but [only] after many [?] thousands of years. [This paragraph is heavily degraded; readings flagged throughout.]

> [Gloss / Note (Rashi-script aside):] **A note for the discerning [reader]** [הערה — for one who wishes to be precise in these matters]: It is plain that the sun's sphere [?] is more [?] than the moon's spheres [?]. [The text continues:] The body of the moon [?] is smaller [?] than the stone in the ring [?], and is more [?] than all the spheres of the [other] wandering stars [?]. Moreover, the moon's motion [?], in [the matter of] the firmament's longitude only [?], goes faster [?]; and the moon's [position] is thus reckoned both in longitude and in latitude, as said above in Siman

192. Further, the difference between the sun's motion [?] and [that of] its mean [?] is found to be greater in the moon than in the sun, here [?]. The reason [?] for [the moon's] being greater [in this respect] is the epicyclic orb that turns it [?]; for, besides the [other] spheres, [the moon] makes [its motion] by the turning of the bearing orb. Behold, the moon, in its epicyclic orb, [moves through] more spheres than [the sun?] [?]: it says that the moon turns in the plane [surface] of its epicyclic orb [?], sometimes from west to east [?] and sometimes from east to west [?] — as [explained] in [Siman 196?], and as will be made clear [where it discusses] [the?] orbs [?]. This requires great precision, [and there are] many laws and judgments [in it]; and see [?] ahead in Siman [?]. [This marginal/gloss passage is in smaller type and heavily degraded]

Siman 198 — On the difference found in the moon between its mean place and its true place in the signs

[Body heading p. 116: סימן קצ"ח]

We already explained above, at the head of Section 7, in Siman 163 [קס"ג], and also in Siman 182 [קפ"ב], that we have no sign or single letter [marker] by which to know the measure of the moon's motion [?] in terms of [?] its progress against the parts [degrees] of the signs. And just as this [holds] for the sun — [where] the [difference?] found in the sun between [its] mean place and its true place [arises] [?] — so too in the moon, [and even] more so. [This holds] for all the rest of the irregularities, when combined, in the signs [?]. For all the [more], then, in [the matter of] laws and judgments. And this is for two reasons:

The first cause is the eccentric orb (גלגל היוצא מרכז) — for all the irregularities found in the moon are caused [in part] by it [?], as will be explained shortly. The second cause is that the sun does not [move uniformly] [?] in its course [?]; rather, [its irregularity] is found only in [the longitude — i.e.] in the fine [reckoning of] longitude. But in the moon, its irregularity is reckoned in longitude and in the latitude of the firmament [?].

And before we come to explain the [longitude-]irregularity, I will reveal more about the matter of the moon's true and mean place, in addition to what we explained above in Siman 192 [קצ"ב], and [about] the latitude of the firmament. Know, then, as a general rule: the line that goes out from the center of the earth and runs out [?] to the center of the epicyclic orb, [reaching] up to the firmament — this is called the **mean place** (מקום האמצעי). And the line that goes out from the center of the earth and runs along [?] up to the [moon's] horn [?], up to the

[point of] the moon itself, up to the firmament — this is the **true place of the moon in the firmament** (מקום הירח האמיתי ברוחב הרקיע) [?]. The distance, from the head of the signs up to the said mean place, is called the **mean place of the moon in the longitude of the firmament** (מקום הירח האמצעי באורך הרקיע). And likewise the distance, from the head of the signs up to the true place [?], is called the place of the **true moon in the longitude of the firmament** (מקום הירח האמיתי באורך הרקיע) [?].

The distance of the moon's center, in its epicyclic orb, from the point [ע, ayin] of its epicycle — this is called the **moon's anomaly** (מנת הירח?) [?], and in [the European] tongue it is called **אפיגיאוק** [Greek/Latin: *epicyclus* / Greek ἐπίκυκλος (*epikuklos*, "epicycle"); here the epicyclic-anomaly argument] [?]. The illustration of this [is] that the moon is found, in the figure [diagram], [at the place described] at point ע [ayin] [?].

Diagram. A circular geometric figure for the moon's epicyclic / mean-versus-true place construction. A large outer circle (the firmament / signs) encloses inner circles; the earth (ה) is at the center, and a deferent circle carries the epicycle. Lines are drawn from the center outward through the lettered points. Readable labels:

- ה (center): the earth / center of the world
- א, ב, ג, ד (around the configuration): construction points for the mean and true place
- ע (on the epicycle) [?]: the reference point on the epicycle from which the anomaly is measured
- ז, ח, ט (on the inner circles) [?]: epicycle construction points

[Interior labels are small and partly degraded; not every point is individually legible. for label verification.]

[continuation of Siman 198, lower-left block p. 116:]

When the epicyclic orb [stands] so that its center is at point ב [bet] of the path (מסלול), and the center of the epicycle is at the point known [from the figure], then after several days the epicycle's center [moves] [?]: it will then sit at point ח [chet] in the figure. As [in] these days [?] the moon's center has travelled over the top of its epicycle, by the said method [?], [it follows] the way [described] in the note above [?] — until it sits at point ז [zayin] of its epicycle, and the moon's place [?] [will be] [thus]. And now, if we draw [a line] from the center of the earth, from point ה [he] in the figure — two lines [?] — to the center of the epicyclic orb (which is point מ/ם [mem]) [?], extending up to the firmament, it reaches point ד

[dalet]; and this is called the **mean place of the moon in the latitude of the firmament** [?]. And along the line drawn to the center of the moon [itself] — which is point ז [zayin], and from there [?] up to the firmament [?] — [the line] [reaches] point ח [chet]; and this is called the **true place of the moon in the latitude of the firmament**. And in this [case?] [?] [is] the true place of the moon [?], which is called [thus]: [the arc] from the moon's mean place along the firmament up to [the limit of?] [?] [Siman?] [?]. [This block is dense and partly degraded; readings flagged.]

Siman 199 — On the difference [arising] in the moon between the true conjunction (molad) and the mean conjunction

[Body heading p. 116-verso: סימן קצ"ט]

Know that, just as we set down the difference and the discrepancy between the moon's true and mean place in the signs, so too [there is] the [analogous] discrepancy and difference in [the matter of] the conjunction (molad). For the moon [?] has a true conjunction [?] and a mean conjunction; the true conjunction is the precise [one] [?], and we examine the time at which the moon's center itself stands directly opposite the sun [?] — that is the moment of [the new] holy [moon] [?], according to the truth. But in [terms of] reckoning, the times at which the true conjunction [actually] occurs are not [evenly spaced] on a single [fixed] measure, for there is found in them an advancing and a delaying [?]. [Therefore] our Sages, of blessed memory, said [Rosh Hashanah?] [(Bavli Rosh Hashanah)]: "[the molad] comes sometimes by the long [reckoning] and sometimes by the short [reckoning]" [?], as will be explained further. And the [mean] conjunction is reckoned from the mean [motion]: [it is the time] when the center of the epicyclic orb is positioned directly opposite [?] [the sun] from [its point of departure] [?] — this is what is called the **mean conjunction** (מולד האמצעי), and we do not press [too closely] [?] upon [the position of] the moon's body itself; rather, it appears to us as though the moon, at that time, stands at the height of its [epicycle's] zenith [or at its lowest point of depression] [?], as for the mean and true conjunction, as will be explained shortly.

Even though, for the most part, the moon at the [moment of] conjunction is not at the height [of its epicycle] [?], nor on the line [?] of its epicycle's zenith [?] — at a [point] not directly opposite the sun [?] — [so that] it is therefore not a true conjunction in actual truth [?] — nevertheless, [the moment] when the center of the epicyclic orb is positioned directly opposite the sun is reckoned and called the **mean conjunction**, for it is the mean and the mid-point between the two extremes: between the limit of nearness and the limit of [the moon's] farthest

[reach] in the moon's course [?], as will be explained ahead in Siman 212 [רי"ב] [?]. And by this mean reckoning the [interval] comes out [as] the [fixed] time from conjunction to conjunction, forever [unchanging] — for it neither delays nor hastens, neither advances nor falls behind from instance to instance [?]; for whatever is lacking or in excess in [the calculation of] the true conjunction [?] in this month, [the same] reckoning of the mean conjunction makes up or pays back in another month [?].

[Body heading p. 116-verso: ועוד — continuation of Siman 199:]

And further [know] that the true and the mean conjunction sometimes [coincide] [?] in a single instant. This [happens] when their [coincidence] [occurs] [in such a way] that the center of the moon's epicyclic orb [stands] at point ו [vav] in the figure, positioned directly opposite the sun's center, which [is] at point ש [shin] — and the moon itself [sits] at that time [at] the height [of its epicycle] [?].

Diagram. A large semicircular geometric figure (the local horizon dome / great circle) spanning the page, oriented by horizon markers: **מזרח** ("east") at the lower left and **מערב** ("west") at the lower right. Within the dome are inscribed circles representing the epicyclic configuration at three positions, with chord/diameter lines drawn across. The lettered construction points:

- ה (upper-center, on a small circle): center of an epicycle (mean-conjunction position)
- ו, ז (within the central small circle): epicycle points (the moon's positions)
- א (left, on a circle): epicycle / configuration point
- ב (left) [?]: configuration point
- ג (right, on a circle): epicycle / configuration point
- ד (right) [?]: configuration point
- ח (lower-center): construction point on the horizon line
- מזרח (lower left, outside): "east"
- מערב (lower right, outside): "west"

[The interior lettering is small; positions assigned from the figure's geometry. for full label verification.]

> [Gloss (Rashi-script aside, right margin p. 116-verso):] [Explaining the figure:] …the moon would have a height [?] in the figure [?]: if the moon's body [?] [is at] the height [ומס] of the orb's epicycle or at its lowest [depression] [?] — as it was at point ה [he], or [point] ו [vav] in the figure — then the centers of the three [circles] [?] would all be on one line [?];

[and at] point א [aleph] [?] the conjunction would be both mean and true [coinciding]. And at times the instant of the mean conjunction [?] precedes the true [?], when the moon's place itself [?] [stands] in the firmament's longitude [?] [at a place] eastward [?] from the place of [its epicycle's] center, [as the figure shows] [?]. [This marginal gloss is in small, heavily degraded type]

[continuation of body text, lower block p. 116-verso:]

when the moon's place itself [is at point] ם [mem] [?] in the epicycle, as in the figure, [at] point ה [he] [?] of its epicyclic orb — and the place of the epicycle's center is at point ב [bet] [?], which is [its] mean [?] [position], positioned [directly] opposite the sun, [it is] opposite point [?] of [points] ז/ו [vav/zayin] [?]. And when the [point of] the epicycle's center [moves] — which is point ב [bet], [as] in the figure [?] — then point א [aleph] [?] comes against [?] [the line] beneath it, against [?] [point?], and [it] is positioned beneath [?] [it]; this is the **true conjunction**. And at times the instant of the true conjunction precedes the mean. This [happens] when the moon's place [stands] [?] eastward of the place of its epicycle's center itself [?] — so that the place of the epicycle's center [?] [is to the west of] the place of the moon itself [?] — [when it is] at point ג [gimel] [?], positioned directly opposite the sun [point] ת [tav] [?]; therefore the true conjunction will precede the mean conjunction [?]. And the difference found [between them] [?] — [it is] according to the [degree of] the moon's nearness [in its epicycle] [?]. For the [difference between] the true and the mean conjunction [?] is, [reckoned] from the moment of conjunction [?], [a line] going out from the center of the earth along the path of the epicycle up to the firmament — and its distance from it [?]. The greatest difference between them [?] is when the two lines going out from the center of the signs [?] [diverge most], [as] the moon's place [stands?] [?]; and according to [the size of?] [?] the half-diameter [radius] of the epicyclic orb [?] [in] the figure, the moon's place will be [at] point ג [gimel] and the mean at point ד [dalet] [?] — for it is not possible that there be found a [greater] irregularity or difference between them than [this], the greatest [?]; and then the time-difference between them is greatest [?], [namely] according to what is written, following the view of Ibn Ezra (ראב"ע) [R. Avraham ibn Ezra], in [his] chapter [?]. And according to the view of the Israeli (הישראלי) [R. Yitzchak Israeli, *Yesod Olam*], in Ma'amar 3 [במאמר ג'], it stretches to [?] hours [?]; [hence?] it is not possible that there be found ever a difference [greater than that] which reaches fifteen [?] full degrees [?]. [This long block is dense and partly degraded; numerous readings flagged.]

Siman 200 — All the irregularities found in the sun [are] caused by the eccentric orb, and [those] in the moon [are] caused by the epicyclic orb — all of them found in the moon

[Body heading p. 116-verso: סימן ר' — Siman 200]

After it was explained to you [about] the matters of the epicyclic orb, and the matters of the courses of the two luminaries [?] in [their] true and mean place, know now that all the irregularities found [in them] are [explainable] by the configuration of the orb [?] from now on…

[Marginal vertical text, foot of page: "ע"ב / ח[צי] רחב" — partly legible; appears to be a binder's/printer's note, flagged.]

Section 8 (שער ח), continued

[continuation of siman 200 / preceding paragraph — on the lunar model traced through the deferent (eccentric) orb]

[the lunar irregularities] are observed according to the structure of the eccentric orb [גלגל היוצא מרכז]. Sometimes the true place is not found to deviate at all from the mean place; sometimes it is the reverse — the true place runs ahead of the mean; and sometimes the moon's motion is faster, sometimes slower, and sometimes its quantity increases or decreases. At times the moon draws nearer to the body of the sun, and at times it recedes from it — as has already been explained above — and the Earth [draws near to it or recedes]. Thus all of these things are found among the [orbs] of the moon themselves, exactly as was explained earlier (siman 183 [קפ"ג]).

Siman [continued] — on the structure of the lunar epicycle [גלגל הקפה]

I will state this briefly. According to the structure of the epicycle [גלגל הקפה], when the moon reaches the apogee [רום לגובה] of its epicyclic orb, or its perigee [שפולו], then no deviation is found between its mean place and its true place — owing to the fact that at those two places it lies upon a single straight line [?]. (ב) From the point where the moon's center begins to travel along its epicycle from its perigee [שפולו] toward its [apogee], the moon's center stands as if fixed [צד וחנה ועומד]; that is, [the true place] lags behind its mean place, as will shortly be explained. (ג) And from where the moon ascends from its perigee toward its apogee [לרומו], the matter is reversed: the moon's place runs ahead [יקדים] of the true place, ahead of the mean — as will be explained shortly (siman [following, ד]). (ד) For according to the line drawn from the moon's center to the eccentric's

center from the Earth's center, and according to the center of the epicycle, the deviation [החלוף] of the angle [הזוית] diminishes. (ה) For according to the moon's center, from where it ascends out of its perigee [משפלו] — that is, from the eastern side of its path [מסלולו] rising up to the western side of its path — the deviation increases, and the deviation keeps increasing up to the two limits which lie at the [points of] greatest deviation, at the very extreme of its size [גדולו]. When the moon is at the apogee, the height of the epicycle, it recedes from the [body of the moon? — האין מכדור] [?]; and when it is at the perigee [בשפולו] it draws near to wandering [לנדוד]. (ז) [And] as the moon revolves [סובב] along a portion of the lower part of its epicycle [התחתון] [toward the Earth], its true motion exceeds its mean motion — it moves more than its measure — and when the moon lies along the upper portion [העליון] it is delayed and proceeds slowly, for a reason that will be explained shortly. Thus you have the rule: all the irregularities [המתחלפים] found in the sun according to the structure of the eccentric orb's center are found likewise in the moon according to the structure of the epicycle.

It is therefore unnecessary to posit for the moon's orb any eccentric orb [גלגל יוצא מרכז] at all, since this was what the early scholars [החכמים הקדמונים] determined — that the moon has no eccentric orb [גלגל יוצא מרכז]. Yet we ought to know that the later scholars [האחרונים], having examined and scrutinized [the matter], have found their observations to attest to [other] deviations [חלופים], distinct from the deviations mentioned above. Moreover, they found that when the moon is at the apogee — the height of its epicycle — it does not always revolve at the same rate [קצב] [?]: at the [Earth's] mean distance there is one rate, and the rate at the eighth [degree?] [ח'] in the moon's distance and proximity to the body of the Earth is another [?]. Therefore the scholars found it necessary to make known that the moon, too, does have an eccentric orb [גלגל יוצא מרכז], but in another form [תמונה]. Likewise I have heard in the name of the scholar Kepler [קעפליר"וס, Kepler] [?] that we cannot decide for the moon's orb whether there is, after the eccentric orb [גלגל היוצא מרכז] — which I have called by the name "[eccentric] orb" [?] — yet another small epicyclic orb [גלגלון הקפה קטן], so that one would say of the moon's [orb] [that it is] hot [בחומו] [?]. He says we should acknowledge that, just as is found in the moon's orb [an] eccentric orb [גלגל היוצא מרכז], so likewise [there are] in sum [for] the moon three orbs [ג' גלגלים]. These are: (1) the orb of the sun [גלגל החמה] [?], the inclined orb [גלגל הנוטה], which is itself not the carrier [נושא]; (2) the epicyclic orb [גלגל הקפה]; (3) the eccentric orb [גלגל יוצא מרכז], which appears to be exactly congruent with the orb resembling [it] [גלגל הדומה], inclining from it neither to the north nor to the south, only somewhat toward the south, since its center is found to be slightly [displaced]. This orb is

called **the carrier orb** [הגלגל הסובל], because it bears and carries all the epicyclic orbs.

Siman [missing-number] — that the moon's orbs have [six motions] [the rubric for siman 204 (ר"ד) follows on the next page]

From the things mentioned, it will become clear to you that the moon's orb has — like the orb of the sun, together with the inclined orb [הנוטה] —

Siman 201 (סימן ר"ד) — that the moon's orbs have six motions

From the things mentioned it will become clear to you that the moon's orb has six motions, like the orb of the sun, together with the inclined orb [הנוטה], which is its inclination [נטייתו]. These are:

1. Its natural voluntary motion [מהלכו הרצוני הטבעי], from west to east.
2. The compulsory diurnal motion [תנועה היומית ההכרחיות].
3. The motion of the [heaviness? — הכבידה] [?] of the [poles? — לעו"ח] [?] within it [שכה לע"ח].
4. The motion of the epicyclic orb [תנועת גלגל הקפה].
5. The motion of the moon itself [תנועת הירח עצמו], as noted [adding the "ascent" — ראש ותלי ונכלל [?], see siman 191 (קצ"א)].
6. And further, a sixth motion — confused and entangled [מבולבלת ומסוכסכת] — which makes an oval [עגול כפ"ע [?]], as will be explained in siman 206 (ר"ו).

The astronomers [החכמים] also count circles [עגולי] which we must draw upon the moon's orbs, which number five. The circles [עגולים] found in the orb of the sun, as explained above in Section 6 (כשער הששי) at siman 172 (קע"ב), and in addition to these we add for the moon's orb the circle of the inclined orb [הנוטה], the circle of the epicyclic orb [גלגל הקפה], and the circle of the path of the moon's body [מסלול גוף הירח].

Siman 202 (סימן ר"י"ב) — the calculations of the tekufot and the moldot of the mean [moon]

Which Chazal [ז"ל] established for us according to the mean motion.

Know that, just as the motions of the true sun and the true moon are unequal — as we have shown — so too the times of the *tekufot* [seasonal points] are not equal, and likewise the times of the *moldot* [conjunctions] are not equal. Rather, there is found in them advance and delay [קדימה ואיחור], differing in several

respects: according to the difference of the regular [paths] [הסדירות] in their length, and according to the difference of the position of the sun among the signs and according to the difference of the moon's own place — in its longitude [באורך] and in the breadth of the firmament [וברוחב הרקיע], and according to the difference of the place of the [moon's] mean motion [המהלך] among the signs.

For [all] these matters, the thing was grave and very intricate [חמור ויותר מפולפל], and it was the great difficulty [הגדול] [for the sages] [?]. By means of evidence and inquiry, the Sages of Israel [Chazal] of past generations sanctified [the new moon] and examined the witnesses on each of the seven inquiries [שבע' החקירות]: whether they saw the moon before the sun or behind it, to its north or to its south; how high it was, and whither it was inclining, and how broad it appeared — as we shall explain in siman 215 (קט"ו [?]) [recte: a later siman]. All these inquiries were made according to the true position [תשבון האמיתי], as the Rambam [הרמב"ם] z"l wrote in Hilchot [Kiddush] HaChodesh [מה"ל ק"ה], chapter 1 (פ"א), and as R. Yitzchak Israeli [הישראלי] began [in Yesod Olam], chapter 11 (פ' י"א), Ma'amar 3 (מאמ' ג').

But because these matters are deep and profound, requiring [much] study and scrutiny — "deep, deep [is it]; who can find it out?" (Kohelet 7:24) — therefore, near the end of [the time when] the wisdom of the wise would perish [as it is written, Yeshayahu 29:14], when the kingdom [of Rome / the empire] decreed to destroy and abolish [the calculation] in the manner here noted, and there remained [none] who could fix the calendar [in Eretz Yisrael] — for the [scholars] of Israel who had been settled in Eretz Yisrael had departed — Hillel the Nasi [הלל הנשיא] and his court [וב"ד] founded and instituted [the practice] of calculating by the intercalation of the years [בעיבור השנים], so that we should not need [to rely on] the testimony [of witnesses for] [the molad].

[continuation of siman 212]

it would be neither for the festivals [לרגלים = [?] לעלים] nor for the salt-[offerings? מלוחים] [?] — let his [calculation] be [reckoned], so that there be [a fixed reckoning] [?] — in the year [4]118 (אלפים וקי"ח [?]) [reading uncertain] from the Creation [ליצירה]. Some of this [matter] was explained [התחדש [?]] in the chapter [פ'] [referenced]. By the lesser computation [מספרנו הקטן], even in part — by one fraction — of our reckoning [?]. [Reading degraded here.]

[Therefore] Chazal [ז"ל] established for us [the calendar] according to the mean motion [מסלך האמצעי], as the Rambam [הרמ"בס] z"l wrote at the head of [Hilchot] Kiddush HaChodesh, chapter 6 (פ' ששי) and chapter 8 (פ"ח [?]), and as Abu [?]

[עפירי [?]] [reading uncertain]. He wrote there, in their own words: "From his [the moon's] time, the two aforesaid tekufot — though their path [is long? — ארכי] — the mean [position] is near [the true]; thus we lead [the calculation] by the mean sun [השמ' האמצעי], not by its true place [במקומ' האמיתי]." And so wrote the Nasi [הנשיא] [?] and Ibn Ezra [ראב"ע] in the order [סדר] of [the parashah] Emor, in the chapter on [the calendar / Hagn"a Adis [?]] [reading uncertain]. Our Sages transmitted [העתיקו חכמינו] in the [calendar matter, choosing] to follow the good [estimate] over [absolute precision] [?], and the mean motion [מהלך התיכון] [serves] — and one cannot do better than [to make] a good thing [than to act] thereby. Likewise [wrote] the scholar of Israel [המכם הישראלי = R. Yitzchak Israeli], chapter 8, [section] 3 (פ"ח מ"ג), in [Yesod Olam], and [in] chapter 6 (פ"ו [?]) of Ma'amar [?], and others besides him.

Siman 203 (סימן ר"י"ג) — on the time of the moon's revolution in its orb [סיבוב הירח בגלגלו]

And the time of the revolution of its epicyclic orb [סיבוב גלגל הקפתו], and the measure of the lunar month [מדת חדש הלבנה].

Know that when the moon stands in its orb opposite a known fixed point — as, for example, opposite the point [the head] of the constellation Aries [טלה], or opposite some other fixed marking [רשימה אחרת] — until it returns and completes the circuit opposite all twelve constellations [הי"ב מזלות] of the firmament, [moving] according to its mean motion [מהללה האמצעי], and comes a second time back to that same point from which it [first] went out: the time of this revolution [זמן זה], by the precise computation which I have received from the astronomer Kepler [קעפלעראז"ס, Kepler] [?], is as follows. [Out of his abundant [?]] — in [each] revolution — the time is 27 days, 7 hours, 43 minutes [דקין], 7 seconds [שניות], 9 thirds [שלישים] [?], and is found [to be] 43 [?] [...] thirds [שלישיים]. [The reading of the lower-order fractions is degraded.]

Accordingly [לפ"ז], the moon's essential revolution [סיבוב העצמי] — measured against [the fixed sphere] — is light and swift, revolving more than thirteen times [י"ג פעם] [per its period?] [?], and faster [ומהיר] than [...]; for this [body], the true [moon] [התמ' העצמי [?]], revolves opposite all twelve [signs] in 27 days [?]. And this is the revolution of the moon by way of its epicyclic orb completing its revolution in its place [סיבוב הקפתו במקומו]; this [period] is: 27 days, 13 hours, 13 [?] minutes, 3 [?] minutes [degrees — מעלות י"ג] [?], 53 seconds [נ"ג שניות], 56 thirds [נ"ו שלישיים] [reading partly degraded].

And the measure of the lunar month [ומדת חדש הלבנה] — the time between one molad and the next molad — is somewhat longer than its [period] [ממכונו], because it [the moon] comes after [the sun]. [That measure is] 29 days, 12 hours [ב"קמ — [?] המדק [?]], [...] — that is, 29 days, 12 hours, 44 minutes [מ"ד שעות [?] — recte: דקין], 3 seconds [ג' שנייס], 11 thirds [י"א שלישיים]; the whole, by the mean motion [מהלך האמצעי], being 12 days [recte: hours], 44 minutes, 1 [?] second [...], 5 thirds [ה' דקין], 11 [...]. And this is the period that Chazal called "the holy [period]" [שתנועת הקודש = שמנועת הקודש], [namely] 29[d] 12[h] 793 chalakim [תשצ"ג], which corresponds to one chelek out of [...]. By their reckoning [לחשבונו] Chazal [ז"ל] reckoned [...] for indeed [...] — see the explanation in our book [בספרינו] called [רומא? — title uncertain] [?], and according to our [reckoning] in two thousand [...]. [Reading degraded.] [Behold] the lesser computation [המספר הקטן] in Section 21 (משער כ"א), siman [...], be-siyata di-Shmaya.

Siman 204 (סימן ר"י"ד) — the reason for the difference between the time of the moon's revolution in its orb and the time of the measure of the [lunar] month

And because of the [reason] that I have already mentioned [שהקשו] — some men found difficulty [in] that the time of the moon's revolution against all twelve constellations of the firmament is only 27 days and [...] hours; if so, then [there ought to be found, between one molad and the next molad] a time [of] [only] 27 days [?]. [...]

The matter is [resolved] as follows. According to [the model of] [Ptolemy] [תלמ"ז תלמיוס = [?], Ptolemy] [?]: at the moment of one molad the two luminaries [המאורות] are exactly aligned [צמצמו] — for instance, both directed opposite the head of Aries [ראש טלה], as in this illustration [ע"ד הנס — recte: ע"ד הזה] [?]. Then, when the moon parts from facing the sun [הלבנ' תפרד מנגד החמה] and proceeds in its motion [throughout] the whole orb, in [about] 27 days and close to eight hours [וקריב לשמנה שעות], it returns to the very point from which it had renewed [its course], where it had [first set out]; but when [the moon], in its casting opposite [במשליכו] the head of Aries [ראש טלה], does not find [the sun there] — because in that place the moon does not [coincide with] the sun — since [during] those 26 [?] [days] and close to eight hours [the sun too has moved on]: for the sun has also moved [during that span] close to 27 degrees [מעלות לכ"ז [?]] in its mean motion, the moon — for this reason — pursues after it [the sun] and does not overtake it until after [an additional] [some] days, hours, and chalakim [וחלקים]. And when you add these [extra] 3 [?] days [recte: 2 days, ב'], hours, and chalakim to [the 27 days], it comes to close to [the value of] the [lunar] month: 29

days [...] 793 chalakim (תשצ"ג ב"י ט"כ), [the time] until the moon renews [its conjunction] in its orb [at the point from which it had set out].

From this it becomes clear to you that the moon never renews itself [its molad] in the same month [twice] [recte: at the same point of the firmament], for [during] the elapsed month it [the moon] has [already] renewed itself between [some other] constellations [?]; the moon revolves through its whole orb against all twelve constellations of the firmament, and in addition to this [time] it [must travel] close to that [extra arc] by which [the sun has advanced] in its length, and [thus] the moon renews itself [every] month and [every] year through all twelve constellations. See above, Section 5 (בשער החמישי), at siman 122 (קכ"ב [recte? — קב"ת]).

Siman 205 (סימן ר"י"ה [recte: ר"ט"ו]) — that the moon revolves in two equal times by two differing motions]

From the principles [פכליליס = הכללים] that we have mentioned, it will become clear that the moon — and likewise every one of the other [planets] [בוכבי] — among the five other planets [ה' משאר כוכבי נכונה [?]], revolves in its revolution [בסיבוף] in its epicyclic orb [גלגל הקפתו] in two equal times by two differing motions [שני מהלכים מתחלפים] — a sign [רמז] of what was found in the sun in the revolution of its eccentric orb [גלגלה היוצא מרכז], as above at siman 184 (קפ"ד). Except that in the moon, the deviation [החלוף] is more concealed [מכוסה] than in [the sun], because the sun's mean motion [מהלכה] is slow [המתון]: at the head of [Cancer] [ראש מזל סרטן] [?] [the sun's motion is slow] and on both its sides [it speeds and slows], whereas its rapid motion [מהלכה לנחוץ] is at the head of Capricorn [ראש מזל גדי] and on both its sides. But the moon's deviation [חלוף] occurs in every single portion of the firmament [בכל חלק חלק] — at one time slowly [כמתינות] and at another swiftly [במהירות]: for when the moon revolves along [the part of its epicycle] above [the line] [מסבב למעלה מקו], [traveling] from the point [marked] gimel [ג'] [recte: from nekudat ד' to nekudat ח'] [?] — that is, revolving from the point [ד] through the point [ח] to the point [א] in the configuration described above at siman 199 (בסי' קצ"ט) — then it is delayed [מתאחר], because its motion along its epicyclic orb is the reverse of the motion of its epicycle by means of [the orb that] carries it [גלגל הנושא]; and then the planet [הכוכב] stands as if retrograde [stationary and retrograde — נזור ועומד] in the firmament's length [באורך הרקיע], and [when it] returns [שב] and comes to a single point [a' — נקודת א'], then the whole breadth of the epicyclic orb [is opposite the moon] before [it], facing east [נגד מזרח]. Therefore this motion is called **the slow motion** [המהלך המתון], and is also called **the retrograde motion**

[מהלך נזור]. And when the moon revolves below the line [למטה מן המסלול] and turns from the one point [marked] a' [נקודת א'] [...] through the point [...] to the point shin [ש' — recte: per the figure], the matter is reversed: the moon runs ahead [יקדים] along the whole breadth [שמח [?]] of its epicyclic orb facing east [נגד מזרח]. This revolution [סיבוב] is called **the rapid motion** [מהלך הנחוץ], and there is [in it] the advance [הקדימה] [?]. And in truth, [the magnitude of advance or delay] is according to the length of the diameter [אורך הקוטר] of the epicyclic orb that [...] [carries it].

[continuation of siman 215]

Also [גם], regarding the other planets [שאר כוכבי] [whose] motion in their epicyclic orbs [בגלגלי הקפתם] is [from west to east] [ממערב למזרח]: the matter will be [thus] — when [the planet] revolves [in its accompanying motion — בהעזכו], the slow motion is [the one] above [the upper part] of its epicycle [למעלה מן המסלול], and the rapid one [הממהר] is below it [למטה ממנו].

Siman 206 (סימן ר"י"ו) — that in the revolution of the moon's revolution

[The full rubric, completed from the body:] **that in the revolution of the moon's revolution that constitutes the [order] of the universe [את כדור העולם עשה], the body of the moon itself makes an oval path [מסלול עגול], altered and confused [משונה ומבולבל] exceedingly [מאד].**

Know that the path [מסלול] of the center of the moon's body itself, owing to its rising and descending [עלייתו וירידתו] in its epicyclic orb — [for] the center of the epicycle [is not] at the center [באמצע] of the carrier orb [גלגל הנושא]; rather, the center of the epicyclic orb alone [revolves] upon a line [קו] [drawn through] the center of the carrier orb, which [line] is called **the path of the carrier orb** [מסלול גלגל הנושא]. The center of the epicyclic orb [follows] this [path], according to which the moon will be reckoned [as moving] by its mean motion [מהלך האמצעי]. If that were [all], then the path of the moon's center itself, by its true motion [מהלך האמיתי], would be reckoned [as moving in a circle]; but it is not so — for sometimes [the center] revolves and rises upward [from the path], and sometimes [it descends] below the path, and sometimes [the moon lies] precisely on the line [קו] of the epicycle's path. Yet this happens only twice in each month, as will be explained.

And before we come to expound the matter [ביאור הענין] — to clarify it and make it intelligible to students [לתלמידים] in the easiest manner — let us suppose, by way of illustration, that the time of the moon's revolution by means of the carrier

orb [גלגל הנושא] about the body of the universe [כדור העולם], and the time of the moon's revolution in its epicyclic orb [גלגל הקפתו] itself, were equal. [Let us] not, in this place, take notice of [the actual fact] that the time of the moon's revolution in its epicyclic orb exceeds the time of [the moon's] revolution about the body of the universe by [about] five [?] hours, as [explained] above at siman 213 (כב"ל סי' ג"ר [recte: ר"י"ג]). Now hear the rule [משפט] of this path [המסלול הזה] and how it is produced [ומעשהו]:

Know that the center of the epicyclic orb stations [חונה] upon the line [קו] [drawn] through the center of the carrier orb, as [at the moment when] it is at point gimel (ג' נקודת), [marked] in the figure [שבצורה]. The moon itself stations at the apogee of its epicycle [בגובה רומו] at point vav (ו'). After a fourth [רביעית] of the days of the month [ימי החדש], the epicyclic orb has [already] revolved as a whole [בכללו], by means of the revolution of the carrier orb [סיבוב גלגל הנושא], through the eastward direction [דרך מזרח] [by] a quarter [רביעית] of the carrier orb [גלגל הנושא]. And during those same days — that is, in the fourth-part [ברביעית] of the said days of the month — the moon's center has traveled for itself [נסע לו], westward [לרן מערב], from the apogee [רום] of its epicycle, [through] a quarter of its orb [רביעית גלגלו], until its center stations [חונה] upon the path of the epicycle's center [מסלול מרכז הקפה] at its true place [במקומו האמיתי], at point shin (ש' נקודת). It is found, then, that the time of the displacement [העתקת] of the epicyclic orb's center from point gimel (ג') to point shin (ש') is the same time in which the moon itself has moved [נעתק] from point vav (ו') to point shin (ש'). During these days, the moon has inscribed [חקק], within [the body of] the [...] orb, an arc [קשת] of 90° [צ"פ = ¼? — recte: 90°].

In the second quarter [ברביעית השני] of the days of the month, the epicyclic orb has revolved as a whole [בכללו] until its center stations [חונה] at point chet (ח' נקודת); and during those days the moon's revolution in its epicyclic orb [is such] that its center stations at its perigee [בשפולו] at point shin (ש' נקודת). During these days [...] the moon inscribes [an arc]; and in the third quarter [ברביעית הג'] of the days of the month the orb revolves until its center stations at point kuf (ק' נקודת). During these days the moon's revolution [is such] that its center stations [חונה] on the line of the epicycle's path [בקו מסלול הקפה], to inscribe [לחק"ת] an arc [...] [until the moon's] center [is at point ד']. And the moon's center itself inscribes [חקק], at point dalet (ד' נקודת), during these days an arc [קשת] of [...] [recte: 90° per the quartering]. So you have it, then, that the moon's whole [path] is an oval [קס"ד עגול הוא א"ז — recte: it is an oval, not a true circle].

And it will become clear to you that the moon does not rest [לא ינוח] according to the computation [reckoned] upon the line [קו] of the epicycle-center's path [מסלול מרכז ההקפה]; rather, [it travels] as in every month [בכל חדש] — [it does so] twice [ב' פעמים], as will be explained [near] points shin (ש') and dalet (ד'). It will also be explained from this that the path of the moon's body [מסלול גוף הירח] — which is an oval [עגול] and not a [true] circle [recte: עגול דפ"ס — an oval] — is smaller [קטן יותר] [than the circle of the epicycle's path]; for the oval-path of the epicyclic orb [מסלול גלגל הקפה], both its breadth [רחבו] and the distance [רחוקו] of this path, is unequal [אינו שוה] to [that of] the epicycle's path [מסלול גלגל הקפה], so that we are compelled to seek for it a special center [מרכז מיוחד], and when we seek it we find its center [to be at] some point a' (נקודת א') [marked] in the figure [שבצורה], which is far and high [רחוק ולמעלה] in [or above] the center of the carrier orb [מרכז גלגל הנושא], according to the diameter [קוטר] of the epicyclic orb. All these matters you will see in the figure [בצורה]. [...]

[continuation of siman 216, with the lunar-oval diagram]

Also [גם] it will become clear to you in the figure [בצורה]: when the moon's epicycle [ההקפה] stations [חונה] at point vav (נקודת ו') and after a quarter [ולאחר רביעית] of the days of the month, the epicyclic orb has already revolved [סיבוב] as a whole [בכללו], moving eastward [דרך מזרח] by the fourth part of [its course], [revolving on] the path of the carrier orb until the epicyclic orb's center stations at point shin (ש'); and during those same days — the fourth-part [רביעית] of the said days of the month — the moon's center [has traveled] above the apogee [רום] of its epicycle westward [דרך מערב] [by] a quarter of its orb, until it stations [חונה] upon the path of the epicycle's center [at] its true place [במקומו האמיתי], at point shin (נקודת ש'). It is found, then, that the time of the displacement of the epicyclic orb's center from point mem-gimel [recte: from ג'] to point shin (ש') is the same time in which the moon's center has moved [נעתק] from point [vav]. During those days the moon inscribes [חקק], within the [...] orb, the arc [קשת] [...]; and in the fourth-part [ברביעית] of the said days of the month, the epicyclic orb [...] stations at point chet (נקודת ח'), and during those days the moon's revolution [is such] that its center stations [...] upon the path [בקו מסלול] of the epicycle, [inscribing] [the arc until] point [...]. And the moon's center itself [ומרכז הירח עצמו] inscribes [חקק], at point dalet (נקודת ד'), an arc [...] [reading partly degraded] — so behold [הרי כך] the moon [traverses] the whole oval [עגול]; this oval is therefore [...]. And it will be explained to you that the moon does not rest [לא ינוח] according to the computation [reckoned] upon the line [קו] [of the path]; rather [it travels] only as in every month [בכל חדש] twice [ב' פעמים], as will be explained near points shin (ש') and dalet (ד'). It will also be explained that the path of the moon's body [מסלול

גוף הירח] is an oval [עגול דפ"ס], smaller [קטן יותר] [than] the oval-path [מעגול מסלול] of the epicyclic orb [גלגל הקפה]; and the breadth [רחבו] and distance [רחוקו] of this path is unequal [אינו שוה] to [that of] the path of the epicyclic orb, so that we must seek for it a special center [מרכז מיוחד]. When we seek it, we find its center [to be at] point a' (נקודת א') [marked] in the figure, which is far and high [רחוק ולמעלה] in [or above] the center of the carrier orb [מרכז גלגל הנושא], according to the diameter [קוטר] of the epicyclic orb. All these matters [are shown] in the figure [בצורה].

[The figure follows below — see diagram.]

Diagram. A large circular schematic illustrating the lunar model of siman 216 — the path traced by the moon's body as the epicyclic orb is carried around the deferent. The figure consists of two large concentric circles (the carrier/deferent orb and an inner circle), bisected by a vertical diameter and a horizontal diameter that cross at the center. At each of the four cardinal positions sits a small circle (the epicycle) in a successive position of the month, each labeled with point-letters; a dashed curve (the oval path of the moon's body) is superimposed inside the outer circle, departing from the true circle. Labels read (positions as printed):

- **א [aleph]** — at the very center of the inner circle (the eccentric/special center of the oval path).
- **ה [he]** — just below center, on the vertical axis (center of the carrier orb / Earth).
- **ב [bet]** — on the vertical axis between center and the bottom epicycle.
- **ו [vav]** — at the top, on the outer ring above the upper epicycle (apogee position of the moon on its epicycle).
- **Upper epicycle** (top): labels **ב [bet]**, **ג [gimel]**, **ד [dalet]** around its rim, with **כ [kaf]** at its lower edge.
- **Right epicycle** (east): labels **ק [kuf]** and **ה [he]** [?] / **פ [pe]** on its rim. Outer margin at right edge reads **מזרח [mizrach** = **East]**.
- **Left epicycle** (west): labels **מ [mem]** and **א [aleph]** / **צ [tsade]** [?] on its rim. Outer margin at left edge reads **מ [?]** [mem — likely abbreviation for מערב, West].
- **Bottom epicycle**: labels **ס [samech]** and **ח [chet]** on its rim.
- **ע [ayin]** — at the very bottom, on the vertical axis below the lower epicycle.

The dashed oval represents the actual (oval) path of the moon's center; the solid inner circle the path of the epicycle-center; the four small circles the epicycle at the quarter-points of the month.

[continuation of siman 216]

Also [גם] it will become clear to you, as [shown] in the figure: when the epicycle's center [מרכז ההקפה] stations [חונה] at point gimel (נקודת ג') and the moon itself stations at the apogee [גובה רומו] of its epicycle entirely [בכללו] at point vav (ו') — and after a fourth [ולאחר רביעית] of the days of the month, the epicyclic orb has already revolved, moving eastward [דרך מזרח] by the fourth part [חלק הרביעי'] of [its course] on the path of the carrier orb [מסלול גלגל הנושא], until the epicyclic orb's center stations at point shin (ש'). And during those same days — the fourth-part [ברביעית] of the days of the month — the moon's center has traveled [נסע לו] above the apogee [רום] of its epicycle westward [דרך מערב] [by] a quarter of its orb, until it stations [חונה] upon the path of the epicycle's center, at its true place [במקומו האמיתי], at point shin (נקודת ש'). It is found, then, that the time of the displacement [העתקת] of the epicyclic orb's center from point gimel (ג') to point shin (ש') is the time in which the moon's center has moved [נעתק] from point vav (ו') to point shin (ש'). During those days the moon inscribes [חקק], within the [...] orb, the arc [קשת] [...] in the second-quarter [וברביעית השני]; and in the second-quarter of the days of the month the epicyclic orb has revolved as a whole until its center stations at point chet (נקודת ח'), and during those days the moon's revolution [is such] that its center stations at its perigee [בשפולו] [...] at point shin (ש'). And the moon's center itself [נמרכז הירח עצמו] inscribes [חקק] at point dalet (נקודת ד'), during these days, the arc [קשת] of 90° [90° = צ"פ]. So behold [הרי כך]: thus the moon [traverses] the whole oval [עגול] — this [path] [...]; for the moon does not rest [לא ינוח] according to the computation [reckoned] upon this line [קו] of the path, but [travels] only as in every month [twice], as will be explained near points shin (ש') and dalet (ד').

And the center of the moon itself [נמרכז הירח עצמו], at point dalet (ד') [...], inscribes [חקק] [its] arc; behold [הרי], then, [the moon's] center is an oval [עגול], not a true circle [recte], and it will be explained [...] how [it] is reckoned [לפי חשבון]. This [path], upon the line [קו] of [the epicycle's] path [מסלול], [happens] only twice [ב' פעמים] in each month, as will be explained near point dalet (ד'). It will also be explained [...] that the path [מסלול] of the moon's body [גוף הירח] is an oval [עגול דפ"ס], smaller [קטן יותר]; and this oval-path [מעגול מסלול] of the epicyclic orb [גלגל הקפה], both its breadth [רחבו] and its distance [ורחוקו], is unequal [אינו שוה] to [that of] the epicycle's path [מסלול גלגל הקפה], so that we are

compelled to seek for it a special center [מרכז מיוחד]. And when we seek it [וכשנידן], its center [is] at some point a' (נקודת א') [marked] in the figure [שבצורה], far and high [רחוק ולמעלה] in [or above] the center of the carrier orb [נושא], according to the diameter [קוטר] of the epicyclic orb. All these matters you will see in the figure [בצורה].

Siman 207 (סימן ר"י"ז) — that the moon's body, by [these] circles [עגולים], inscribes special figures [ומשולים מיוחדים]

[Full rubric:] **that the moon's body, by these circles [על ידי שה עגולים], inscribes special [figures] [משולים מיוחדים] which are entangled and confused [מסוכסכים ומבולבלים] exceedingly [מאד], so that for most of them there is no number** [אין מספר].

To understand [לדעת] all that we have explained above in this siman [בסי' זה], it is as if [the moon] is cast [וישלך כאילו הוא] [along these paths]. Were the time of the moon's revolution by means of the carrier orb [גלגל הנושא] equal to the time of the moon's revolution by means of its epicyclic orb [גלגל הקפתו] — [were] their times [made] equal — then the matter would be [as follows]: it would be found, in the model of our universe [בנידון דידן של עולם], that at every Rosh Chodesh [ר"ח] the moon would stand at the apogee [גובה רום] of the epicycle, and at every mid-month [אמצע חדש] at its perigee [שפל רוחו], and at every half-month [חצי חדש] [it would be] upon the epicycle's path [מסלול ההקפה]; nor would there be in this any difference [הבדל] between [one] month [and another] for all the days of the universe [כל ימי עולם].

But in truth it is not so, for the extra hours [השעות היתירות] found in the time of the moon's revolution in its epicyclic orb [סבוב הירח בגלגל הקפתו] over the time of the moon's revolution about the body of the universe [את הירח סבוב כדור העולם] — these are what cause [גורמים] the body of the moon [גוף הירח] to be found [sometimes] at the apogee [גובה החתו [recte: גובה רומו]] of the epicyclic orb at Rosh Chodesh [בר"ח], and sometimes at the perigee [בחצי [?]], and so on [וכן] for every day and every part [חלקי] of the month. And you should further know, from what was explained above, that the body of the moon [גוף הירח] is found to revolve [in] oval paths [עגולים מסלולים] — many [paths], indeed [most of] which [are so] numerous that they have no number [אין להם מספר] — for according to [...]

Section 8 (שער ח), continued

Siman 207 (continued) — the moon's oval path

[The page opens with the two marginal columns of Rashi-script gloss flanking the large circular diagram; the body text resumes beneath and around it.]

[Right marginal gloss, Rashi script:] As we explained above, when the moon's body is found at the apogee [גובה], whose place is as [described] above, the center of the carrier orb [גלגל הנושא] is aligned with the center of the second orb [?] at point ב. The radius of the epicycle [גלגל הקפה] is then equal to the radius of the carrier orb, so that the diameter of the epicycle is half the diameter of the carrier — and the whole place of the carrier orb [?] is thereby [established].

[Left marginal gloss, Rashi script:] Consider and know that, just as the moon's body is found higher at the apogee, as [shown] here at the point opposite the apex marked with the letter ע [?], by the measure of the radius of the carrier orb [?], so too the measure of the radius of the epicycle [גלגל הקפה] is added at point ב, as [shown] there [?].

Hence the moon traces an oval path [מסלול עגול], and the place of its apogee [גובה] is found to differ at every single new month — never twice the same. Were it not so, [the moon's true and mean positions would coincide]; and indeed the months of a [solar] year, and even the second and third [years], yield [different oval paths] [?]. Therefore this path is, as it were, an utterly tangled path [מסלול מבולבל], and from all this it becomes clear to you that the moon is [carried along] entangled, intertwined paths, as we explained above in siman [216 — printed קצ"י, read קצ"ז, by the dropped-yod convention][?]; and as [described].

Diagram. A large circle divided into the twelve zodiacal signs by twelve radial lines drawn from the center, each sector labeled at the outer rim with a Hebrew sign-name or its abbreviation. Within the band, four small epicyclic circles are drawn (at roughly the top, the right, the lower-left, and the bottom positions), each carrying a small circle (the moon's epicycle) whose moving point traces the dashed oval curve that runs around the figure between the zodiac rim and the center. The dashed line represents the moon's actual entangled oval path through the signs.

- Outer rim, top sector: שור [Shor — Taurus] (label reads שׁד/שור [?])
- Outer rim, clockwise from top, the readable zodiac labels: ב/ג [point letters within the epicyclets]; signs marked with their names around the wheel

- Top epicyclet: small circle with a moving point and a sign-letter שד [?] beside it
- Right epicyclet: carries point ד [dalet] on its small inner circle
- Lower-left epicyclet: carries point marked [?]
- Bottom epicyclet: plain circle (carrier) with the dashed path passing through it
- The dashed oval: the moon's traced path winding among the signs
- Central point: common center, with the twelve radii

[More than two labels here are uncertain]

[Bottom-right body text, beneath the diagram:] And so its rule [משפטו] [holds] for the whole upper [revolution] and for the whole circle of place and position [?]. [The moon's true place] differs at the apogee, and it traces an oval path [מסלול עגול], for by this [model] alone — and in no other way — were it possible to account for [the lunar motions] [?]; the heavenly bodies [are governed by] this. Likewise the third [motion] [?], and so on, as [the figure] shows, an oval path.

[Bottom-left body text:] [The moon at apogee] was never twice [the same], for its [position] varies; and all the days of the month, the moon [?] [is carried] along a tangled path [מסלול מבולבל], and the body [traces] innumerable oval paths, as we explained above in siman [קנ"א = 151][?].

Siman 208 [printed ריח] — The difference [parallax] between the line drawn from the center of the earth and the line drawn from the pupil of the observer's eye standing on the surface of the earth's globe

The difference [parallax]. There is a great difference between the line drawn from the center of the earth — extended up to the firmament [רקיע] — and the line drawn from the pupil of the eye of the observer standing on the surface of the earth's globe. The line drawn from the center of the earth, passing through the center of the moon's body and continuing up to the firmament, marks the moon's **true place** [מקום האמיתי] among the signs; whereas the line of sight [קו ההבטה] drawn from the pupil of the eye of the observer standing on the surface of the earth, passing through the center of the moon's body up to the firmament, gives a different **apparent place** [מקום הנראה] of the moon. To this [discrepancy] the Israelite [R. Yitzchak Israeli, *Yesod Olam* — attribution disputed][?] gave the name *parallax* [פרולאקסון], and in the Latin tongue it is called *parallaxis* [פרולאקס, Latin: *parallaxis*]; and so the wise have called it, to make it intelligible to students.

Likewise consider the fourth [circle] in the figure, an oval path [?]. Here is the figure: a quarter of the globe [as drawn], with the center marked ז [zayin], and [the points lettered] ד and ה around the arc [?]. The eye [of the observer] sees [the moon] from the surface of the earth at the place [marked], and [the line of sight] reaches the firmament at a point displaced from the [true place]. [See] there at the point רה"ו [?]. From the center of the earth the line passes through the center of the moon up to point [?], and that is line דה"ב [?].

The figure [explained]. I have drawn a fourth oval [quarter-]circle [רביעי עגול] so that the matter be illustrated to the eye for students [להבינו ל...]. Let the globe of the earth be the quarter-circle, its center being point ז [zayin], and let the eye [position be] point ה. We say, and let us picture: the line drawn from the center [ז] passes [up], and now the center of the moon is set there [?]; let it be line דה"ב [?]. It is [the moon's] place up to point ע [?]. From the center of the earth, line דה"ב is drawn out through the center of the moon and the firmament to point ב [bet], which is the true place among the signs; and the line of sight — which is the line [from the pupil] of the observer standing on the surface of the earth — points as though the moon were at point ל [lamed], which is a lower point of the firmament, nearer point ג and closer to the horizon [אופק].

[Body, left column:] As a general principle and a particular [one], know this: the change in the moon's apparent place [שינוי מראה הירח] [arises] from the [angle] [?]. The nearer [the line of sight] to the lower place and to the horizon, the more the arc of [the moon's] apparent [displacement] from its true place is enlarged; and the more its apparent [position] differs accordingly. By contrast, the higher [the moon] above the horizon, the more the arc of apparent change [שינוי מראהו] diminishes — until [the moon] reaches a place directly overhead [ממעל א'], the apogee [גובה הירח], directly above the horizon at ninety degrees [מעלות צ'], where this difference [parallax] ceases entirely. All this you will see plainly in the figure.

[Body, continuing:] As to all this — the astronomers [חכמי התכונה] took special care and were precise about the change in the moon's apparent place [specifically], and not about [that of the other bodies], because the moon is near the earth's globe; and there is a perceptible ratio [ערך ניכר] between the diameter of the earth and the [distance of the moon] [?]. The difference between the line drawn from the center of the earth and [the line drawn from the surface] of the earth's globe [matters here]. By contrast, with the sun [משא"כ בחמה] [?], the great height and remoteness of [the sun] are such that half the diameter of the earth is reckoned as nothing [אין] in the eyes [of the observer]; it is not a thing worth heeding. Nevertheless, know that even regarding the sun there is a [parallax];

and if someone says there is something to scrutinize even in the change of the sun's apparent place, [that is] a very fine and exact matter.

Diagram. A quarter-circle (one quadrant) illustrating lunar parallax. The vertical radius rises on the right from the center; the horizontal radius runs along the bottom; the curved arc joins their ends at the upper left. From the center two lines are drawn: one (the line from the earth's center) to a point high on the arc, the other (the line of sight from the observer on the surface) to a lower point on the arc, the gap between them being the parallax.

- א (top of the arc / firmament): true place direction
- ב (point on the arc): the moon's true place among the signs (line from earth's center)
- ג (lower point near the horizon): nearer the horizon
- ד (on the arc): point on the firmament [?]
- ה (lower right, the eye / observer's position on the surface): observer's eye
- ז (center of the quadrant): center of the earth
- ל (lower point of the arc): the moon's apparent place (line of sight from the eye)

Siman 209 [printed רי"ט] — The definition of the molad [conjunction], its essence, its time, and its cause; and the cause and time of its waxing and fullness; and [the reason for] the moon's deficiency [in light] on all the days of the month, and why it always appears [first]

He said: The writer [I] saw fit to explain here, for students, the definition of the molad [conjunction], its time and its cause, its waxing and its fullness, and the cause of the moon's deficiency [in light] on all the days of the month; and why the new moon always first appears at the start of the month, in the evening, low in the south-west; and why at the end of the month [the waning moon] is seen at dawn, low in the south-east [?]; the [reason for] the indentation of the moon and the turning of its horns [קרניו], sometimes facing east and sometimes facing west; and why day by day, from the start of the month [its light] keeps increasing up to mid-month, and from then on keeps diminishing until the end of the month; and why from the start of the month [it] remains above the horizon longer [past midnight] than the night before, until its end, [whereas after the full moon it rises later] than the night before, until close to its end; and why [the waning moon] is then seen near dawn [?], and not seen [as on] the other days of the month; and that the first thing one must know in order to understand the molad is the matter of time [?].

And this is the matter [of the molad]: When [the moon] revolves in its orb and approaches, drawing opposite the sun, until its center stands aligned directly beneath the center of the sun — at that moment, which is the end of the past month and the start of the coming month, at that time the moon's light is wholly hidden from our sight, for about one day before the molad and about one day after the molad, as will be explained. [So much for the definition.]

And now I will come to explain and give the reasons for all these changes mentioned. Know that the form of the moon is a globe — a body somewhat coarse [מעובה], somewhat resembling a reddish [?] [substance]; this reddishness is like polished copper [נחושת]. [The moon's body] is not [as] clear and pure as the heavenly bodies, like sapphire; and from itself it has no light at all, by clear proofs, as will be explained further ahead, at the head of the ninth section [שער ט], explicitly. The light by which the moon gives us light [?] is not from itself; rather, it comes only from the cause of the rays of the sun shining upon it, from which it receives radiance and light; and like a copper [mirror], it [in turn] emanates and sheds light to the inhabitants of the world. [The moon] is like the appearance of a casting of polished copper or steel [?], such that when you set it opposite the sun, the surface of that copper [reflects light]. Understand: to know [how it] sheds, emanates, and radiates light [from itself].

[The moon's body] is thus disposed to receive light from the sun in every place [it faces], on all its sides; for in every place [the sun's light strikes] it, the moon is illuminated and gives light. Therefore, since the moon's body is not [itself] clear and pure [as] the heavenly bodies are, it can receive and [reflect] light, [whereas] this moon [if it were clear] could not [hold] the light, and the rays [of the sun] could not [be retained] upon it [?]. For this reason its body is mentioned [as coarse]; and on this account it can give light to the inhabitants of the [world] [?] — because the rays of the sun [strike] it [?].

Half of the moon's globe — the half facing the sun — is illuminated; and the [observer below] sometimes sees the illuminated half. This is [the basis of the phases] [?]. According to the moon's distance [from the sun], so [much] of [its illuminated face] is seen by the inhabitants of the world. The nearer [the moon] is to the sun, the less of its light is shown to the inhabitants of the world, and [its visible light] diminishes; for from the start of the month its light keeps increasing and growing for the inhabitants [of the earth] up to mid-month, and from then on its light keeps decreasing until the end of the month, as will be explained.

Moreover, since these matters [need to be made] clear to students, I saw fit to draw a figure to make the matter visible to the eye. This is that figure: a spread

surface [שטח], [in which] the upper circle is the form of the sun [שמש], and the great lower circle [represents the field of view]; its center, as before [כקודמת], is [the earth], and within it is drawn the form of the moon's path [מסלול הירח], and the two of them [together represent] the [system]. To the pupil [point], from the surface of [?] [the earth], the eye of the observer looks from the surface of the earth and gazes upon the moon. Now we mark upon the line of this path a portion [קצת] [of it] [?] from the place [marked מחנה — "station"], and we begin to count the first [station], which is the place at the time of the molad — there where the moon is nearest, at the extreme of nearness to [the sun], the point directly beneath it [the dark point], where both [moon and sun] are aligned, one beneath the other; for then the sun shines [upon the moon's far half].

Diagram. A phase diagram. At the top, a circle inscribed שמש [Shemesh — the Sun]. From the sun, many straight rays descend over the figure. Around a large central circle (the moon's orbital path about the earth) are arranged the moon at successive stations of its monthly cycle, each drawn as a small disk half-shaded (black) and half-light, the shading turned to show the phase: at the bottom-center station the disk is dark (new moon / conjunction, the moon between earth and sun), and progressing around, the lit portion grows through the half-lit quarters to the fully lit disk opposite the sun (full moon), then wanes again. The shaded halves consistently face away from the sun; the lit halves face the sun. The inner circle is the earth's position / observer.

- Top: שמש [the Sun]
- Bottom-center small disk: fully dark — the moon at molad (conjunction), aligned beneath the sun
- Left and right mid-level disks: half-lit (the quarters)
- Upper disks flanking the sun: nearly full / crescent toward the sun
- Lowest disk opposite the sun [in the schematic placement]: the fully illuminated half toward the sun (full-moon phase)
- Central/inner circle: the earth and the observer's eye

[Body text below the diagram, spanning columns:] The moon's body is disposed to receive light from the sun on all its sides, in every place [the rays strike]; know, then, this — [that] when [the sun's] rays fall upon [the moon] [?]. From its [own] substance it is not clear and pure [as the heavens], on which account it is mentioned [as coarse]; for the rays of the sun cannot [be retained] upon a clear body — so that this moon could not [reflect light] [?]; and the matter [is so] because the [moon's] body is somewhat coarse, [enabling it] to receive light on its surface. Thus the whole half of the moon's surface facing the sun is illuminated,

and the [opposite] half facing away [from the sun] remains dark, receiving no light. The reverse of this [holds] when the moon [moves] to the extreme distance [from the sun] — that is, at the time of mid-month [the full moon], when the sun is in the west and the moon in the east and the earth between them. Then, too, the centers of the sun, moon, and earth are [aligned], one opposite the other, at the extreme of distance; and the rays of the sun shine upon the [whole near] half of the moon's globe [facing the earth], so that the inhabitants of the world [see its] whole illuminated disk. This [configuration of] sun [and moon] opposite one another the astronomers [חכמים] call **opposition** [נגד / ניגוד; printed ניגוד/ן"זח][?]. From the totality of these matters it will become clear to you that the two ray-lines [קוי הניצוצי] of the sun, issuing from it and from its bounds [גבוליה], and the two lines of sight [קוי ההבטה] issuing from the eye of the observer from point מ' [mem], at [the time of] opposition then [also reach] the moon's surface facing [the eye, namely] the illuminated half [?]. And at the moment of the molad it is exactly the same rule [as] [?], that the two ray-lines [draw near] and meet and touch one another. So too the two lines of sight at the time of the molad [?]. [And there is no need] for the two stations [מחנות] mentioned, since both are clear [?]; and all this is clear [in] this [figure]. [Further treatment of] the bounding lines [קוי הגבלות], to draw and turn [?] the bounding lines [continues].

[Right margin, bottom, Rashi-script:] [The bounds] — namely the lines of sight and the bounding lines, two [lines] visible [?], facing [?]; the eye [?] [?]; and [as for] all this here, you need to know [?] the secret of the bounding lines [סוד קוי הגבלות], to draw and to turn the lines [of] the bounds.

[NOTE: of this batch actually presents two folio sides; the column headed by folio סב continues the parallax/phase exposition and runs deep into the molad-visibility material. Transcribed below.]

[This dense column carries the continuation of the molad-and-phases discussion and a long detailed account of the moon's daily progress in light (the "fingers"/אצבע measure) and its rising/setting times. Heavily degraded; partially transcribed.]

The line of sight [קו ההבטה] [does] not [reach] [?]; the rays of the sun [fall] upon the moon's surface, [issuing] from point [מ'] on the surface [of the eye] [?] upon the moon's body; for as the lines multiply, [the figures] become entangled. [Thus] the forms would become [confused] were they drawn for all the other stations [מחנות]; therefore I have drawn for them only one station, [in fact] two — one [here] and [the other] [?]. Know that in the quarter [-month] — the fourth [station], which is for [the time of] the molad [?] — [the matter holds]. The rays of

the sun and the moon [?] meet [?], and the bounding [rays] from the moon [reach] one point upon [the moon], to be [a] point [of division] [?], which are the two ends of the diagonal [אלכסון א"ג][?], this being [the line] that bounds and divides. In this figure [it divides] the globe of the moon, [marking off] the illuminated [half] from the dark half [חצי הקודר].

It is thus found, in the [model], that the half-surface of the moon turned away, facing opposite the sun — that is the dark surface אכג"ה [?]; and its other half, which is the surface [facing the sun], is the illuminated surface אהג"ד [in the figure].

And when the line of sight [קו ההבטה] is drawn to the moon, from point מ' which is on the surface of the earth's globe — that is the pupil of the eye [אישון העין] in the figure, and that is line מ"ב [?] — [the two lines] meeting it at point ב and at point ד complete [the bounding]; the two ends of the diagonal ב"ד, which bounds and divides between [the moon's] half facing [the eye] — which is the surface כגז"ס [?] [facing] down — and its half facing downward, which is the surface בה"דא [?]. In this [case] its half facing downward is partly illuminated and partly dark, in such a manner that [of] the whole surface בה"דא [only part is seen] [?], and only the surface אב"ה [is illuminated], the lower [part]; and it is one-eighth part [חלק השמינית] [of the disk] [as drawn] in the figure.

And although this illuminated part appears below as a triangular surface [שטח כעין משולש] in the figure, [that is] only because it is impossible to draw the [curved] surface of the moon's globe simply, without dividing it. Picture it to yourself thus: as though a lower globe — or an apple [תפוח], [seen] from above downward — were [divided] into eight parts; then the eighth part appears to you as a part of the upper region [?], which is [drawn as] a triangle. And just as the rule [holds] in the fourth quarter of the month, so is the rule in the fourth [quarter — day 8 of the month][?]; for in the fourth [day] of the month, which is [about] day [3 or 8][?], we then see one quarter [רביעית] of the moon's surface, which is a fourth of its disk, in the figure. From this [the matter] is well disposed [in the figure].

And further, know this as a general rule: that on the [days flanking] the two quarters of the month — [the days] of the molad [?] — the bright [illuminated] part visible to us is always less than [a full quarter] by some part [?]; while on the two sides of opposition [צידי הנגוד], which is mid-month, [day 15], on the [days flanking it] [it exceeds a quarter] [?]; for the [bright part] of the radiant disk exceeds the dark [part] [?]; and the radiant [exceeds] the dark [more than] half against half [for us] [?].

[New paragraph:] For according to what has already been explained — that half the diameter [קוטר] of the firmament's globe is [the radius] above every horizon, namely 180 degrees [ק"פ מעלות] through which [the moon] revolves, [the degrees] of the orb [גלגל] being [360] — the moon, in its motion from the day of its molad up to the day of its fullness, [takes about] fifteen days [ט"ו יום]. Thus it covers about [180] of the orb's [degrees], that is twelve [degrees per day][?]; and so the moon's radiance increases [by] one part [each day] like [the rest] [?]. The fifteen [?] [...]

And the astronomers who measured [the surface] of the moon's globe have already divided the illuminated half-surface of the moon's globe into twelve parts [י"ב חלקים], and they call each part one "finger" [אצבע]; so [in] fifteen [?] [days] [...] one part — that is, the [measure] of its surface — is four-fifths of a finger [ארבע חומשי אצבע]; and so the moon's light increases day by day. Likewise the moon comes to be later in rising above the horizon, by about [a fixed amount] each day, [so that] it remains [longer] above the horizon than the night before [by] about [a measure]; and thirty-fifths of an hour [ל' חומשי שעה][?] — so that [...] the moon [stays] above the horizon longest of all the days of the month [at mid-month, day] [15][?], when it remains overhead about twelve hours [י"ב שעות], as will be explained. [...]

[A worked daily-rate computation follows, mostly degraded:] each of the [fifteen] days [...] of the month [...] four-fifths [of a finger] [...] in your hand [?]. And when these [are added up] [?] in [proper] order, I will explain to you the moon's waxing and waning. Let us begin its account [...] of the molad.

Know that, according to what has already been explained: at the close [of] every month, when the moon stands aligned beneath the sun, its dark [קודר] half then faces downward [toward the earth] and gives no light at all to the inhabitants of the world. Know, then, that from the time after the molad [...] the moon [appears] dark [...] after the molad [...] about [a few] hours [?]; for then it is seen [as a thin crescent] after sunset, low in the south-west, with a radiance and light like a very thin arc [קשת דק מאד]; and then, a short while after the sun's setting, the moon sets [too], following the [sun's] setting [...] beneath the western horizon at the start of the night [?]. [As] the moon moves away [...] from the sun [...] twelve [degrees] [?], by [the same amount] [as] [...] one-half of [?] [...]. From the half of the firmament's globe, then, the added light in it [...] more than [...] one part — its surface being four-fifths [of a finger][?] [...] like a [thin] finger as mentioned; and then the moon [is] later [in setting] than [...] one part [?] of [...] fifteen [...]. Then the [moon stays] up [...] twelve hours of the day, which are four-fifths [...]; and so

its rule [holds] [...] to return [eastward] toward [the east] and to move away from the sun by some twelve degrees [י"ב מעלות], and according to its receding from it, so its light increases [as it receives] more of its light from the sun, [setting] each day four-fifths of a finger [later] than the night before, beneath the horizon, [the reckoning being] near [a constant] through the eighth day [the close of the moon's first quarter][?].

As the moon recedes from its molad place by about ninety degrees [צ' מעלות], which is a quarter [of the circle] [חציו of the distance between east and west] [?], then half the moon's globe [...] faces the sun and is illuminated, and the inhabitants of the world then see [its half-lit disk] — that half being one-quarter [רביעית] of the whole globe of the moon, namely the [first-quarter] phase. The moon then remains above the horizon about six hours [ו' שעות] [?] until midnight, when it sets; and likewise its rule [from] the [first] quarter of the month onward [?]: that each night it adds [setting later by] four-fifths of a finger [ד' חומשי אצבע], to the [rising point] [?], [so that] by the [fifteenth] day, four-fifths of an hour [?] [...], when [the moon] recedes from the sun to the [extreme] of the firmament, namely 180 degrees [ק"פ מעלות] — which is the distance from the eastern edge to the western edge — then the sun and the moon stand opposed, aligned and parallel, one opposite the other; and that time the astronomers call **opposition** [נגד / ניגוד], and that is the full disk [as above].

The moon, illuminated [?], then remains above the horizon at its fullness for twelve full hours [י"ב שעות שלימות], the [span of] mid-month [וחציו]; and from then on, until the end of the month, the rule reverses: for just as the moon had been increasing its light, from now on it keeps decreasing; and just as it had been moving ahead of the sun and fleeing from it, from now on it pursues it and draws near to it. [So] each day [the moon] is later in rising above the horizon — rising after the start of the night by about four-fifths of an hour [?] [...]; and such is its rule on all the days, that it [rises] later than the night before by some thirty-fifths of an hour [ל' חומשי שעה][?], until [in] the third quarter of the month [?] the moon rises above the horizon at midnight. And as already [explained], one may measure [how far] the moon has [progressed] from the time of its molad up to the time of opposition: it adds light, each day, by four-fifths of a finger [ד' חומשי אצבע]; this [is the measure] from then on [?]; until four-fifths of a finger [...] it draws near [?] [...].

four-fifths of an hour. And as for all these matters [...] [there is] enough in your hand; I have [made] the account great [clear] [...] in your hand, by [the form] of its waxing and [the measure] of the molad.

Know that, according to what has already been explained: at the close, near [the time] when the moon stands aligned beneath the sun, then the moon's dark [קודר] half faces downward and gives no light at all to the inhabitants of the world. Know that, from the time after [the molad] [...] when the moon [emerges] [?] from [under] the [sun], it is seen [...] about [a number of] hours [?], for then [it appears] after the sun's setting, low in the south-west, with a radiance and light like a very thin arc [קשת דק מאד]; and then, a short while after the sun's setting, the moon sets [too], following the [sun's setting], beneath the western horizon at the start of the night. [As] the moon recedes from the sun [...] twelve degrees [...] eastward [...], by [the same] [...] of its surface; and as it recedes [...]. [Heavily degraded passage describing the daily increment of light by four-fifths of a finger and the daily delay in setting/rising.] [...] [the moon] then remains above the horizon longer than the night before by [...] thirty-fifths of an hour [ל' חומשי שעה][?], until the third quarter [...]; the moon [rises] above the horizon at midnight; and according to [the same measure] one reckons how far the moon has [moved] from its molad-time up to the opposition-time. It adds, each day, four-fifths of a finger [ד' חומשי אצבע] of light; this [is the measure] from then on [...] until four-fifths of a finger [...] near [...].

Section 8 (שער ח), continued

[Conclusion of siman 209 — the crescent's appearance and the turning of its horns]

until the moon's light wholly vanishes, when its number of days draws near to the next conjunction. So the month ends as it began — namely, with the moon being concealed from us [as a "hidden" body], as on the day of the conjunction. For from the molad until about 21 hours [printed כ"ט יום, but the sense is the interval after molad; see note] the moon is concealed from us — as will be explained later, in siman 213 [ריי"ג], in fractions [chalakim] of 793 and so forth. [?]

Near the end of its concealment, the new moon begins to appear to us once more, exactly as at the start [of the previous cycle], and not in any other way, just as we explained. For it is established that the body of the moon is a [non-luminous] sphere that has already received its light from the sun, as was made clear earlier. So at the moment the moon withdraws from the sun and departs from its [conjunction-]concealment, a portion of it becomes visible to us — that is, a sliver about four-fifths of a finger [אצבע] in width, or some other small fraction of the surface of one twenty-fourth part of the illuminated hemisphere of the sphere.

It is impossible for this small part to show itself to us except as an arc [קשת]. Take a ball or an apple and cover its entire surface with a thin layer; then, beginning to scrape it away from its top toward the bottom on both its sides, the scraped region, going up and down, is pointed [at its ends] toward the point [from which it began], and it will appear to you as an arc. So too with the moon: every part from which the light increases little by little, until it reaches the fourth [day] of the new month — at which point half the illuminated sphere becomes visible to us — appears in this manner [as an arc with two horns]. [Until then] none of it is visible to us except as a sliver or horns [קרניו].

Siman [marked here as part of the discussion] — why the moon's horns sometimes face one way, sometimes another

[The matter:] The notch [פגימה] of the moon — that is, its horns — sometimes faces west and sometimes faces east. The reason: at the start of the month, since the sun has only just set in the west and the moon still remains above it [above the horizon], the sun — which is below the western horizon — casts its rays upon the body of the moon from the side of the west. Because the convexity [the lit, bulging side] of the moon faces toward the sun, on the side of the sun, it follows of necessity that the notch and the horns of the moon face, and one sees the face of [the moon turned to], the **west**.

By contrast, after the middle of the month — when the sun has set and the moon, by then risen, stands above the eastern horizon before the sun rises in the morning, so that the sun's rays reach it from the east — the situation is reversed: now the arc of the moon's convexity faces toward the sun on the side of the east, and it follows of necessity that the notch and the horns of the moon face, and one sees the face of [the moon turned to], the **east**.

To this our Sages of blessed memory [Chazal] alluded in their fine phrasing when they said: "Never did [a man] see the notch [the deficient side] of the moon facing the sun." [Aramaic-Hebrew dictum; cf. the principle of the crescent's orientation — see Rosh Hashanah]

Siman 210 [סימן ר"י] — The shapes and measure of the great [waxing] moon, and its diminution and [the measure of] the hours [it] remains above the horizon all night

A practical aid for teaching the common people to recognize, at first glance, whether the moon is waxing [growing larger] or waning [diminishing].

I shall give it to the young students of our land, the children of the Talmud Torah, and to others, as a good sign for themselves [a mnemonic], and a charming one — as the wise have illustrated it. They [the children] should imagine, and it should be impressed upon them, that were their left hand long enough that they could stretch it out and reach all the way to the place of the moon, take hold of it, and feel within it the notch [פגימה] of the moon — then if the moon were still young, and so its notch were grasped by the right hand[-side], you should know that the moon is then still in the first half of the month [waxing]; and whenever it seems to them, as it were, that its notch is grasped by their **right** hand, then the moon is waxing and growing larger. But if it were grasped by the **left** hand, [the moon is] after the middle of the month [waning], and the moon is then waning and diminishing.

[Continuation of siman 210 — the great lunar wheel diagram]

and the measure of the hours [it] remains above the horizon all night.

Since the matters mentioned [are obscure] to the students, in order to render them more accessible — and out of love for the young — I have seen fit to set before you a single figure here, in which you will see, plainly to the eye, all the matters explained in siman 207 [כסי… 'ז'; printed letters garbled — read רז] above: how the moon, from the start of the month onward, goes and increases its light up to the middle of the month — at which point it is full and complete — and from then onward goes and diminishes its light. And upon every camp [מחנה — i.e., each ring-segment of the wheel] you will see the figure of the [light-]increase, and from the camps upward are marked the days of the month, and below [them] are marked how much is the measure and value of the moon's own light, together with the numbers of the hours and the fractions [chalakim] during which the moon remains above the horizon that night.

For example, in this [diagram], a circle marked with the letter **ת** [tav, = 400] indicates that on the eighth day after its molad the moon appears as in the figure before us, [shown] as a camp whose half is full of light; and in the circle below that camp is written the letter **יוד** [yod, = 10], indicating the hours [it remains above the horizon], and still below that is written the letter **ג** [gimel, = 3], indicating one-fifth [chumesh] of the hour. From this, know as a rule: that on the eighth [day], the moon's illuminated [surface] is 6 fingers [אצבעות] — which is half its surface — and a remainder of more than 86 [76 = ,ו"ע? printed ו"ע; read as fractions] two-fifths of a finger [?]. Likewise it is made known to you that the moon will then stand above the horizon that night for 6 hours and two-fifths of

an hour. And though the computation is close [approximate], for the truly precise reckoning [requires] many calculations, refinements, and conditions.

> [Note: the value "ע"ו (76) for fifths-of-a-finger reads oddly against "half its surface = 6 fingers"; transcribed as printed and flagged. See Numerical impossibles.]

Diagram, source PDF p. 126 — the great lunar phase wheel

Diagram. A large circular volvelle-style figure (a phase wheel). The **outermost ring** depicts the moon at successive phases as a series of small disks, progressing from a thin crescent through half, gibbous, and full, then back through gibbous, half, and crescent to dark — illustrating the waxing and waning of the moon across the month. Within this are several concentric ring-bands subdivided into compartments by radial lines; the inner bands carry Hebrew letters serving as numerals (day-of-month counts, the moon's light-value, hours above the horizon, and fractions). The center is blank. The compartments are read around the ring; the type is degraded and many inner labels are individually uncertain.

Readable / partially readable labels (positions around the wheel, from the textual key):

- Outer ring: phase-disks from new crescent → full → waning crescent (illustrative, no letters).
- Day-count band (upper arc): letters including [ה [4], ד [3], ג [2], ב [1], א [8] ח, [7] ז, [6] ו, [5]… continuing around. [several individually uncertain]
- "Light-value" band: includes ת [tav, used in the worked example for day 8].
- Hours band: includes יוד [yod = 10].
- Fifths-of-hour band: includes ג [gimel = 3].
- Central inner band: scattered letters, mostly illegible [?].

[More than two inner labels are illegible at this resolution]

Siman 211 [סימן ריא] — That the computations of the hours mentioned just above are exact only according to the reckoning of the seasonal [temporal] hours [שעות זמניות], and the reasons for the fixing of these hours

Know that all we explained just above regarding the [phase-]signs in siman 210 [ר"י], and in siman 210 [ר"י again; see note] — that the moon will remain above the horizon for such-and-such hours — this holds exactly only for the inhabitants of the [terrestrial] equator [קו השוה], who at the tekufah [equinox] points of Nisan

and Tishrei, and indeed for all the inhabitants of the climes, [have] always twelve hours of day and twelve hours of night, [under] the "upright" [equal] reckoning that holds for them all. But for any other [latitude] this is not so, for it cannot be; and it is impossible that one [single fixed figure] should suffice for all the months of the sun [the solar year], since the matter [varies]. For at the winter solstice [tekufat Tevet], the night for us, the inhabitants of Prague, is 16 hours [printed ט"יו; read 16 = ט"ז] [?]; whereas at the summer solstice [tekufat Tammuz] the moon will remain for us [above the horizon] only 8 hours, and not [a fixed amount].

We need not be exacting about the small surplus arising from the inclination [נטייה] of the moon's inclined orb, and the consequent [variation in] the moon's remaining above the horizon, for it cannot be that there would be two [equal values]. As you can yourself work out, if by our reckoning the moon should remain above the horizon for [say] 9 hours [על' מט' שעות; garbled — read = ט' 9?] [?] — how can this hold in this [winter] month, [when in summer] at the season of Tammuz the moon would not remain above the horizon for us more than 8 hours? Therefore know this, that [the figures] written [in the wheel hold for the equator]…

Siman 211 (continued) [סימן רי"ב] — [On the seasonal hours and the equal hours]

[Rashi-script / secondary discussion continues:] …[the moon's remaining above the horizon] for all the inhabitants of the world, [as] their nights are not all equal. For we did not divide the night [equally] in all months, nor [is there] any difference between [one] new moon and [another], nor between [one] season and [another], nor were their nights of equal [length]; nor, again, is there any difference between [one] country and [another] — long nights [in one place] — because all the computations mentioned are founded upon the seasonal and temporal hours [שעות זמניות], by which [reckoning] every single night throughout the year, and every day, is always divided into twelve equal parts [chalakim]; so the night of summer has twelve [long] hours and the night of winter twelve [short] hours.

And these seasonal hours would suffice for us — as we have already illustrated above for all the months of the year — if the moon were always [risen] above our horizon. But [in our worked figure] the moon rose above our horizon on the [day numbered] in the [diagram], [for] some 8 hours of the night, when the night's measure [in that month] is divided into twelve equal parts. Whereas if the night's measure were 15 [printed ט"ו] upright [equal] hours — as in the month of Tevet

— then the moon would remain above the horizon three "upright" [equal] hours [?]; and in the month of Tammuz, whose night-measure is [short], the moon would remain above the horizon [a different amount]. So that it [the seasonal-hour scheme] should suffice equally for all the months of the year, in any place whatever, we therefore needed a special table [לוח] for the reckoning of the upright [equal] hours for every month and every season of the year.

Siman 212 [סימן רי"ג] — The duration of the moon's concealment each month, [its] cause, and [the matter of] sighting and sanctification of the [new moon by the] court

The moon is concealed each month for about two days — that is, roughly [several] hours before the molad and likewise [several] hours after the molad — and therefore the moon is not visible every month except for about 26 days and a half. Know that this reckoning is not always exactly one and the same, for it has within it [variation in both] earliness and lateness of the sighting [ראיה]: sometimes the concealment turns out to be less than this, or 5 hours [more], or more than this — both before the molad and after it. For the interval between the moon's sighting and [the next] molad, computed by molad-to-molad according to the true reckoning [מהלך האמיתי], does not stand upon one [fixed figure], since there is in it earliness and lateness.

[This is] because there are found certain properties [סגולות] that lengthen and prolong [delay] the sighting, and there are other properties opposing them that shorten and hasten the sighting; and so [too], from the moment of the true molad. (R. Yitzchak Israeli [Yesod Olam] wrote this — at [reference] בת"גפט"ו [garbled folio/siman reference] [?].) The properties that abridge the limit of the sighting and bring it near, and hasten [the interval] from [the moment of true conjunction] to the moment [of visibility], are three:

The first is when the sun moves slowly and the moon swiftly; for thereby the moon can quickly draw far from the sun (as was explained in siman 70 [ע' — number uncertain] [?]). And it has already been made clear that the more they press apart from one another, the more [the sun] adds light to the moon. When the sun stands at the apogee [גובה — the high point] of its orb and the moon at the perigee [שפל] of its orb, the great distance between them — [the moon] being at the height of the firmament — makes [the crescent] appear and be discernible more readily to people. (See siman 2 [שני / קצ"ט — uncertain]) [?]

The second is when the molad occurs while the moon's inclined orb [is so positioned that] the moon is not delayed in setting, [for then] in that brief span

which it grants, the moon's light is set forth to our sight — that is, when the [moon's] setting is far removed from the place of the sun's setting, so that it [the moon] hastens to receive its light [longer before setting].

The third is when the moon is toward the north in the extremity of its latitude [מרחב] — its arc [קשת] being like a bow [קשת], that is, [a configuration of] greater latitude — which delays it [the moon] from setting after the sun. By this its [the crescent's] distance from the sun [grows] both in length and in breadth [latitude], and on the contrary the opposing properties [delay and] hide the moon's sighting. To this matter Chazal alluded at the beginning of the first chapter of Rosh Hashanah [רו"ל אמרו... ר"ה פ"ק; cf. Rosh Hashanah 20a–b], [sometimes the sighting comes] sometimes early, sometimes late, [variations] of small measure. (As above; from our root [reckoning] — siman 105 [ק"ה], chapter 1 [פ"א], and siman 278 [רע"ח]) [?]

[Conclusion:] Thus, **on account of the [changes in the] motions of the sun** (as above, siman 183 [קפ"ג] and siman... [תג / number uncertain] [?]), the time of the moon's concealment is shortened or lengthened, according to the [varying] motion of the moon (the precise figure as above, siman 199 [קצ"ט]):

- If the sun's motion is swift, [and] the moon will overtake it [reach elongation] swiftly, then the concealment-time is short.
- If the moon's motion is slow, the time of [its] concealment in its [position relative to the] sun will be long, since the moon does not overtake it [reach the requisite elongation] except after a long time.
- If both [sun and moon] move swiftly, the concealment-time will be short — but not as short as in the first case.
- If the motions of both are slow, the concealment-time will be long — but not as long as in the second case.

Know, then, that on this account [the interval] from the sighting of the [old] moon until the sighting of the new moon may be **40 days [ל"ט — read 40 = מ'? printed ל"ט] after the [last] complete day from the old molad** [?]; and know that all this which we have said is according to the true [reckoning], from the moment of the true molad up to the place of the sighting, and that the time of the sighting relative to them [observers] is close [reckoned] near to the time of the sun's setting. Therefore know that sometimes the concealment-time may end a short while after the sun's setting, so that it is found that the moon is not seen on the morrow after the sun's setting [until later].

The second molad is about **34 [ל"ד] full [days?]** after the [first] molad [printed כדי ל"ד; the sense is "by about 34 [hours]"] [?]; and after more than 34 [the relevant units] in which it was seen at the new moon [ר"ח], [the moon stands] close to four-fifths of a finger, and also [at] altitude **above the horizon more than 12 degrees [י"ב מעלות]**.

From the general principles we have mentioned, it becomes clear to you that it is possible for the [delaying] properties — those that delay and postpone the sighting of the moon, so that it is not seen until the fourth day [רביע• יום] after its molad — to gather together. (As in the *Sefer Tzuros* [ספר צורות], at the seam between siman 218 [רח"... — uncertain], where the gap between the two luminaries at the time of the sighting, in degrees of the zodiac, runs from a minimum of [some] degrees of the ecliptic [מישור] in a short time, up to 18 degrees [י"ח מעלות] in a long time, the median being 12 degrees [הבינוני י"ב מעלות].) [?]

Siman 213 [סימן רי"ד] — The measure of the lunar month, which is 29 days, 12 [hours], and 793 [chalakim], a thing unknown to us [in full precision]

Know that the measure of the moon[-month], from the moment it renews [conjunction] until it renews again a second time — [reckoned] by its mean motion [מהלך אמצעי] — is already, by the tradition of our forefathers [received] from us [i.e., handed to us], **29 days, 12 hours, and 793 chalakim of an hour [כ"ט יום י"ב שעות תשצ"ג חלקים]**. This is a deep and wonderfully precise computation, more exact than all the computations of the [other] astronomers, the ancients and the moderns; and the wise of [other] nations have already acknowledged it to us from days of old. I have expanded upon this in the *Sefer Me'or HaKatan* [my book "The Lesser Light"]...

[p. 128 — continuation of siman 213 / opening of siman 213 (continued)]

the gentile sages too, in their amazement at seeing [this figure]... [garbled] ...it is founded upon the wisdom of astronomy and the wisdom of the [mathematical] disciplines and the stars. The computation of the moladot rests upon [the figure] **29 [days], 12 [hours, 793 chalakim]**. And [where] it is unknown to us, or unknown whence this precise reckoning [comes], the [oral] tradition tells it to us [as a tradition].

This precise [figure] appears, upon study of the astronomical works, [to be] something received [as halacha to Moshe] from Sinai, like the rest of the

[traditional] matters found in the Mishnah and Baraita. [And] they bring a proof from the sighting [discussed at] Rosh Hashanah 25a [דר"ה דף כ"ה], [the case] there where Rabban Gamliel [רבן גמליאל] tested [the witnesses] with [the question] "did you see [the moon] as in this figure or that?" — [and the dictum:] "It [is shown] in the firmament [that the moon could be] seen [as a likeness of the moon on the 26th of the (lunar) month — ...נראה ברקיע כדמות לבנה בכ"ו לחדש בכ"ט לחדש]." [?]

The people supposed [it right] to declare the [new] month sanctified, [until] **Rabban Gamliel** said: "Thus I have received [as a tradition] from the house of my father's father: the renewal [renewal-cycle] of the moon is not less than **29 days and a half, and two hours, and 73 chalakim** [כ"ט יום ומחצה ושתי שעות וע"ג חלק]" [Rosh Hashanah 25a]. And though [some texts] read it [otherwise], the version that gives only "29 days and a half and two hours" — and does *not* [read] "73 chalakim" — is the [garbled] version [?], for the [correct] reading is 73 chalakim.

Likewise the [great] sage **R. Avraham ibn Ezra** [ראב"ע] brought it, in his great precision, in the chapter on the [New] Month [פ' החדש] in *Sefer HaIbbur* [ספר העבור — "Book of Intercalation"], [where] **R. Avraham the Nasi** [Abraham bar Hiyya, "the Nasi"] cites [it] — [though] in [his] *Sefer* [the Baraita] mentioned [reads] only "29 [days] and a half and two hours" alone, and *does not* mention the 73 chalakim. So too in the rest [of versions], as in *Pirkei de-Rabbi Eliezer* [פרקי ר"א], chapter 7 [פ"ז / פ"ו — uncertain], [the place] where it reckons that the great cycle of the moon returns [to its start] once in 21 years [כ"א שנה] [?], and in [other] minor compositions. [It holds:] the [moon's] great cycle returns, and at the head of every three-of-three [periods of] three years [the cycle of] the moon returns to the start of its renewal; and at the head of every small cycle of three years [it returns] to its start, so that all the [calendrical] computations may rise [come out] from the beginning [aligned]. [Yet] there is no exact precision [in those] except by the reckoning of the measure 29 days and a half and two hours — *without* the 73 chalakim being reckoned.

Also from the words of **the Ra'avad** [הראב"ד; R. Avraham ben David] it appears that he did *not* read "73 chalakim," for he wrote in his glosses [hasagot] upon **the Rambam** [הרמב"ם] of blessed memory, on the matter [parshat] of the count [reckoning], in *Sefer HaMitzvot* [ספר המצות], [at] mitzvah 153 [קנ"ג; printed קנ"ג]. And these are the words of **the Rav HaRambam**: "[This is] a matter received [transmitted] from Sinai for [counting] the months, the moon." Says the Ra'avad: [as to] what is not stated in the Gemara, nor mentioned in any place — [end of his words] — and had he [the Ra'avad] had the reading "73 chalakim" too, he would

have said [so]; [yet] he did *not* mention that this reckoning is found in its source in the Gemara in any place. From all this it appears that the true version [of the Baraita] is *not* [the one with chalakim]; [it gives] only "two hours and a half" [?], and what is printed in our books — "73 chalakim" — appears to be a version [introduced] by some scholarly disciple, his intention being for the good: to attune the precise reckoning [done] by the mean [motion] — which is conveyed to us by the arrangers [editors] of [the calendar] for us, [coming down] from R. Hillel the Nasi and his court — [a version] in which they added to the "two hours and a half" the "73 chalakim," so that [the sum] should come out to 793 [chalakim] in their composition [reckoning].

And I say further, that according to my humble opinion it cannot be that the figure should be there [in the original Baraita], **and I add** that Hillel's intention in the Baraita was [to point] toward the precise [mean-motion] reckoning of "29 [days], 12 [hours], 793 [chalakim]," which is always equal [uniform] every single month — because it is founded upon the reckoning of the mean motion, as the Rambam of blessed memory, and the Ra'avad, and the Israeli [R. Yitzchak Israeli] testified, as explained above in siman 212 [ר"ב; the missing-yod convention, = 212]. And [Hillel] did *not* speak by the mean reckoning — without doubt at all — for Rabban Gamliel's statement there was [made] by the *true* motion, [reckoned] from the moon's sighting, which goes precisely by the true motion, as the Rambam of blessed memory wrote in chapter 11 [פי"א] of *Hilchot Kiddush HaChodesh* [the Laws of Sanctifying the New Month], and as the sage **the Israeli** [wrote] in siman 11 [סי' י"א] of [his] third treatise [מאמר שלישי]. By this true reckoning, the measure of the months is not [uniform], as above in siman 199 [קצ"ט] — as Rabban Gamliel himself [taught] in [Rosh Hashanah] chapter 2 [פ"ב; the second perek] and said of the moon's motion that sometimes it comes [at] length and sometimes [at] brevity. From all these matters it appears that we have no proof at all for the precise reckoning of the moon's measure from the Baraita [of Rosh Hashanah].

Siman 213 (continued) [סימן רט"ו] — [On accepting the tradition of 29-12-793 even though it is not in the Gemara]

Yet it appears that although there is no complete [explicit] proof from the Baraita for accepting the above reckoning of 29 [days], 12 [hours], 793 [chalakim], and even though this received tradition is not mentioned in the Gemara in any place [as] in the words of the Ra'avad of blessed memory — Heaven forbid that we should deny it, for the reason that this reckoning is a tradition in our hands from our forefathers, and our forefathers from their forefathers, back to Mount Sinai.

To this inclines the view of the Rambam of blessed memory [too], who wrote in chapter 2 [פ"ב] of *Hilchot Kiddush HaChodesh*, [the laws] of [reckoning] 105 [מהלכות ק"ה], and these are his words: "[This] matter [is a] halacha to Moshe from Sinai — that in the time when there is no Sanhedrin established [to sanctify by] sighting, we reckon by this reckoning by which we reckon today" — end of his words. And what is not received [explicitly], let no man labor with any forced argument [to derive it] in the Talmud, since this matter is, without doubt, one of the foundations and roots of the secret of intercalation [סוד העיבור]. Therefore it was not given to be written in the Talmud at all — just as we find that in all the Talmud no [full] reckoning of the seasons [tekufot] and intercalations is set down, except for [the tekufah-reckoning of] Rav Adda, which is more accurate and truer than the tekufot of Shmuel. [Only] three times in the Talmud do we find the order of intercalation [referred to by the mnemonic] **גז"ח אדז"ט** [GaZ"Ch ADaZ"T — the leap-year sequence]; and many such matters the Sages knew but did not transmit, except to the ordained ones [the semuchim], and to singular pious individuals — to the great ones [generation by generation], as the Rav wrote — [those] of the [stature of the] prophets, and not to the rest of the common folk of Israel.

So too the Israeli, in chapter 15 [פ' ט"ו], [in the words of] "Thus says the Lord" [cited there]. We have expanded the explanation of this in our book *Me'or HaKatan*, in Section [שער] "The [New] Month," siman 15 [ט"ו], with God's help [בס"ד].

Siman 214 [סימן ריי"ו] — On which place on the earth the reckonings of the moladot and the tekufot were founded

Concerning the bases [the "heads" — the reference data] of the signs of the moladot of the moon, and likewise the bases of the signs of the tekufah of the sun, which have been mentioned to us [in tradition], Chazal have ruled for us [to consider]. We must take to heart and study and strive to understand — and to know upon which place on the earth the reckonings of the moladot and the tekufot were founded for us.

Now, from what follows [we learn this]: from the example that the molad of Tishrei came out for us at the midnight [midpoint] of the day [night] of Shabbat [the molad of Creation — BaHaRaD]. (Even though that one molad belongs to the whole world together, it nevertheless cannot be said that the molad's moment was at midnight of Shabbat-day in all the places of the earth's regions.) For it has already been made clear above, in siman 17 [ח"ז — read 17 = י"ז], that the start of the daytime for those dwelling at the eastern edge [of the inhabited world] is itself the start of the night for those dwelling at the western edge. Therefore let us

say, for the sake of argument [נ"ח, "for the sake of"], if you will: that molad mentioned [occurred] at midnight at the eastern edge.

Behold then, when it reaches the people of the west at midnight of Shabbat-day, [the time] has already passed and gone — twelve hours from the [original] moment of the molad. And if you say that this molad was here in Jerusalem [as the reference], then for all the places that are to its east, the moment of this molad fell for them *after* midnight, and all the places that are to its west, the moment of this molad fell for them *before* midnight of that day — even though in truth the molad is one [single] instant for them all, [yet] that [same] instant [falls] for some of them [before and after midnight]: for some, before midday; for some, after midday. Therefore some place was founded [chosen as the reference] from which [the molad's instant] was reckoned at midnight…

Section 8 (שער ח) — continued

[The siman opened in the prior batch concludes here.] On this matter no greater wonder can be raised. Chazal said [?]: there is a thing that one set aside for a fixed time — and it does not change [?]. So too [the obligation incumbent on Israel to guard their seasons — for the molad and the appearance of the crescent vary] depending on which reference place one chooses to compute the molad for, since the bow [horns] of the crescent change [?]. The visible appearance differs from place to place according to the width of the earth [latitude] and according to the lunar distance, and the appearance of the constellations from the line of the zodiac differs by the changes in its altitude — in length and in breadth — and according to its [the place's] elevation and depression and its atmosphere, and so forth. The Israelite scholar [R. Yitzchak Israeli, author of *Yesod Olam* — disputed attribution] applied himself to this, as is fitting, and elaborated upon it at length, in the seventh discourse [ma'amar], chapter [?] of his book, treatise four [?].

In truth this matter is great and exalted, wondrous and very deep — "Who can find it out?" [cf. Koheles 7:24]. The Israelite rabbi resolved it [?]. He went to great lengths in resolving this doubt, with both long, drawn-out arguments and short ones; but I have seen fit to bring up in my book only the gist of his intent, in brief.

The rabbi [R. Yitzchak Israeli], of blessed memory, said: Since our Sages of blessed memory established for us a fixed reckoning [keviut, the calendar], so that the days, nights, and all the seasons of the year should be perpetual for us — as explained above, Section 4, siman 103 — and they revealed it to us so that we might be guided by it [the molad and tekufah computations], it follows that, for those who dwell on the equator, where the day and night are always equal, the

reckoning is straightforward. Even so, in computing the tekufos and the moladot we generally rely on a single one of the fixed places on the equator [?]. But to know which place this is — the scholar contemplated this, and the aforementioned sage [R. Yitzchak Israeli] determined and decided it.

In his discussion — long and broad, by the science of astronomy — he set his investigation upon the determination of the place of the moon [?], and said that [the reference is] the navel [center] of the earth, which is the midpoint and center of the inhabited world, or the navel of the inhabited world [?]. The world was founded [?] upon the point that lies upon the equator, equally balanced between the eastern extremity and the western extremity, each of them ninety degrees away [from it] — as we explained above in Section 3, siman 89 [?]. This is the gist of his intent, of blessed memory. And until it becomes known to us, after his good resolution, we then accept his words.

He said: every person must reckon according to the proportion of his distance, in degrees, from the navel [?] — the molad-instant or the time of the tekufah where [he is], for some [places]:

> What the moon appears to be [doing] after its renewal — [it does not set] for the same place [?] always, but later in [each successive] place [?].

You may ask and say: Since the moon, between every molad and the molad [?], its whole orbit-and-renewal adds about thirty degrees on this account [?] — when it appears [?] upon the horizon, then it should follow that after the molad it comes later [?]. You would see it rise from the horizon by three degrees [?], and the third molad [?] [adds] sixty-three [?] degrees [?] — but the answer to this question is self-evident from what we explained above in Section 5, siman 128. The cause and reason is that every month one [new] constellation rises upon the horizon, just as the cause is also the same with the moon when we see this month's renewal [?]: for example, after its renewal [is] at the head of the constellation Aries, and the beginning of night then stood at the western horizon, by three degrees [?] — since it [the moon] traversed against [?] the zodiacal sphere more than a complete revolution, by about thirty degrees [?] — then in the second month [it adds] about thirty degrees. If it [the moon] was first seen at the head of the constellation [Aries] at thirty degrees [?], then it will be seen [?] at a place [?] — at the head of Aries three degrees above the horizon, in the manner of three degrees above the horizon. At the head of the constellation Taurus [it appears] likewise by three degrees [?], in the manner by which the moon renews itself and is seen again after each renewal, year by year, throughout the twelve constellations of the firmament.

Siman 216 [printed: רי״ז] — That no star whatsoever circles [in the time of] a complete revolution in the time of [one] revolution of the diurnal sphere

Know that you will not find any star whatsoever — even among the stars of the spheres of the constellations [the fixed stars] — that circles the globe of the world in the time of a complete revolution of the diurnal sphere; for the diurnal sphere is to the world like a "rider" [?] over it [?], in that the diurnal sphere carries the globe of the world a complete revolution before the light of any star can circle it. We have already explained this matter — at the end of Section 4, siman 106 [?] — concerning the backwardness and the deficiency, and a fortiori the greatest [delay] in the circuit of any star: it is so with the moon, which itself does not circle the globe of the world in the time of [one] revolution of the diurnal sphere; rather it falls short of [a complete circuit] by about twelve constellations [?], because in the twenty-four hours in which the diurnal sphere carries the moon's sphere from east to west by the necessary [forced] motion around the globe of the world, in that same time the moon's sphere itself circles by its own voluntary motion from west to east — the opposite of the upper [diurnal] motion — by about twelve degrees. Hence the moon remains above the horizon higher [?] than it was on the preceding day by about twelve degrees, more than the height of [what it was] the day before. So it has been explained above, in siman 209 [printed: ר״ט], that the deficiency that accrues to it [?] is twelve degrees, which accumulate [?] every day and on every day of the months of the year, in such a manner that the moon's sphere circles, each month, 360 degrees of the sun's [path]; in every month of thirty-one [?] days [?] — the aforementioned deficiency, which we lacked [?]; it [the moon] exceeds more than any other star because of the swiftnesses and rapidnesses [?] of the voluntary motions.

The deficiency and backwardness in the circuit of the sun [the solar sphere] we have already explained above at the end of Section 30 [?], that it is no more than [the residue we wrote] above; that it is one [degree] less by [the magnitude of] the sphere itself [?]. The smallest deficiency among any star of the seven heavens belongs to the star Saturn [Shabbatai], and that is by [reason of] the slowness of its motion — that it [its deficiency] does not reach [?]. Nor does any star of the sphere of the constellations [the fixed stars] go around to its endpoint [?]; it does not orbit a complete [revolution]. But this deficiency is exceedingly small and trifling, like one part of a thousand of a degree [?]; the senses do not perceive it at all.

Siman 217 [printed: רי״ח] — To make the voluntary motion perceptible in all seven of the wandering stars [planets]

The proof for the eastward motion that belongs to the moon's sphere [is] not [hard to demonstrate], for even our villagers and the rustics of our land perceive it. According to the general principles that we [stated] above, near siman 29 [?], you will see eye-to-eye that it [the moon] is a circler [?], as is necessarily demonstrated to anyone learned [?], by about twelve degrees a day. But to make perceptible to the senses the voluntary motion of the other wandering stars [planets], explanation is required. Therefore I will reveal to you one method by which you can perceive their voluntary motion with the senses, as follows.

You already know that all the stars of Saturn [Shabbatai], on account of the great heaviness and the slowness, sluggishness, and quietness [of their motion], appear forever and always [?] as if their circuit is in the sphere of the constellations [the fixed stars]; for —

— [their motion] for a few years scarcely [?] amounts to anything [?]. Now, [if] you seek to perceive with the senses the voluntary motions of one of the wandering stars [planets], take to you [the following]:

[Gloss / instructional rubric:] **A method, that you may seek to examine and to perceive with the senses the voluntary motions** of, say, the planet Mars: take you the magnitude [?] of one [other] star, and observe and measure the distance that lies between them [?]. Look well [?] at the planet Mars and at some other star [?] near it, on the night [?] of the first [?], second, third, and fourth [days?]. If the planet Mars is east of [?] the [reference] star [?], then you will see [?] that it [Mars] has a surplus [?] between them [?]; the next day [you will see] that the planet Mars has circled toward [?] the customary path of return [?], and increased its distance [?] from the fixed [reference] star [?] in its eastward motion [?], day by day. And if the planet Mars is west [?] of the [reference] star [?] [then the situation is reversed]: the distance between them will diminish and grow less in its [Mars's] motion, until the planet Mars draws near again [?] and returns to its [former] place relative to the fixed [reference] star [?]. By means of these [observations], in a few days, joined to the degrees of arc [?] — which one easily reckons [?] with a quadrant instrument [רובע], which I am destined [?] to teach you of in Section 18, siman 264 [?] —

You should know that at the time when the sun is below the horizon [at night?], no star whatsoever appears [?]. [In order] that the voluntary motion of one [planet] become known to you, the matter [follows] thus: take you one of the stars

[?] and [observe?] [Mars], which [?] [in the case of?] the [planet] returning [?] and rising [?] high above the western horizon [?] at the onset of Sabbath [?]; observe it again on the night [?] of the second, third, and fourth [days], and you will find [?] that its altitude goes on increasing [?] and adds nearly one degree each day. Then take you [a star] that is at the end [?] of the night [?]; observe and note its altitude [?] above the eastern horizon. Observe it again on the night [?] of the second, third, and fourth [days], and you will find [?] that its altitude does not [increase?] but rather draws near [diminishes?] [by] nearly one degree each day. This [is governed by] the proper [intrinsic] motion of the sun, which circles [?] every day nearly one degree [?] — that is, when in the month of Nisan the sun rises [?] upon the horizon [together?] with the head of the constellation Aries [?], and in the month of Iyar [it returns?] with the head of [Taurus?], as has been explained above in Section 5, siman 130 [printed: ק"ל]. This teaches that no fixed [reference] star [?] orbits [?] and shifts [?] from its place [?], for we have already established [?] that the circuits of the stars of Saturn [Shabbatai] are slow [?]. Beyond this [?] it is not possible [?] — to say that there are stars of this kind that have motions according to the measure [?] of each star. So [the planets] cannot be found [?] [moving] like this [?], [each with its] own special [path?].

Siman 218 [printed: ר״ט] — [The objection] that no eccentric sphere [galgal yotzei merkaz] nor epicyclic sphere [galgal hakafah] is found, and no opposing motion [?]

Know that the ancient sky-sages [astronomers] [?], among the men of antiquity who came before [?], who probed deeply and embedded themselves [?] in the science of the stars, and computed and reckoned [their] hosts [?], and filled their hearts to take up the fundamental principles and the foundation [?] — and they ruled the names [?] — and the rest [of them] — Ptolemy [בטולמיא"ס, Ptolemy] and Avrani"s [אברני״ס = ? possibly al-Battani or Apollonius — flag] and others — these scholars said and ruled that no eccentric sphere [galgal yotzei merkaz] whatsoever is found, nor any epicyclic sphere [galgal hakafah], and that there exist in the world only nine spheres alone [?], and that no opposing [contrary] motion is found. They gave a reason and rationale for their words, saying that the motion of all the spheres is by themselves [?] essentially [?]; that they [the spheres] all revolve [?].

In the firmament [?] that we see [?] — the diurnal motion [moving] westward [?] every day, the moon falls short [?] more [?] than [the rest?] [?] on the line [meridian?] [?] of [its motion] by twelve degrees [?]; only [?], according to their reasoning, the moon's rising against [?] the east [?] [is] by twelve degrees [?] [is]

not [accepted?] [?]. So they held [?] that the moon, in its circuit from east to west, in order to complete a single circuit [hakafah] from moment to moment [in 24 hours], falls short [?] by twelve degrees from moment to moment [?] — [namely] that it did not move [an] opposing [contrary] motion. So too what they say [?] [is] that the sun, [in] its completing [?] each day [?] [a deficiency?] [is by reason] — if so, this [too] is from [the same cause?] [?]; that its sphere is encompassed [?] westward [?], and it [the moon] is faster [?] in motion by an adjacent [?] motion, in such a manner [that] it [?] is faster [?] [in] its daily circuit [?] [as] explained above near [?] [siman ?].

It is the eighth [sphere] [?], and so too the ninth above it [?]; thus they say [that] this eighth sphere is [the very same one] above which [?] is faster [in motion] than [all] the rest. In such a manner [it is] faster in its motion than all the [lower?] spheres bound beneath it [?], in such a manner that they [?] make one circuit [hakafah] each day [?] westward [?] [whereas] there is less by a trifling amount, [so small] that it is not noticeable [?] — until [the residue] amounts [?] over the course of [?] a hundred or seventy years [?] to a [perceptible] degree [?], as the [astronomers] of [past?] generations [?] drew up [?]. And so the law [holds]: that you should know [?] that every day [?] the rest of the [other?] spheres [?] [circle?] [?] in general [?]. So too you should know that, according to their reasoning, the proximity [?] of each sphere [?] to the diurnal sphere [?] — the closer [?] [a sphere is to the diurnal sphere], the faster [?] it is found to be in its motion, in the manner [?] that when [?] [the residue?] [?] [it is] a complete sphere [?] [?]. [And the lowest sphere] is faster in its motion than all the [other] spheres; and the moon [?], being the most distant of all the spheres [?] [actually?] [...] I have to attribute to it [?] [?] a delay [?], and slower in its motion than all the rest of the spheres [?].

This matter was already mentioned [?] by the Israelite [R. Yitzchak Israeli] in his book, treatise 2, chapter 19 [מ"ב פי"ט — *Yesod Olam*, ma'amar 2, ch. 19], with great alarm [?]. He attributes the proof [maaseh, "the construction"?] to one sage [?] — [people] heard of him and called him a man [who is "a great noise" / "earth-shaker," i.e. a man of renown] [?] — and his name [?]. He lived in the year 7[?]11 [?] of Creation [?].

[Gloss:] I heard from the mouth of the master Kepler [קעפלירוס, Johannes Kepler] that the sages of antiquity held [this view] [?]; that he [this sage] lived before Avraghu"s [אברכו״ס = Hipparchus] and before Ptolemy [בטולמיי"וס]; and this is more than a thousand years [?] [earlier] — for from the great antiquity of their precedence [?] it was not known to you [?]; according to their reasoning [?]. So too

you will see [?] that our villagers [?] — that he died [?] [?] in his investigation [?]; that even our villagers [?], when they look [?], it appears to them above the horizon [?] [...] more particularly [?] — they did not reckon [?] on an opposing [contrary] motion at all [?]; rather they reasoned [?] that the moon completed [?] its circuit [?] around [?] only from point to point [?]: each day [?] it removes itself [?] from its [the moon's?] [position] [?]; thus it distanced itself [?] from its original place [?].

These aforementioned scholars — [namely] Ptolemy [בטולמיא"וס] and the [other] sages who hold that the diurnal sphere is the [primum] mobile [?] of the world [?], and that the twelve [?] [signs] are also [carried?] [?]; together with [?] the [sphere of the] planets [?] [...] in such a manner that the diurnal sphere has one [proper] motion of its own [?] [...] toward [?] [the east?] [?], and the [seven] wandering stars [planets] [each have] their [own?] motion [?] [...] [and so the spheres] all [face?] toward the west [?]. So too [?] they agree [?] that nine spheres are found, [as stated] above [?], whose center is the center of the earth [?], and each one of them has a motion [?] new [?] [?] by its own self [?].

According to their view — according to the view of the Israelite [R. Yitzchak Israeli] — there are found, for each and every one of the six [?] spheres of the [seven?] wandering stars [planets], its own special [?] poles [?] [...] [The galgal hakafah / eccentric] — its poles are not [aligned with] the poles of the uppermost sphere [?], nor [aligned with] this pole of the zodiacal sphere [?], nor is this pole aligned with the pole [...] [Rather, only?] the poles of the sun's sphere alone are aligned [...] [the poles of?] these [?] [planets?] [...] are aligned [?] with [?] [...] [whereas] this one [?] [...] is not aligned with the pole [?] of [its sphere's?] [?] form [?]. According to this view it necessarily follows that each [sphere] is "engraved" [set] [?] within six poles [?] — a circular line [?] around the pole of the seventh [?] sphere, and the ninth sphere [?] circles it [?]; which descends [?] by the force of the strong diurnal sphere [?] [...] sometimes [?] [...] [the cause is] [?] the diurnal [sphere] [?] [...].

— and the [moon's?] sphere [?] [...] also [?] [...] [it is moved?] sometimes northward and sometimes southward, together with [?] [its drawing?] [the moon?] [...] toward the globe [body] of the earth [?]; and when the matter is [thus?] [...] we will not need [to posit] any eccentric sphere [galgal yotzei merkaz] or epicyclic sphere [galgal hakafah] at all.

But by this path, when we wish to weigh [?], the view of Ptolemy [בטולמיא"ס] and the ancient sages is the more acceptable and the more correct [?] to accept, for it is [the path] more [?] [...] To say that the spheres are nine alone, against [?] all the

[?] motions [?] that appear in the firmament — and they are [all] possible [?] to cross over [?] [?], all of them upon nine [?] [...]. We will posit [?] a single point [?], which is the center of the earth [?], and around it [?] [...] [each] sphere for each star [?] [...]; and they do not all move [?] to one side [?], nor do they all conduct themselves by one [path?] [...] and not around a fixed center [?], but rather each [...] this sphere has [?] [a center?] [...]; and the center of the world [?] [...] this sphere has [?] [a center?] [...]. These are the things [matters] upon which the First One [HaKadosh Baruch Hu] [?] leans [established?] all [of them].

The Israelite [R. Yitzchak Israeli] further wrote, in the aforementioned section, that these [astronomers] [?] [who] sent forth [?] their hand [?] — the aforementioned [scholars] [?] [accomplished?] their deeds [?] — gave a sound reason [?] for each one [?] of the variations [?] and the changes [?] that are seen [?] in the stars at all times [?], and [for] the cause of the eclipses [lekuyim] and all their laws [?], just as Ptolemy [בטולמיא"ס] did [?]. And every doubt [?] [—] [yet] the scholars who were [?] inclined [?] to their [view?] [?] would listen to them [?]; but afterward [?] [it appears] that the matter [?] is not [as supposed?] [?] [...] — either because his [own] hand [?] fell short [?] of completing [?] [the demonstration] as is fitting [?], or [because] [their?] [...] were [?] [...], or because the time did not suffice for them [?] to clarify it [?]. They [therefore] did not [conclude?] thus [?]; nor were they assisted [?] [by what would] nullify [?] their [own?] deeds [?]. Therefore [?] let us [?] [set aside?] [?] their proof [?] [...] and return to listen [?], all and entirely [?] [?], to the path [view] of Ptolemy [בשולמיא"ס] and to those who walk in his footsteps [?] [...] [who] clarified [?] [the matter?] [...] [with] sound and clear reasons [?]. Thus far [is the matter?] — [from the Israelite].

> Praise to the God, the Refuge of my strength, my Shield and my Shelter. ✻
> [פצל את — flag: a doxological line, partly damaged]

Siman 219 [printed: ריי״ט — see anomaly: repeated numeral] — How much higher [farther] is the moon's altitude from the center of the earth, and the author's [account] of the difference between its nearness and its distance from it

Know how much the moon's altitude is from the center of the earth, and [how to] distinguish [?] between this its altitude — [whether it is at its] apogee [highest point], its perigee [lowest point], and the difference that exists [between them].

Know that this matter depends on the thickness [?] or [the breadth?] of the breadth of its sphere [?]. There is great dispute and [divergence of] views [on it] among the ancient sages [?]. For according to the view of Rosh [?] — that is, R.

[Chai?] [?] — who is foremost [?] among those who treated [?] [these matters] in astronomy, as is [explained?] in my book *[Me'or HaKatan]* [?] — they wrote that the moon's altitude from the center of the earth is fifty thousand and four [?] *kanim* [reeds; a *kaneh* = a unit of measure], and the utmost limit [?] [is] thirty-three [?] thousand [?] *kanim*. [The measure of] the *kaneh* is as is known [?] — [equal to] half the thickness [diameter] of the earth's body, that is, [from] the center of the earth [out] to [its surface] [?], which [is the altitude] [...] approximately [?]. If so, then for me [the difference] between the moon's distance from the center of the earth [at apogee] and its nearness [at perigee] is thirty-one [?] thousand *kanim*, and that is the measure of the radius [diameter?] of its epicycle [hakafah], according to his view [?].

According to the view and investigation of the scholar Nicolaus [ניקלא"וש = **Nicolaus Copernicus** — confirms "Nicolaus" and the "Copernicus" (קופערני"קוס) named just below are one and the same person, not two authorities], in Section [?] [?] [...] the moon's altitude from the center of the earth [?] [is such that] the difference [?] is found [to be...] *kanim* [?]; and according to his view they are sixteen *kanim* [?] [...]. And for his precise investigation, the great inquirer Tycho [טיח"א ברא"הי, Tycho Brahe] [?] found that the moon's altitude from the center of the earth [...] [and] its nearness [is] 22 [?]; whence I find, in my opinion, that the difference between the [two figures] mentioned for [its] nearness and distance is no more than eight *kanim* [?].

According to the view of Copernicus [קופערני"קוס], the difference between [its] nearness and distance is found to be no more than about half the difference [given] in the view of Ptolemy [בטולמיא"ס]; and the difference, according to the view of Tycho Brahe [טיח"א בראה"י], is no more than [about] half the difference [given] in [Ptolemy's] view [?]. The fourth part [?] [is the view] of Copernicus [פעדני"קום] [recte: קופערני"קוס], and the view of Ptolemy [בטולמיא"וס] — and I myself [the author] write [?]: I heard from the mouth of the great scholar Tycho Brahe [טיח"א בראה"י], that according to a proof [mofet] [...] from his measurement and investigations he said [it is] better [?] and [more] reasonable [tov ta'am] [...] that it is impossible to believe [?] that there should be so great a difference, of about fifty thousand [?] *kanim*, between the two [extreme] distances. For if it were so, it would follow that the moon, when at its perigee [bashefel], would appear larger [?] [in size] than when it is at [...] — larger by [...] [?].

Section 9 (השער התשיעי) — The Ninth Section

In it is explained the matter of the darkening of the eclipses of the sun and moon, and the things that cause them, and that the eclipse of the sun appears in one place in its entirety, in another place in part, and in [yet] another place not at all [it is hidden]. [It explains] all of these together with the principles and foundations particular to them.

After we explained above the motions of the two great luminaries [Bereshis 1:16], let us [now] explain the cause of the [astronomical] matters that cause the moon, during certain months, at the time of opposition [niggud, full moon] — when it [the moon] is [normally] in its [fully illuminated] form and its light is brilliant — and likewise at times, at the time of the molad, the moon to be hidden [eclipsed] from the sun, so that its [the sun's] light is [withheld] from the eyes of part of the inhabitants of the world [?]. All these matters are called, in our holy tongue, *kadrut* [darkening], from the language of Scripture: "all the bright lights of heaven [I will make dark] over you" (Yechezkel 32:8); "[the sun and moon] shall be darkened" (Yoel 4:15); and "the moon and its lights [?]" [Yeshayahu 13:10 — context: "the sun shall be darkened"]; and the eclipse is called by the term *likui* [defect/eclipse], from the two names [?].

The cause of the moon's *kadrut* [eclipse] is already explained [?] and more obvious [?] and simpler [?] than the *kadrut* [eclipse] of the sun [?], for [its] darkening [?] is [an outcome] of [its position?] relative [?] to the sun [?]. Moreover, the moon has no darkening in itself [?], for its light [?] [is borrowed] from the sun [?] — its light truly comes from it [the sun]. This is unlike the sun, whose light [is intrinsic and] is never extinguished, nor does it cease from the sun itself for all the days of the world; rather, [the sun's eclipse occurs] only [from?] the cause that the moon stands and interposes between the sun and our eyes, and then it darkens [it] for us, just as will be explained.

[Continuation, top of Section 9 text:] [...] is already explained and very obvious [?]. Because the body of the moon is by its nature dark and has in it no light by its own essence — but [is] like a body that has the color of redness [?], its own side [being dark] — it receives only [?] from outside [?], [as] the sun, which is dazzling [?], when its [the moon's] body [?] [is rendered] like cast iron or polished copper [?], such that when you set [?] [it] facing the sun, light [?] goes out from it [is reflected from it]. This is its light. Now let me make it known to you, from two [given] facts [?]: the one, that the moon takes its light [from the sun] from its [the month's] beginning [?], and goes on [increasing] up to the middle of the [lunar]

month; and from then onward its light goes on diminishing [?] until the light is severed [?] from it entirely, as was explained above in siman 219 [printed: ר"ט — see anomaly] [?]. The second consideration — concerning the [solar] eclipse, which will be explained [later] [?]:

Now you should understand: when the moon is opposite the sun, and the earth [is between them] [?] — then either there will be between them [the sun and moon] [the body of the moon?] [?], or the body of the earth [as] an interposing screen [chotzetz].

[The case of the solar eclipse:] When the moon is between the sun and the earth, in such a way that by the cause of this interposition of the moon [?] the sun is unable [?] to cast [?] its light upon the moon [the earth-ward observers?] — for it [the sun] is hidden [?] [—] then the sun, by the cause of the earth's interposition [recte: the moon's interposition], [is] therefore [seen] in its *kadrut* [darkened state], as in the rest of its darkenings. This is called, according to the [astronomers], the *likui* [eclipse] of the sun. And this [the solar eclipse] occurs only at the time when the sun and moon are conjoined [?] and aligned, this one opposite [next to?] that one [?] — and this is specifically at the time of [the conjunction] in the middle [?] of the lunar month [i.e. at the molad], the time which the [astronomers] call the opposition [recte: conjunction], as [explained] above in siman 219 [printed: ר"ט — anomaly]. This is the matter [reason] of the *kadrut* [eclipse] of the moon — [thus] the general rule of the matter [?].

And then the form [?] of [...] [?] [the eclipse?] of the moon [?] [...].

Siman 221 [printed: רפ"א — see anomaly: should be רכ"א] — By which the moon is eclipsed [?], and [its light] diminishes [?] and is withdrawn [?]

We explained above, in siman 104 [printed: ק"ד], that after the setting of the sun [?] [...] a [cone?] of shadow [tzel] [?] is [cast] upon the earth [?] [...], [shaped] like a cap [?] [pointed]. Were the body [globe] of the earth larger than the body of the sun, then the earth's shadow would be larger than the body of the earth itself; and were the body of the earth equal in its magnitude to the body of the sun, then the earth's shadow would be equal to the magnitude of the body of the earth, going on at an equal measure [a cylinder of constant width] up to the sphere of the constellations [reaching to infinity?]. In that case the moon would be eclipsed not only at the middle of the month [full moon] but also before the middle and after the middle. But because it has already been demonstrated to the sages by clear [?] proofs that the sun's diameter is longer than the earth's diameter by five

and a half times, as will be explained [further] on — by reason of this it necessarily follows that the sun shines upon [more than] half the globe of the earth [?], illuminating [?] toward the sun [?] and around it on all four of its sides [?]; in such a manner that, by the cause of the sun's largeness relative to the smallness of the globe of the earth [?], the earth's shadow goes on [tapering] and diminishing to a point [pointed cone], until it returns to a single point — which is point א [aleph] [the cone's apex] [?]. And the astronomers determined [?] that the shadow [cone] is entirely annulled [vanishes] there [at point א].

Diagram. A geometric figure illustrating the earth's shadow-cone and a lunar eclipse. At lower left a small circle represents the sun (or its body), from which two straight tangent lines run rightward and converge to a sharp point at the right, forming the long tapering shadow-cone; a small circle on the cone's axis represents the globe of the earth, and the dark wedge-shaped cone narrows to its apex. An outer circle (the moon's sphere/orbit) frames the construction, with the moon's transit through the shadow shown as an arc. Several point-labels are placed along the axis and at the cone's bounding lines.

- א (apex of the shadow-cone, at right): aleph — the single point at which the earth's shadow vanishes
- ב (on the axis, at the earth's center): bet — center of the earth [?]
- ג (where the shadow ends / on the bounding line): gimel — terminus of the shadow [?]
- ד (on a bounding line of the cone): dalet [?]
- ה (on a bounding line of the cone): heh [?]
- ו (on the sun-side bounding line): vav [?]
- ח (on the moon's-transit arc): chet [?]
- ט (on the moon's-transit arc): tet [?]
- Axis line א-ב-ג [aleph-bet-gimel]: the "column of the upright" (the axis through sun-center and earth-center to the cone's apex)
- Arc ח-ט [chet-tet]: the moon's passage through the shadow
- Triangle ג-ד-ה [gimel-dalet-heh]: bounds half the earth's globe together with the shadow-cone

[The geometry of the shadow-cone, with reference to the diagram:] It [the shadow-cone] passes through the thickness [shell] of the elemental world [the sublunar sphere] and through the thickness of the moon's sphere [?] and the thickness of the star [planet?] sphere, and enters into [the shell] of the third [?] sphere [?]. And at the entry [?] of the moon into this shadow, the moon falls into

this measure of the shadow's length [?] — and the astronomers gave this shadow [cone] [as reaching] up to its endpoint [apex] at [a distance from?] the earth [?]; that the astronomers measured [?] [its] length [?] [...] [Their] measurement [is that it equals?] ≈148 (קמ"ח) [recte: first-pass "256" rejected — the leading letter is ק (100, not ר (200); middle letters degraded, so ≈148 with the units uncertain] [...] half the diameter of the earth [?] [...] — [thus] half the diameter [?] of the earth [...] [reaches up?] toward the earth [?]. Point א [aleph] is [the apex]; the center of the sun [?] [...] and point ב [bet] is the center of the earth [?]; point ג [gimel] [is the place] where the shadow ends [?], and its endpoint [?] is upon the line of thickness [?] [drawn] upon the two centers [of sun and earth] [?]; and upon this [line] [—] the middle of the length of the earth's shadow [—] is line א-ב-ג [aleph-bet-gimel], and it is called the column [pillar] of the upright [the axis] [?]. The endpoint [head] of the column [?], which is the endpoint [terminus] of the [shadow-]cone [?], stands [?] [aligned] opposite [?] the place of the true center of the sun, which [lies] within the constellations [along the zodiac]. The lines that bound the shadow on the sun's side [?] are found [to be], in the figure, line ד-ו [dalet-vav] and line ג-ח [gimel-chet] [?] and point ג-ט [gimel-tet] [?]. Thus there is the triangle ג-ד-ה [gimel-dalet-heh] [?], which bounds half the globe of the earth together with the entire shadow-cone, drawing [it out] [?] and darkening [it] [?].

When the moon enters in its sphere [orbit] into this shadow — which is the arc ח-ט [chet-tet] [?] — and the body of the globe of the earth is intermediate between the sun [?] and [the moon] [?], then the moon, at the time of opposition [full moon], is entirely hidden within the shadow [?]; and its center [?] is upon the line that [runs] straight [?] [along] line א-ב-ג [aleph-bet-gimel] [—] then it [the moon] will be eclipsed entirely [a total eclipse]; but if [only] part of it [enters], then part of it is eclipsed — [namely the part] that enters into the shadow toward the [pointed] cone [?]. So part of it is eclipsed [the arc] ג-ד-ה [gimel-dalet-heh] [?], and that which goes out of it [the shadow], whether on the side of [...] [?] or on the side of [...] [?], is not eclipsed.

The proof that the shadow [cone] diminishes [tapers] and goes on [narrowing]: when its [the moon's] sphere is at its perigee [shefel], [being then] close to the body of the earth, then its [the shadow's] darkening [coverage of the moon] is then greater and more unified [?] than when it [the moon's sphere] is at its apogee [rum], distant from the body of the earth — because at the perigee of its sphere [?] the shadow [there] is more [...] [?] [...].

Section 9 (שער ט) — On Eclipses, continued

[Continuation of siman 221]

[Continued from the prior discussion of the moon's bearing-sphere and the inclined orb.] As we explained earlier, the moon's bearing-sphere is inclined relative to the orb of the ecliptic [siman 189 referenced in the margin]. By this inclination, half of the moon's path lies above [north of] the ecliptic and half lies below [south of it]. The bearing-orb [?] is inclined to one side and the deferent [?] to the other. The inclined orb's deviation from the ecliptic on the one side and the other produces the inclination of the moon, just as we depicted in the diagram here.

Yet even though every body has volume — which the diagram cannot show, since each of the figures here is drawn merely as a circle and the ecliptic line as a circle, when in truth they are not. It is impossible to draw them so as to capture the true situation; the eye must complete the picture.

As was already explained above regarding the path of the zodiac, the circle [of the ecliptic] and the straight line meet one another and cut one another, each [crossing] at the midpoint of the other — namely, the two orbs, the ecliptic and the inclined orb. The two points of intersection are: the point on the western side, called the **Head of the Dragon** (ראש התנין), from which the inclined orb of the moon begins to incline northward; and the second point, on the eastern side, called the **Tail of the Dragon** (זנב התנין), from which it begins to incline southward. The straight line that issues from the crossing-point and passes over and through the center of the earth — the line **א-ב** — is the **axis of the Dragon** (התנין) itself.

From this you may now understand: when the sun and the moon stand at the Head of the Dragon or its Tail (or near them), the center of the sun, the center of the earth, and the center of the moon all lie upon line **א**, which is the straight line, as above. In that case the center of the moon is aligned directly opposite the center of the sun, and it inclines from it neither east nor west, neither north nor south. The moon is then at a perfectly balanced position, mediating between the two. At that moment the sun's light is blocked from reaching the moon, since the earth's shadow interposes; the moon has no escape from concealment in the earth's shadow, and its whole body is eclipsed — as I shall show in this diagram.

Diagram. [Top-left of the page.] A shadow-cone construction: a large circle (the earth's shadow-sphere) with a smaller circle to the lower-right (the sun) and the

dark cone (the shadow-cone) tapering leftward to its apex, with a small disc (the moon) shown within the cone. The caption-strip above the figure reads **כמו שתבאר בצורה זאת** ("as is explained in this figure"). A point label **א** [alef] appears at the upper right, in the body-margin — it is the body point-letter **א** of the axis line.

- א (upper right): the body point-letter of the axis line

A second figure on the same page (right column):

Diagram. Two intersecting circles forming a lens-shaped overlap, representing the ecliptic orb and the inclined orb of the moon, with the central diameter line through points **ד** and **ג**. Labels around the figure:

- אופן הנוטה (top): "the inclined orb"
- אופן הרמה (center, on the lens): the apogee-bearing orb (the raised/elevated orb)
- ד (upper, under הרמה): point dalet
- ג (lower): point gimel
- מזרח (right side): "east"
- מערב (left side): "west"

Siman 222 [printed: סימן רכ"ב]

On why the moon is not eclipsed every single month, when its center stands opposite the center of the sun.

The reason the moon is not eclipsed every single month at full moon — when the two luminaries stand directly opposite one another — is this: were the moon's path aligned exactly beneath the midline of the zodiacal belt, just as the sun's path is, then it would be eclipsed at every opposition, every single month, and there would be no need to reckon the Head of the Dragon and its laws and rules at all. But because the moon's bearing-orb is inclined away from the great circle of the zodiac — to the north on one side and to the south on the other — this causes that not at every opposition do the centers of the sun and moon, together with the center of the earth, lie upon a single straight line. Therefore, since the moon inclines away from the breadth of the firmament, the earth's sphere does not interpose between the two luminaries, as in this illustration.

When the conjunctions [new moons] arrive, you will find the sun, say, at the Head of Capricorn (if the moon were then moving beneath a deferent orb) [?]; then, by the rule, the moon would stand opposite it at the Head of Cancer, or it

would stand for the whole month upon line **א** [?] (and would be eclipsed). But the moon is then inclined from the Head of Cancer up to [some] 5 degrees [ה' מעלות], so the three centers are not [aligned], and we find the moon to be off line **א**, since the moon inclines from the straight line. Therefore in most months the earth's sphere does not interpose between the two luminaries, and the moon does not enter the earth's shadow — so the moon escapes [eclipse]. [Marginal/inline ref: cf. above.]

Siman 223 [printed: סימן רכ"ג]

On why the moon is eclipsed at every new moon [recte: every full moon] when its center stands opposite the center of the sun. [The heading as printed reads "every new moon"; context requires "full moon" / opposition —]

[Marginal sidebar text — what the eclipse looks like:] "as I shall show in this diagram — the moon will be eclipsed when its center is opposite the center of the sun."

The moon is eclipsed when, at full moon, the two luminaries are aligned opposite one another, the moon's center upon the line. You should know that if the moon's path ran exactly beneath the midpoint of the zodiacal belt, just as the sun's path does, then the moon would be eclipsed at every opposition, every single month, and there would be no need for the laws and rules of the nodes. But because the moon's path is inclined, the earth's sphere does not always interpose, and so an eclipse does not occur every month — only when the moon is at the Head or Tail of the Dragon (or near them) at opposition.

[The body text here is partly degraded; the argument restates siman 222 in the affirmative form. Transcription of the worn passage:] When the three centers — of the sun, moon, and earth — combine upon a single line [קו א'], then the moon is eclipsed; but in most months the moon is inclined from line **א**, and so it is not [eclipsed].

Siman 224 [printed: סימן רכ"ד]

On the fact that sometimes the moon is not entirely eclipsed — only a partial darkening (קדרות) in part of its body — and how the moon escapes from total eclipse.

Know that the sages [the astronomers] set the width [breadth] of the dark shadow-cone, and its diameter at the place [of the moon] — which is the arc **ח-ט**

mentioned above [שהוא קשת ח"ט הנ"ל] — of the inclined orb. Half of this shadow inclines to the north of the line of the inclined orb, and half of it to the south.

The moon's diameter is about half a degree [for its radius], reaching half a degree [?] on the inclined orb. Half of it [the shadow at the moon's place] inclines north and half south. When the two diameters [?] [meet]… So when the moon is more than half a degree [?] from the inclined orb [?] — that is, more than the radius of the shadow at that distance — it escapes from total eclipse, since its body does not fully enter into the shadow-cone; and when it is at the very line of the inclined orb [on the axis], it enters wholly into the shadow and is totally eclipsed.

If the moon is [displaced] from the line of the inclined orb by a quarter-degree [רביעית מעלה], it is a partial eclipse — part of its body enters the shadow's edge and part remains in the light; thus only part of the moon darkens, while the rest stays lit. And when the moon's distance is less than a [full] degree from the inclined orb's line, it is at least slightly eclipsed — whether much or little, all according to its nearness to, or distance from, the inclined orb (or the [node of the] Dragon). [The passage works through the partial-eclipse geometry: the further the moon's center from the shadow's axis, the smaller the eclipsed fraction.]

On the matter of the moon's standing within the firmament's length [longitude] until it escapes eclipse: [Citing] the **Israeli** [R. Yitzchak Israeli, *Yesod Olam*; attribution disputed — flag] wrote in the name of **Ptolemy** [בטולמיאו"ס = Ptolemaeus], in his [work, the] *Almagest [?]* [פי"ב — "Book 12" of his work], that an eclipse occurs when the moon's center is near the Head or the Tail [of the Dragon], at the time of the true opposition — whether before it [ahead] or behind it — by less than 12 [?] degrees of the firmament's length [longitude]; if the moon is further than that, it does not eclipse, though it may eclipse very slightly. If it is even a little further from that, it does not eclipse at all. The possible range is 12 degrees and 12 regaim [י"ב מעלות וי"ב רגעים], and no further can it eclipse. At the **mean opposition**, when the moon's center is at the Head of the Dragon or its node [zenav], the figure is 15 degrees and 12 regaim [ט"ו מעלות י"ב רגעים]; within that it is possible for it to eclipse.

Siman 225 [printed: סימן רכ"ה]

On the astronomers' division of the moon's eclipse into five intervals of time.

The astronomers, in [reckoning] the lunar eclipse — when the whole body [of the moon] darkens — divide it into five [times], and they have set down their durations in their tables, [giving] the hours and minutes of each in their charts:

1. **First** — the hour and moment of the **beginning** of the moon's concealment within the shadow-circle, when its body begins to darken from its eastern edge.
2. **Second** — the time of the **full entry** of its whole body into the shadow-circle.
3. **Third** — the **mid-eclipse** moment, which is the time the moon's center stands opposite the sun's center.
4. **Fourth** — the time when its body begins to **emerge** from the darkness and to recover light, which appears at its western edge — the place [where] the eclipse [began] [?].
5. **Fifth** — the **end** of the eclipse, when the moon has fully left the dark shadow and returns to shine with its whole body as before.

If the moon's whole body is not [fully] darkened, only three times are reckoned for that eclipse: the time of the **beginning** of the eclipse, its **middle**, and the time of the **end** of the eclipse.

Siman 226 [printed: סימן רכ"ו]

On how many distinctions there are between a solar eclipse and a lunar eclipse.

A solar eclipse has many more laws and judgments [than a lunar eclipse], and is far more complex. The matter of [solar] eclipses is unlike that of the moon: the moon's eclipse is, as it were, in its own body — its eclipse is one and the same for the whole world; whatever its [degree of] eclipse, it is eclipsed [the same] for everyone, [a "real" eclipse]. By contrast, the sun's eclipse is not in the sun's own body. Sometimes the sun is eclipsed for [observers of] one climate, and for those of the second climate or the third [it appears different], as will be explained; and it is much easier for the sun to escape eclipse [for a given observer] than for the moon to escape its darkening.

Know, as a general rule, that the reckoning of a solar eclipse involves many laws and conditions, and for this reason it is a great and very deep matter [גדול ועמוק מאד]. I cannot expand on all these topics; I shall explain to you only the most necessary matters, all in brief.

Siman 227 [printed: סימן רכ"ז]

On the cause of a solar eclipse — namely, that the moon stands before the sun and blocks its light.

A solar eclipse is not on account of the sun itself, for its body neither eclipses nor darkens, and nothing diminishes its light at all. Rather, its "eclipse" comes about as follows: at the end of the [lunar] month, at the time of the molad [conjunction], when the sun and moon are each aligned in their orbs one opposite the other — then sometimes the moon interposes, blocking [the line] between the sun and a person standing on the earth's sphere. So although on the sun's side nothing whatever has changed in it and its light has not diminished, the body of the moon comes between the sun's body and the eyes of human beings, preventing them from seeing it — like a wooden board that blocks a person and prevents him from seeing — and so it withholds from us the spark or shining of the sun. This, in general, is the cause of a solar eclipse.

Siman 228 [printed: סימן רכ"ח]

On how the moon, in its smallness, can block our sight of [the sun], which is more than six thousand times [larger] than it.

If you should ask and say: behold, in a lunar eclipse it is the earth's sphere that blocks and withholds [the moon's] light from it, because the body of the earth is larger than the body of the moon — as will be explained below in siman 239 — being 39 [ל"ט] times the moon's body, and the sun's body, whose diameter is larger than the earth's diameter by 5½ times [ה' פעם ומחצה], from which it follows by the calculations of measurement that the sun's body is 166⅜ [קס"ו וג' שמינית] times the earth's body, and the sun's body is 39 [?] [ל"ט פעם] times... [the moon's] — so that by the calculation of measurement it is found that the sun's body holds more than the moon's sphere by six thousand four hundred eighty and ⅝ [ששת אלפים ותפ"ד וה' שמינית] times, as will be explained below at the end of siman 239 in section 10 [שער יו"ד] —

[Then the question:] If so, how can the moon, in its smallness, prevent the sight of the sun, which is so much larger than it?

Answer: Were the orbs of the sun and the moon adjacent and close to one another, there would indeed be room for this question. But because the moon is near to us while the sun is distant and high above us, up to the sphere of the [fixed stars / the *galgal* without stars] [גלגל הלא"ין = the starless orb / "the orb that has none" (the ninth sphere)] [?], there is no room for this question at all — as you can observe: when you bring a small dinar [coin] close to your eye, it prevents you from seeing a large mountain. You see, then, that the sun, though its body is far larger than the body of the moon, is not held back in its [apparent] eclipse on account of the sun's own affair, but on account of the moon's affair —

just as the moon is held back [from our sight] in its concealment on account of the earth's sphere.

Siman 229 [printed: סימן רכ"ט]

On why a solar eclipse does not occur every month.

The reason a solar eclipse does not occur at every conjunction of the two luminaries is the same as we explained above [in siman 223] regarding why the moon is not eclipsed at every opposition. The cause is the moon's inclination: the sun travels through the breadth of the firmament along the ecliptic, while the moon's path inclines away from it, up to [some] 5 degrees [ה' מעלות עד] to the north or to the south of the [sun's] place; the moon does not stand directly between the sun and the pupil [of the observer's eye]. [Reckoning the inclination,] the moon inclines neither toward the [observer's] meridian nor away from it [?], to north or to south — so although it is in conjunction, it is not aligned. Therefore in most months the sun escapes eclipse, since no [proper] solar eclipse can occur unless [the moon] is at one of the two nodes — the Head or the Tail of the Dragon — or near it.

[Citing] what **R. Yitzchak Israeli** [*Yesod Olam*] wrote, in [his work, *Yesod Olam*] part [maamar?] 4, chapter 16 [נמ"ג פי"ו — flag], in the name of [Ptolemy?]: the mean breadth [latitude] of the moon at the time of the molad [conjunction], when the moon is at the Head [?], must be less than ten degrees and sixteen regaim [פחות מעשרה מעלות וט"ז רגעים] from the Head — whether before [the node] or behind it, [reckoning to] the Tail [?] — for the sun to be eclipsed at that conjunction. Beyond these limits, the sun is not eclipsed at that conjunction. He further wrote there that, for the sun to be eclipsed in its whole body, [the moon's latitude] must be small in breadth — as [it is] in [its] length [longitude] — and at most [?] there is no eclipse.

[The end of this siman touches on the requirement that the latitude be small enough for totality. Transcription partly degraded.]

Siman 230 [printed: סימן ר"ל]

On the fact that a solar eclipse is seen in one place in its entirety, in another place [only] part of it, and in another place nothing at all.

We have already explained that the moon's eclipse [darkening] — since it is in its own body — is the same for everyone, in every place where it is night and [the moon is] above the horizon; all the inhabitants of that land will perceive and see

it. By contrast, the sun's eclipse is not in the sun's own body; its rule is not so. Even though Reuven, Shimon, and Levi all see the sun, it can happen that one of them sees the eclipse in its entirety and another does not see it at all — one sees part of it and another none of it; one sees no darkened thing in it whatever, as appears in the diagram:

Diagram. [Bottom of the page, above the Section-9 sign-off.] A solar-eclipse parallax construction: a large upper circle (the sun) and a smaller lower circle (the earth), with crossed sight-lines drawn from points on the earth's surface past a small disc (the moon, shown between them) up to the sun's disc. Point labels:

- ת [tav] (upper left, on the sun)
- ד [dalet] (upper right, on the sun)
- ב [bet] (lower left, on the earth)
- א [alef] (lower right, on the earth)
- (small disc, center): the moon

[Prose continuation keyed to the diagram:] Reuven, standing at his point on the earth, whose line of sight to the sun meets the moon's body with his whole field of view, sees the sun wholly eclipsed [darkened]. Shimon, standing at his point — whose line of sight to the sun meets the moon at [only] half [?] — sees the sun eclipsed by half, [a partial eclipse]. And Levi, standing at his point [?] — there is no point lettered for him on the figure; the third observer is keyed only in the prose — whose line of sight to the sun does not meet the moon's body at all, sees the whole sun and its full disc [no eclipse for him].

Siman 231 [printed: סימן רל"א]

On how much time elapses between one eclipse and another, and how many eclipses are possible in a single year.

An eclipse of either of the two luminaries occurs only when the [moon] is at a node — the Head or Tail of the Dragon — or near it, when the distance between them and the two limits [the bounds of the Head and the Tail] [is such that] the [arc] equals [?] half the circle of the sun's path [the ecliptic], and the time in which the sun completes its revolution [through that arc] is about half a year. By rule it follows that when the sun is eclipsed, it will not have a second eclipse [at the next node] until about six months pass — or, at the least, about five months — for the time from one eclipse [node-passage] to the next; sometimes more, sometimes less. Likewise the moon, which revolves in its orb between the Head of the Dragon and its Tail — before it completes half a month [?] [it cannot reach

opposition to the sun at both nodes; rather only after the previous eclipse is completed, by about six or five months]; and the reasons that change the [intervals] between one eclipse and another [vary], for sometimes a first eclipse is found a known number of degrees before the Head of the Dragon, and the second after the Tail of the Dragon (or the reverse). Each of the two luminaries has its own measured, regular course, and this accounts for the differences in the intervals between one eclipse and another.

You should know that sometimes the sun is eclipsed in one month, and the moon in that same month [its half-month later], and the like; so the matter reverses [Head/Tail], such that in a single year there can be six eclipses — three of the sun and three of the moon — one at the start of the year, one in the middle, and one at the end of the year, and so on by this method. It is possible for there to be three lunar eclipses in [a single] year. This has already occurred. In the year **1429 of the sixth millennium** [אלף תכ"ט — i.e., AM 5429, = 1669 CE], which is the year **ש"ם [?340] / ש"ס [?360]** [?] to their count [the final letter is a worn mem/samekh; not securely read], we found six eclipses in it — three of the moon and three of the sun. Here are the particulars. The three lunar eclipses: the first was on the **twentieth of January**, which is the 15th of Shevat; the second lunar eclipse was on the **14th of July**, which is the 15th of Tammuz; and the third on the **1st of Tevet** [טבת א'], which is the **9th of January** [ט' יאנוא"רי] of the following year — and a full year had not yet elapsed from the time of the first eclipse mentioned above, which was the 20th of January [ך' יאנוארי]. And the three solar eclipses that occurred in the said year: the first solar eclipse was on the **6th of February** [ו' פיברוא"רי], which is the 2nd of Adar [ב' אדר]; the second solar eclipse was on the **30th of July** [ל' יול"י], which is the [?] of Tammuz [the Hebrew day-numeral is worn]; and the third on the **26th of December** [כ"ו דיצעמביר], which is the [?] of Tevet [the Hebrew day-numeral, כ' or ה', is worn].

[Closing devotional line:] **"I shall hope to God, my Rock, my refuge and my deliverer — at the conclusion of the Ninth Section."** [אורה ולאל צורי מחסי ומושיעי… בסיום שער התשיעי = a brief pious sign-off concluding Section 9.]

Section 10 (שער העשירי / שער י)

In which are explained the courses of the five wandering stars [planets] (חמשה כוכבי נבוכה) — in part by way of the bearing-orbs [deferents], in part by way of the epicyclic orb [גלגל הקפה], the period of revolution of the planet itself by means of its epicyclic orb, and how the planets sometimes [seem to go forward and sometimes backward]; the spark and light of the sun; and the period of revolution of each one of the planets. The [matters of

the] wandering stars are hidden, [obscured] beneath the light and spark of the sun, and the words of others besides them.

Siman 232 [printed: סימן רל"ב]

On the reason the wandering stars [planets] sometimes go forward, sometimes backward, and sometimes stand still.

Know that the astronomers of [the science of] astronomy found and measured, with their new instruments, that the wandering stars [the planets] — sometimes go forward, sometimes go backward, and sometimes are seen to stand still, neither moving here nor there. The cause and reason of this matter appears in the diagram, [keyed to] the aforementioned arc [קשת]:

Diagram. A retrograde-motion construction. A large inverted triangle (apex downward at the earth) frames the figure; within it is a circle (the epicyclic orb, גלגל הקפה) whose center is marked, and a horizontal diameter line through the labeled point. At the bottom apex is the earth's sphere; the top edge represents an arc of the eighth firmament. Labels:

- ב [bet] (top left of the triangle): point on the arc of the eighth firmament
- א [alef] (top right of the triangle): point on the arc of the eighth firmament
- ג [gimel] (top of the epicycle): point on the epicyclic orb
- מזרח (right margin): "east"
- מערב (left margin): "west"
- הקפה (word-label on the left half of the epicycle's diameter): the epicyclic orb (גלגל הקפה)
- ז [zayin] (center of the epicycle, below the diameter midpoint): the center of the epicycle (מרכז)
- ו (one end of the epicycle's diameter): a position of the planet on the epicycle
- ד (other end of the epicycle's diameter): a position of the planet on the epicycle
- ח [chet] (bottom of the epicycle, where the diameter meets the lower arc): point on the epicyclic orb
- ח [chet] (bottom, at the apex): the earth's sphere / center point [מרכז כדור הארץ] — the figure reuses ח for both the epicycle foot and the earth
- The two lines drawn from the earth-point ח up to the firmament — the lines **ח-א** and **ח-ב** — tangent to the epicyclic orb on either side

This is a representation [דמיון] of a portion of the firmament — the arc **א-ב** — which is part of the eighth firmament (רקיע השמיני = the eighth heaven), above which are the [fixed] stars; and below it, drawn from it, is the form of the epicyclic orb (גלגל הקפה) with its center **ז**. At the lower edge of the figure, point **ח** marks the earth's sphere, whose center is the point **ח** [marked here]. From the point **ח** of the earth, two lines are drawn upward, forming the arc **א-ב** by the two lines (which are the lines **ח-א** and **ח-ב**), touching [tangent to] the epicyclic orb on either side.

Now behold: when one of the wandering stars passes its course in the epicyclic orb [reaching] point **ו** or point **ד** in the figure, then in our observation [from the earth] it is as if the star stood up above in the eighth firmament at point **א** or at point **ב** — for our line of sight [to it] meets one [of those] points. So it appears and seems to people as though [these planets] are [up among the fixed stars] in the firmament. Just as you know that the star — every one of the planets — when it revolves in its epicyclic orb, [moving] its center from west to east [the epicycle's own carried motion] from above (as a model and illustration for us): then we, [the observers] standing below upon the earth's sphere at point **ח**, [trace its apparent path]. When the star goes in the eighth firmament from point [one] to point [another], thereafter the star revolves [back] from the deferent [המסלול] around the epicyclic orb in its course; and we, observing from the earth, [see] as if it went, in the eighth firmament, from the apparent point [one] to [another] point — that is, an apparent reversed motion from point [one] to point [another] toward the west [retrograde].

This [behavior] is attributed specifically to the five wandering stars and to no others, although [the sun] [?] too follows this same custom — that it sometimes revolves in its epicyclic orb by way of the east and sometimes by way of the west, as was explained above in siman 195 [קצ"ה]. Nevertheless, this is not perceived by direct sense-observation as it is [with the planets], because the [planets, whose] centers [move] slowly… [degraded].

[The passage continues, explaining that because the planets move slowly, one can at any time take one of the wandering stars standing opposite a fixed star above it, using that fixed star as a sign and mark to gauge the motion of the wandering star — which is not so [easy] with the swiftness of [the moon's] revolution of its epicycle-center, for the moon does not stay opposite one of the fixed stars even for an hour.]

Siman 233 [printed: סימן רל"ג]

On the reason we see one of the planets [appear to] stand still in its place, moving neither here nor there.

Now you will readily understand the matter. Behold [as I have shown you] the reason that a planet appears to stand still in its place, neither going forward nor backward: because when the star, by the motion of the epicyclic orb, reaches point **מ** and goes along line **ד** [line dalet] up to point **פ** in the said figure — where its whole course [from] below to above is upon line **ח-ב** — the star's travel is prolonged in its revolution; sometimes for 2 or 3 days [ב' או ג' ימים] or more. For some of the planets do not revolve in their epicyclic orb [a full revolution] except after [many] years [?]; in such a manner that a small arc of the epicyclic orb [corresponds to] a revolution-time reaching 2 or 3 days or more. And the observer, from point **ח** up to point **ב**, it seems to him that all the time the star travels in the epicyclic orb upon that line, it is as if it stands still in its place; and likewise the same matter [holds] when the star reaches the opposite point — from point **ח** to point **ב** — it again appears to us as if standing in its place.

Siman 234 [printed: סימן רל"ד]

On the fact that all the stars are hidden beneath the light of the sun — their coming [setting] and their going-out [rising] from beneath its light.

It is known that all the while the sun is above the horizon, no star is visible to us, on account of the brilliance and the rays of the sun; [the stars] cannot appear until the sun sets below the horizon. At once, the stars emerge from beneath its light, and a lamp [?] — its light — is revealed to us. So too the stars that are near to us [low] toward the western horizon — they too do not appear immediately after the sun's setting, on account of the spark of [residual sunlight], which is still close to them, until the sun moves further [below the horizon] — and there is a great difference between the [setting] of [one] star [and another] [?].

Section 10 (שער י) — continued

[The opening lines of this page continue the discussion from the prior batch — siman 234, on the visibility of the five wandering stars (planets) and the difference between them and the fixed stars in becoming visible after sunset.]

concerning the light of the sun (אור החמה) and the difference in the visibility of the planets versus the fixed stars. Of the matter of the fixed stars we have already spoken a little; and at the head of [Section 8 — siman 178, as was explained to you

above in the eighth Section] we likewise explained the law and the matter of [the moon's light]. It remains for us [now] to clarify [the visibility of the planets].

There is a great difference between the visibility of the five planets and the visibility of the fixed stars with respect to their emergence from the light of the sun. The light of each of the five planets lies beneath the [horizon? — region degraded] for a reason connected to their great altitude; and the visibility of these five planets, being nearer to the body of the earth than all [the fixed stars], is seen above the horizon immediately after sunset. This is not so for the fixed stars: because of their great height, and because they are far from the body of the earth, the sun shines upon them even after its setting beneath the horizon. For this reason their bodies and their light, on account of their smallness, become visible only some time after the sun's setting — each one according to its altitude and the number of its degrees above the horizon.

From here on, then, [the discussion] passes over the five planets, and we begin with the planet **Venus** (נוגה), on account of the many variations and novelties found in it more than in the other planets.

Siman 235 [printed: רל"ה] — How the planet Venus is at times seen before the sun and at times after it, and at times not seen at all

The planet **Venus** (נוגה) — how many laws, variations, and rulings we need to know concerning the sighting of its rising and its setting:

Sometimes the planet [Venus] precedes the sun and rises above the horizon before it, so that it is seen in the east before the break of dawn; and it is then called *the Morning Star* (כוכב השחר). [The verse Yeshayahu 14:12 (וכי ישעי' — Yeshayahu) reads "Heilel ben Shachar" (הילל בן שחר), and the commentators explained it as referring to this star (Yeshayahu 14:12).] And sometimes [Venus] travels [in the opposite sense] and is seen after the sun, above the western horizon immediately after sunset, and is then called *the Evening Star* (כוכב הנשף) or *the Evening Star* (כוכב הערב).

Apart from these two times, [these two] are never two distinct stars, contrary to the opinion of the masses. And sometimes [Venus] is not seen above [the horizon] at all after the sun's setting, while at times it remains above [the horizon] for a brief while, and at times it remains above it for as long as one or two hours. At times it adds [time] and at times it diminishes [it]. So too is its rule at dawn in its rising over the eastern horizon: sometimes it does not precede the rising of the sun except by a brief time, and sometimes it precedes [it] by one or two hours. Sometimes, too, it is found close to the sun, and sometimes far from it — as in the

evening, so in the morning. Sometimes it is not seen at all, neither in the morning nor in the evening, for several days.

The reason and the cause of all these matters you must come to know. It is that the center of the epicycle (גלגל הקפה) of the planet Venus lies always upon the line drawn from the center [of the earth] through the center of the body of the sun. [That is, in the figure] one line passes from the center through the center of the sun, and in the figure before us [the line] passes through all three [centers], upon the line **א–ג**. This line is called *the common line* (קו המשותף), for it is the line shared in common by the three [centers]; and there is none of the three centers [that departs from it]… [region degraded] …only that the orb of the sun is at its furthest remove on either side in [the course of] its epicyclic revolution. This is when [the planet] is at point **ו** or at point **א** of the figure, which is the point of maximal distance from the common line.

Likewise we say that the period of revolution of the two centers — the center of the epicycle and the center of the sun — is one and the same. The time of revolution of the center of the epicycle of the planet Venus, [carried] by means of its deferent orb (גלגל הנושא) about the [center of the] world, equals the period of the sun's own revolution about the [earth], which is 365 days and nearly a quarter. The period of revolution of the body of the planet Venus itself upon its epicyclic orb (גלגל הקפה) is 1 year, 218 days, and 15 hours.

When these matters are set in order for your hand, you will know that when the planet Venus is upon its epicyclic orb, with its body at point **ז** of the figure, it is then at its closest to the sun. And then the center of the planet Venus itself, like the center of its epicyclic orb, all of them are aligned opposite the center of the sun [and will be either] beneath the sun, [as it were] upon the common line. At that time the sun and the planet Venus are aligned upon one line, so that in its rising over the horizon and its setting [beneath it], the sun and Venus [move together]. And at that time the planet Venus is not seen from it [i.e., near it], because of the brilliance of the sun's light; for that star Venus is at that time not seen at all, neither in the morning nor in the evening, since it is hidden beneath the light of the sun — or [likewise] when it is at point **ד** as above, or close to it on either of the two sides.

For when the sun sets at that time beneath the horizon, the planet [Venus] sets together with it; until afterwards, as is known, [Venus] revolves by means of its epicyclic orb and draws away from the common line a little toward the east. Then, when the sun sets beneath the western horizon by reason of the daily motion (תנועה היומית), Venus remains above the horizon after [the sun's] setting; it

becomes uncovered and revealed and seen. The planet Venus then behaves as it does on each [such] day, until it has revolved through half the sphere of its epicyclic orb — which is the arc **ה–ד**. In this passage along the arc it grows later and is seen each day always after sunset, by some [increment of] new time. Throughout all the days of that period it is called *the Evening Star* (כוכב הנשף) or *the Evening Star* (כוכב הערב).

[Diagram]

Diagram. A geometric figure illustrating Venus's epicycle. It shows two concentric circles (the deferent and an outer reference circle) with a central label, and a small circle (the epicycle) set on the upper part of the deferent, carrying its own labeled points.

- א (center): the central point (the earth / center of the world)
- ד (on the epicycle): a point on the epicycle
- ה (on the epicycle): a point on the epicycle (the arc ה–ד named in the body text)
- ו (on the epicycle): a point on the epicycle
- ב, ג (top cluster): points at the small circle at the top of the figure

[Caption at the foot of the figure: הגלגל ("the orb") [?]. The visible epicycle letters are א (center) and ד, ה, ו, with ב, ג at the top cluster — matching the body-text references in Siman 235 (points א, ג, ו, ז, ד, ה and the arc ה–ד). Legible at native resolution; not a]

When the aforementioned planet [Venus] reaches point **ה** of the figure, as [shown], it is then aligned opposite the center of the sun, so that it is again at the limit of remoteness [from the common line] on the [other side]; and it too is then not seen in the morning, and is also [not seen] in the evening — because it is once more swallowed up beneath the light of the sun — until afterwards, as known, the planet [Venus] draws away again from the common line toward the west. Then, by reason of the motion of the daily orb (גלגל היומי), it appears each day above the western horizon before the rising of the sun, which [time] precedes the rising of the sun. It is [then] called *the Morning Star* (כוכב השחר), and behaves as is its custom, until it revolves through the second half of the sphere of its epicyclic orb — which is the arc that [completes the circuit], and lasts [for] some time, more than a month. From all the foregoing it will become clear to you that, according to [what we have said], close to point **ג** of the figure as [shown], the epicyclic orb of the planet [Venus is so disposed] that the [remoteness] above the western horizon, and the length of time [it remains there], is at its greatest.

[Then,] as it draws closer to point **ז** little by little toward its lower position, so does it advance — the height of the epicycle, and the time of its [rising] above the horizon, [diminish?]. And as [Venus] draws closer to point **ה**, so does the sun draw away from the eastern horizon… [and] the closer it draws to point **ד**, [according to] all that [Venus] draws near the sun [region degraded].

All these matters you will see in the figure. And you should know that the things mentioned above in Section 8, siman 212 [printed: רי"ב] — the impediments [to visibility] — those same matters that hasten the sighting of the moon and [delay the sighting of others], are themselves also among the things that hasten and delay the sighting of the planet Venus, just as [they affect] the other planets.

Siman 236 [printed: רל"ו] — That the planet Mercury (כוכב), too, behaves as the planet Venus does, and the law and judgment of both are alike

Know that the center of the epicyclic orb of [Mercury], too, this planet — it too lies always beneath the center of the sun, like the planet [Venus]. The reason is that the period of revolution of the center of [Mercury's] epicyclic orb about the [center of the] world equals the period of revolution of the center of the epicyclic orb of the planet Venus about the [center of the] world, and equals the period of revolution of the center of the sun itself: the period of all three is the same, 365 days and nearly a quarter for each of them. Consequently it follows likewise that this planet [Mercury], too, behaves as Venus does: after sunset and [also] its rising above the horizon [it appears at the appropriate times]. In combination with all the other [impediments] mentioned above [in siman 212], take note that in this planet [Mercury] one does not perceive the variations and properties mentioned [as one perceives them] in the planet Venus, for the epicyclic orb of the planet Venus is much greater than that of the other planets. The astronomers (חכמי תכונה) reckoned its diameter to be close to [?] degrees — [whereas] the epicyclic orb of [Mercury] is only about a third [?] [as large] in its diameter… so that [Mercury] does not depart from the common line opposite the sun by more than about one and a half degrees [region degraded].

[Siman 237 — printed רל"ז (heading partly degraded)] — On the three upper planets [Saturn, Jupiter, Mars]

[The body heading reads, in degraded type: "סימן רל"ז … ג' כוכבי … העליונים … אור החמה" — "Siman 237 — the three upper planets … the light of the sun." Treated as siman 237.]

It is not fitting to undertake to set forth in detail [region degraded] ...regarding the three upper planets (שצ"מ = Saturn [שבתאי], Jupiter [צדק], Mars [מאדים]), namely the matter of their [emergence] from beneath the light of the sun, and the times of their rising and their standing above the horizon. [This matter] is very weighty and very difficult, for this subject is exceedingly deep; nor is the practical determination uniform for these three planets, nor is it uniform at all times and in all places; for the climes (אקלימים) that hasten or delay their sighting are many. I have therefore left this [topic] for others who come after, to wall themselves in [i.e., to build upon it]. With this brief and scanty remark I will speak of it only in general.

At the head [of the matter], know that the opinion of most of the astronomers is that the stars do not emerge from beneath the light of the sun until the arc found between the western horizon and the sun is about 16 degrees (and these reach about one hour [of time] — at times more, at times less). And I will now set forth and say that of the three planets mentioned, inasmuch as their motion is heavier and slower than the sun's motion, when one of the three is found before the sun toward the west, [the case follows]: [for example,] by the measure of one sign (מזל), or [by] the upper motion, that planet — [so as to be] above the western horizon — stands [at] the measure of half a sign, [for] a time of one hour, and is then called the *Evening Star* (כוכב נשף), by the rule [given] for the planet Venus above.

And by night, [secondly,] as the sun draws near to the star [planet] — close to about 1 degree above [it] — its remaining above the horizon then diminishes, by about [the equivalent of] 1 hour and 15 chalakim. And so it continues to diminish in this way until the sun draws near to the star itself; so that [the planet] is then by about half a sign caught up in the light of the sun, and is not seen — until the sun, in the course of its proper motion (כמהלכה העצמיי), pursuing after the star, passes before it. [This continues] until you find [that the planet returns]: [it remains hidden] by about the measure of half a sign, or a little less, after which the star returns to acquire light; and it rises in the morning over the horizon, of its return, before the rising of the sun. It is then called the *Morning Star* (כוכב בקר). [Its time of] remaining above the eastern horizon then keeps increasing, day by day, as the sun draws further away from the planet toward the east by, say, the measure of one sign — should it occur in a brief time [region degraded] — [in which case the planet] then precedes [and] rises over the eastern horizon before the rising of the sun by two hours. And so the matter continues to grow large, up to half a year's time, until the planet remains hidden above the horizon for [up to] 12 hours, which is the whole time of the night.

Siman 238 [printed: רל"ח] — Whether the light of the stars is from themselves, or acquired from the light of the sun

The light found in the five planets, and likewise the light in all the [fixed] stars — [there is dispute]. Some say (י"א) that the light is theirs from themselves, like that of the sun itself; and some say (וי"א) that the light of all of them is acquired by them, and that they receive their light from the light of the sun, like the moon.

As for why eclipse (קדרות) is not spoken of regarding any of the other stars [as it is of sun and moon], it may be said: because no star enters into the column of the shadow-cone (צל האופל). For, as we explained nearby — that the apex of the shadow-cone, upon entering [the heavens], can [reach] as far as the orb of [Venus] alone, [and] not the orb of [Mercury] — and as for the planet Mercury and all the other stars, which are above [Venus] in their position, it is not possible that they should ever enter into the shadow of the earth (צל הארץ); therefore the stars never undergo eclipse. Even though the shadow of the earth passes within [the orb of Venus, an eclipse of the higher stars is impossible], because of their great distance, [so that] it is impossible for [them] to be eclipsed…

for [the apex of the shadow-cone] does not extend except, as it were, above [a certain limit], by the same reasoning and account, [namely] that the shadow of the earth — [its capacity to cause eclipse] is impossible [beyond a certain bound]. The sun, when it sets, and during the night, [casts a shadow such that the earth's body intervenes] — but it is impossible for the body of the earth to intervene between [the planet] and the sun in such a way as to interpose [the column of] the shadow-cone (צל האופל). This figure [the present one] is not such [a case]; nor is there imposed upon us [the obligation] to give a reason for the planet's remaining [above the horizon]… as was explained to you [by reason of] the position of the earth at the center of all the orbs above it, [as set out] in the first Section (השער הראשון), where the earth's central position was established.

Siman 239 [printed: רל"ט] — How great is the bodily size (גודל גוף) of each of the seven wandering stars, compared to the size of the body of the globe of the earth

This siman gives, for each of the seven wandering stars, the relative size of its body measured against the size of the body of the globe of the earth. [The figures form a numeral-dense size/ratio computation; transcribe the numerals as printed.]

- The sun (חמה) is 5½ times greater [than the diameter of the earth] — חמה גדול על ה' פעמים ומחצה … יתר על קוטר הארץ.
- [Further size/distance figures for the other bodies follow, as earth-diameter multiples and fractions: the printed numeral strings שמינית ,ל"מ ("an eighth"), שתינים ו'נ ל'ק'ז, and the like — transcribed as printed; the exact parsing of these dense ratio figures is SOURCE-AMBIGUOUS in spots, but the section is a size table, not qualitative prose.]

Siman 240 [printed: ר"מ] — The table of periods (לוח הזמנים): the revolution periods of the deferent and epicycle of all seven wandering stars about the globe of the world

[The לוח הזמנים follows, listing for each of the seven planets the period of one full circuit and the time per sign. Table spans both columns of the page; reads right-to-left in source.]

Planet	Period of one full circuit	Time per sign
Saturn (שבתאי)	30 years (שלשים שנה)	each sign 2½ years (ב' שנים וחצי)
Jupiter (צדק)	12 years (י"ב שנה)	each sign 1 year (שנה אחת)
Mars (מאדים)	2 years and a fraction (שתי שנים ומקצת)	each sign 2½ months (ב' חדשים וחצי)
Sun (חמה)	~365¼ days (כשס"ה יום ורביעי)	each sign 1 month (חדש אחד)
Venus (נוגה)	also ~365¼ days (ג"כ כשס"ה יום ורביעי)	each sign 1 month (חדש א')
Mercury (כוכב)	also ~365¼ days (ג"כ כשס"ה יום ורביעי)	each sign 1 month (חדש א')
Moon (לבנה)	27 days 6½ hours (כ"ז יום ו' שעות ומחצה)	each sign 2¼ days (ב' יום ורביעי)

[Body text after the table, on the epicyclic-body periods:] And the time in which each of the seven wandering stars revolves with its [own] body by means of its epicyclic orb (גלגל הקפה) is this (והזמן אשר יסובב בו כל אחד … כגופו ע"י גלגל הקפתו הוא זה):

- Saturn (שבתאי) — about 30 years on its epicycle (שבת … ל"ג; the exact day-figure is SOURCE-AMBIGUOUS [?]).
- Mars (מאדים) — about 2 years (שבת ב').
- Venus (נוגה) — 1 year, 218 days, 15 hours (שנה ריי"ח יום ט"ו שעות).
- Mercury (כוכב) — about 116 days, 12 hours (קט"ז יום י"ב שעה; the leading day-grouping כ"ב is SOURCE-AMBIGUOUS [?]).
- Moon (לבנה) — 27 days, 12 hours (כ"ז יום י"ב שעות).

[Beside the table, body text — the HASHBON (precise reckoning) for the moon:]

This reckoning is most precise (החשבון מדוקדק מאוד), according to what I received by word of mouth, from the mouth and from the book of **Johannes Mulerius (יהני"ס מולירוס)** [a contemporary astronomer; the Hebrew spelling is certain — a Latinized Dutch/German surname, *Yohanis Mulirus*; the historical identification (likely Nicolaus/Johannes Mulerius, the Dutch astronomer, 1564–1630) remains tentative [?identification]], one of the astronomers in residence before the **Kurfürst (קירפיר"שט, the Elector), Duke of Brandenburg (דוכס ברנדי"בורג)**:

The motion of the center of the moon's epicycle by means of the deferent orb (גלגל הנושא) is 13 degrees, 14 minutes, 34 seconds, 43 thirds per day (י"ג מעלות יו"ד דקין ל"ד שניים מ"ג שלשיים = 13° 14′ 34″ 43‴/day), [the per-circuit days/hours figure being SOURCE-AMBIGUOUS in the print spacing [?]].

[Editor's note: the print's 13° 14′ daily motion diverges from the astronomically expected mean lunar daily motion of ≈13° 10′ 35″. Rendered here as printed — a genuine divergence from the named court astronomer's figure, not a misread; whether the source itself errs is for the editor.]

[And separately:] The new lunar month, [the interval] from molad to molad, by the mean motion (במהלך האמצעי), is 29 days, 12 hours, 44 minutes (כ"ט יום י"ב שעות מ"ד דקין — the standard mean synodic month), [followed by sub-minute seconds/thirds terms that are SOURCE-AMBIGUOUS in the print spacing: ≈11 [?] seconds, 3 thirds] — equal to 12 degrees, 11 minutes, [?] seconds, 46 thirds per day (י"ב מעלות י"א דקין … מ"ו שלשים).

Siman 241 [printed: רמ"א] — How much the six wandering stars deviate from the mid-line of the zodiac in latitude (רוחב), toward north and toward south

It was already explained above, in siman 189 [printed: קפ"ט] and siman 153 [printed: קנ"ג], that the deferent [orb] of each star [planet] [is so set] that the line

of the [ecliptic — the line called *Khat ha-Kedarot*?] — [region degraded]. [The imaginary] line, the great circle (עגול הדומה) standing upon the line of the [ecliptic? — קו הקדרות], divides [the band]: half of it [lies] toward the north and half toward the south. The planet is found upon its deferent [orb], standing toward the north or toward the south [of this line], upon that star [position]. The breadth of the [band of] the ecliptic — the measure or the latitude (רוחב) of [the deviation] that each one of the six wandering stars (the planets proper, the sun excepted, though the table still lists the sun's row) has, on the side of the line of the [ecliptic] to the north, and likewise to the south — is, according to what I received from the astronomer **Johannes Kepler (יוסני"ס קעפלי"רוס) [= Johannes Kepler]**, as follows:

Planet	Maximal latitude
Saturn (שבתאי)	3 degrees (שלשת מעלות)
Jupiter (צדק)	about 1½ degrees (מעלה ומחצה), with a sub-clause ובני שלישי מעלה [SOURCE-AMBIGUOUS phrasing]
Mars (מאדים)	3½ degrees (ג' מעלות ומחצה), north and south alike (כן צפון לדרום)
Sun (חמה)	It has no [latitude] at all, for it travels always upon the line of the ecliptic (אין לה רוחב כלל כי רוחה תמיד … תחת קו הקדרות) — 0°
Venus (נוגה)	9 degrees (ט' מעלות), greater than all of them, to both north and south (יותר מכלם לצפון וכמו כן לדרום)
Mercury (כוכב)	3 degrees (שלשה מעלות)
Moon (לבנה)	5¼ degrees (ה' מעלות ורביעי)

We have completed the ten sections. (השלמנו עשרה שערים)

[Cul-de-lampe note at foot in the body: "In trouble may He answer me on the day of [my] distress" (בעת הצוקה יענני ביום צרה — cf. Tehillim 20:2).]

The Eleventh Section (השער האחר עשר) — Section 11

[Section preface, in the heading band:] In it will be explained the making of an instrument called the *kli machazeh*, namely the quadrant (כלי רובע), with which one measures — and there is found, in every place, the altitude of the [celestial] pole (גובה הציר) of the world; and likewise the altitude of any other star of the stars of heaven; how high the sun is above the horizon; the determination of the sun's place among the signs throughout all the days of the year; the duration of the rising and setting of the sun; the length of the days and nights, in every place, throughout all the days of the year — together with many other matters.

Siman 242 [printed: רמ"ב] — On the making of an instrument of [observation], one called the quadrant (כלי רובע), for measuring the altitude of the [celestial] pole and the altitude of the stars

[Said the author:] At the outset, before I begin to instruct the students [in] this Section, [know that] the astronomers in [their] measurement of the stars [employed] various instruments; [region degraded] …each one according to [its] purpose, [and] all of these instruments have names, called [after their forms]. Of these is one observing-instrument (כלי מחזה) called by us the quadrant (כלי רובע) — that is, a *kvadrant* **(קוואדראנט) — Latin/German: *quadrans* / *Quadrant*, "a fourth part"]**, which is one-quarter of a [whole] circle. [Region degraded — partly Rashi-script gloss material on the names of instruments.] [The Hebrew name] is derived from [the word] "fourth" (רובע), and [the instrument carries] a plumb-line **(אנך) — a plumb-line / lead]**, which the Latin-speakers call by another name… [the instrument with the plumb-line is the one] called *the leveling-instrument* (כלי המעיינים / האומטול [?])… [region degraded] …with which one may readily measure the [heights of mountains?] — for instance, the measuring of the height of mountains and the like — [a thing] that the geometers and surveyors (חכמי המידות והרתבי גבולות) make use of in [their] countries, for all such [purposes], [employing] the science of weights (חכמת המשקלות). And we have already written of it at length [region degraded — a reference to another book, perhaps a treatise of the author's, "in [my] books"]; but here is not its place [region degraded]. [The discussion is offered] for the students, [to teach them] how to make use of this instrument [in order] to know the altitude of the sun, and [in] combining all the stars of heaven, in order to know the altitude of the pole in every place, and likewise to measure the place [position] of the sun among the signs every day throughout all the days of the year — and likewise the [number of] hours of the day, together with [several] particular matters special to it [region degraded].

Even though the orb of the signs (גלגל המזלות) is a complete circle, nevertheless the instrument before us, for [its] precision, is a quarter of that circle. The reason is that the orb of the signs, in its entirety, is already divided into 360 degrees — [but] half of it is not visible nor revealed to us, [for] the [other half] above… [whereas] the second half is beneath the horizon, [toward] the earth; and of that second half which is above the horizon… one [sees], at any one time, [only as much as the eye can take in]. [Region degraded.] For [a person] sees, at any single moment of observation, [only one quarter] — that is, from the horizon up to its [zenith] point, those 90 degrees; and that is but a quarter of the circle. From this [follows] the [naming]: the angle of the instrument, which is at the point of the meeting [of its two straight sides], is called the *vertex-angle* (קרן זוית — literally "the angle of the corner"). [Region degraded.] [The face] of the instrument, which is its corner-angle (קרן), is [the part you sight along]. You should know, too, that the way to use the [instrument] of observation (כלי מחזה) is this: bring the corner (קרן) of the instrument close to the [side] of the eye, near the [socket?] of the eye, and shut your second eye. Then sight along the [edge or] side of the instrument [in] a straight line of vision, up to the point [or] place whose altitude or distance you wish to know. [The instrument] is then as if its line [of sight], itself, reaches by [extension] up to that place, [namely] up to the very point you require.

Siman 243 [printed: רמ"ג] — That this instrument [the quadrant] is graded, [and is used] in two manners and in two examinations: the first examination

Know that the making and the correcting (תיקון) of the quadrant (כלי רובע), of which we speak, is [carried out] by means of one of two examinations. The first is by means of the [edge of] a beam [or rod] (בריח), and the second is by means of the [hanging] of the plumb-line (חוט המשקל). We shall now explain the first examination, which is [the one done] by means of the edge of the beam.

[As a model,] I shall make for you, from wood, [an instrument] whose form is [described]: it is, in its entirety, the surface of a quarter-circle [region degraded], as [stated], which we have marked in the figure before us [as] **א-ב-ג**. The left side, [the side] which will be [the upright] side, is the side **א-ג**, [the right side of] the instrument; and the right side [region degraded] — [the side **א-ב** is the base, the recumbent side, the seat (התושבת)]; and its arc we have marked [as] [the arc from **ב** to **ג**]. And this arc — [we have divided it] into 90 parts [of] this [kind], which are called *degrees* (מעלות). [Region degraded.]

[And the manner of] this division, [made] for the students [for] a quick and easy method: first divide this arc into three [equal] parts, which will be three parts; then divide [it] further, each [of the three] into three [parts], which makes nine parts. Then [divide] each of these nine parts again — each one of these nine [region degraded] — into [further] parts; so that of all the [parts], each of them, [you make] further [subdivisions]: each one of these 18 parts you [divide] into 5 parts… … mark these [graduations] on the arc [with] the numbering, from below upward, [from] 1 to 90, up to the completion of 90. And the interval between each mark and [the next] mark [region degraded], [draw] with lines… [dividing] into five parts… all the 90 parts, [which] are called *degrees*; and these, when [taken together], are the quarter of the [whole] of the 360 degrees of the orb (the orb has 360 degrees, [and] a quarter of [it] — [region degraded] — a good sign to you, [in] good fortune).

[Diagram]

Diagram. A geometric figure of the quadrant (כלי רובע): a full circle with a quarter-sector cut by two radii meeting at the centre at a right angle, plus a short inner arc near the vertex marking the angle. The figure carries **no inked point-letters** — the א/ב/ג names appear only in the body prose, not on the figure itself. The text just above the figure confirms this is "a complete circle … hence for our measurements with the instrument … a quarter-shape within the circle" (זה עגול שלם … לכן למדידות שלפנינו בכלי … צורה רביעית בעגול).

[Unlabeled quarter-circle within a circle. Point-letters א, ב, ג are supplied from the body text only; they are not inked in the figure.]

Section 11 (שער יא)

[Continuation of siman 243 — completing the quadrant: the sights and the graduated arc]

[The page opens mid-discussion of the quadrant (כלי רובע) begun in the prior batch. The text is badly degraded here; the following recovers the thread of the argument — the construction of the sighting apparatus and the marking of the arc.]

as we explained regarding its length [?]. From the corner [קצה] of the instrument [?], at the point marked א, you set in place a fixed pin [יתד] to serve as a pivot [ציר], like the central axis, so that you may pivot upon it and shift it across the whole arc, transferring the sight that faces the body whose altitude you wish to find [?]. At the other corner, of wood or of metal, along the edge א-ג [?]… and you make the side [דופן] of the instrument a half-finger [?] thick, of brass [נחושת], in

two small pieces about half [a finger]... and in each of them you make a small hole, in such a manner that the two holes are aligned [מכוונת] one opposite the other along the line — by the method explained above and below — and these two holes shall be called the "sights" [ריח הבטה, the sighting-channel]. *[Cf. the construction in siman 242, above.]*

And these two sights, set facing one another, are the means of sighting. Take care that they sit truly and evenly [שוה וישרה], at a single height [גובה], the two sights together, so that the line of sight runs straight through both.

> **[Marginal / framed note, p. 141, lower right:]** The picture [צורה] of which we have spoken will from now on appear as below [the figure facing the text], when the instrument is properly fashioned and graduated by hand [?]. From the measure of its length [ארך] you will learn how large this instrument should be: namely, that the greater you make it, the more it will be bounded and exact [?] — for in proportion to its size, so will it be the more precise; and the more precise it is, the better you will know that the [graduation] truly corresponds [?]. As for the size we recommend: about a quarter-cubit [רביעי אמה] along its length [?], one half-cubit by one half-cubit [חצי אמה על חצי אמה] in breadth — for another such instrument, half a cubit in length and a half-cubit in breadth [?].

[The degraded passage continues, treating the numbering of the graduated arc:] Here you will find marked the numbers of the degrees [מספר המעלות] which are upon this arc — namely the 23 [כ"ג] which is "the ninety degrees" [?]... an arc which signifies [רמז] the arc of the zodiac [המזלות], from the horizon [האופק] up to... and the arc marked [?] holds [מחזיק] toward the zenith [קדקד]... where there is the appearance of degree upon degree... the arcs being directed each to its fellow [?], the line indicating [המורה] the path... upon each degree... and so the spark [הניצוץ, i.e. the line of sight] will of itself travel and reach [?] the corresponding great [degree] upon the degree marked [?]. By this picture you will see all the matters mentioned.

Siman 244 [סימן רמ"ד]

How measurement is done with the instrument of the quadrant

(כיצד המדידה בכלי הרובע)

When the aforementioned instrument of the quadrant has been made according to its rule [as set out] above, and you wish to determine [?] now... you should call

it [קרא] "the sight-line" [or: the sighting-instrument] [?]. Every star [כוכב] already... as already explained [?] at the end of the second [discussion] in siman 52 [בסי' נ"ב] — that every body which you find named there as the third [?]... it serves to find [ישוב למצוא] the altitude [גובה] of the sun [השמש] or of the star.

And to know how many degrees, of however many degrees, a given body stands above your horizon [אופק], by means of this instrument: take this instrument in your hand and set it up — for instance, upon your one hand [arm] [?] — in an upright, even, and true stance [בעמידה שוה וישרה] toward this horizon, without any tilting to either side [נטייה לצדדין]. Direct the side א-ג [?] of the instrument so that its face looks upon the face of the sky [פני הרקיע], aligned [מכוון] against the point of the zenith above your heads [קדקדכם]. When you wish to find the altitude of one of the stars, close one of your eyes [תעצים אחד מעיניך] and fix the other eye [ותשים עיניך השני] upon the instrument — that is, upon the point נקודת א [א, one of the points [of the arc] — and move the indicator [בריח המורה, the sighting-arm] this way and that, until you are able to see, through the openings [חורי] of the sights of the instrument, the star whose altitude you wish to know. Then you spring [תקפוץ — i.e. lock] [?] it in place; and at the position where the star [is sighted], you read off [?] its altitude.

[The text here is degraded; the following recovers the closing remarks of the siman:] And the inquirers and the seers [החוקרים והרואים] return, again and again, [observing] the motion of the stars... they observe the stars upon the line of this very instrument [?]... as in siman 52, the second [reference] [?]... so that no observer's observation [השגה] is lost [?]... until... measuring [?] every body, until... it is a wondrous model [מופלא / מודל] [?]...

Siman 245 [סימן רמ"ה]

Everything found on a line

[Header rubric, p. 142, top right. The square-type running rubric reads in full: "כל מה שנמצא בקו הניצוץ אף שהאחד יותר גדול מהשני אפי' אלף פרסה גובה אחד יהשב לשניהם" — "Everything found on the line of the ray, though the one be larger than the other by even a thousand parsangs, is reckoned as one altitude for both."]

is greater than the other by even a thousand parsangs [פרסה] of altitude [גובה] — yet for the two of them it is reckoned as a single altitude.

Know that, since the spark [the line of sight] issues from the eye and reaches as far as the orb of the stars [גלגל הכוכבים], everything that lies along that line — even though it [be far off] [?] — is so distant... that the whole is reckoned at a single altitude, even though the one [object] be near and the other distant [?]. As

for the difference [?]... in the orb of the stars [גלגל השמיני, the eighth sphere] — for there the body of the star is at a fixed point [נקודה]; whereas the point... of a tree-top [ראש האילן] [?] reached by the line, even though it lie nearer to the eye, is reckoned the same — for the eye cannot distinguish [?] a near body from a far one along one and the same ray.

> **[Worked illustration within siman 245, p. 142:]** The line of sight that issues from the eye, reaching as far as the eighth sphere — whatever is found at the point where the ray falls [נקודה שמצא בה הניצוץ], that whole [length] is reckoned to it as one altitude, even though the one [end] is near to the earth and the other is a thousand thousand [a million] parsangs distant [?]. And it is found that the line of the ray... reckons all of it [as] one altitude [?]. For example, [if] there is a tree [אילן] whose top is reached at... the point at the head of the line is not the [true] altitude — only its summit [גבהו] [?]. The head of the tree, the point of the eighth sphere of the stars — the altitude of that star is reckoned by it. For from the point at the head of the tree [?]... a thousand thousand parsangs [?]... nevertheless, the point at the head of the tree [?]... a star [is] at this same... and another star; and these degrees of the horizon [האופק]... the degrees of the point at the head of the tree are *short* degrees [מעלות קצרות], whereas the degrees of altitude of the star are large degrees [מעלות גדולות]. *[The argument: equal-looking angular degrees subtend vastly different physical lengths at different distances along the same ray. The prior "23 [כ"ג]" was a misread of an abbreviation, not a count; removed.]*

We have explained the whole by way of an example and an analogy of the instrument of the quadrant, [namely the figure] which we mentioned in [siman] 53 [נ"ג] above.

And though the instrument has been made and prepared by the *first* examination [הבחינה הראשונה], take care to learn well the workings and the rule [משפט] of the quadrant — for it is also made [usable] by the *second* examination [הבחינה השנית], which is upon [the principle of] the plumb [המשקל], by the simple [plain] method [הדרך הפשוט], as was explained above, at the end [?] of Section 2 [שער ב'] — except that here it is augmented [נוסף] by a second consideration [דין שנית], in the deviation [הפלגת] of the [solar] mid-point [החצי] [?], by [some] days [חדשים אות / חדשים] [?].

Siman 246 [סימן רמ"ו]

*The manner of fashioning and graduating the instrument of the quadrant according to the **second** examination*

(איכות מעשה ותיקון כלי הרובע ע"פ הבחינה השנית)

We have said [stated] [אמר], as written above [על דרך שכתב], at the end of Section 2 [בסוף שער ב], simanim 51 and 52 and 53 [נ"א ונ"ב ונ"ג] — [there] we explained the fashioning [תיקון] of the instrument of the quadrant by *this* [other] examination as well [?]; and we said that the whole subject [תוכן] of this section is in itself superfluous [מיותר] — that is to say, [it is given only] to teach the students the essential principle and the gist [עיקר ותמצית] of the way of measuring the heavenly bodies [מדידת הכוכבים]. Yet, since I attained [?] [the means] of clarifying it [?] in this place, I saw fit to set it down [?] — and we have here renewed [ונחדש] [the matter], adding to the fashioning [תיקון] of the instrument of which we spoke above [some] new and wondrous things [דברים חדשים ונפלאים].

This is how you make it: take a piece [רף / לוח] of wood, of one [single] material [מחומר א'], whose entire form [צורה] shall be... a quarter-circle [רביעי, a quadrant]... like the figure before us [הצורה שלפנינו], [namely] the quadrant א-נ-ג [the points], with center at the point [נקודת א] א. Its left side is א-ב, and its right [וימינו] is א-ג; and in its arc ב-ג...

[The text continues across the page; resumes on p. 143:]...you will find marked there [?] the numbers of the degrees [מספר המעלות] on this arc... a single line [קו אחד] or [point] ט from the center of the instrument [ממרכז הכלי], which is the point [שהיא נקודת א] א, and let its measure [be]... one [unit] [?]. The line, [drawn] in the same manner [?], should be somewhat longer than the [breadth of the] instrument, so that it project [?] from the side [מאלכסון] of the instrument in the figure [?]. The line which [is] א-ד [?] — call it the "plumb-line" [קו המשקל], because upon it the plumb-weight [המשקל] will hang [תלוי].

Take a fine thread [חוט] [?]... and to level the instrument [ולויישר], its lower [edge] [?]... attach to this thread [חוט] a little pearl [מרגלית] or a small [bead of] coral [קרע"לי = coral] and small [items]... so that the bead [the pearl or the coral] [?] [hangs] in such a way that the bead [is bored] [?]... insert the thread into the bore [נקב] of the pearl or the coral [?]... fill [it] from the thread, in such a way [?] that you may let the plumb-thread of the weight [קו המשקל] swing [?] freely with the bead, by [its own] great weight [?]. Then attach [it] again, on the side... upon the upper edge [שולי] and side [דופן] of the rim [שפת] of the instrument that is on side א-ג, where you wish [?] — [namely] on side א-ג of the figure.

[Now make] of brass [נחושת] [?], a half-finger [or so] [?], two small pieces about half [a finger]... and in each one make a small hole [נקב קטן], in such a manner that the two holes [שני הנקבים] [are] a straight line [קו ישר] aligned [מכוונת] one opposite the other [זה כנגד זה], by the method explained above [?] and below [ולמעלה ולמטה] [?] — as [in] the adjacent [siman] above [?]. And these two holes shall be called the "sights" [ריח הבטה], as above [כנ"ל].

This is the [account of the] examination [for] fashioning the instrument by the **second** method; and you now have [available to you] [?] [both methods].

Although, to all appearances [כפי הנראה], there is found between the two examinations a great and considerable difference [הבדל גדול ורב] — in that the first examination [הבחינה הראשונה] is carried out by means of the indicator-arm [בריח המורה], while the second [is carried out] by means of the cord of the plumb-weight [חוט המשקל] which [hangs] at the start [בתחלת] of the sighting [ההשקפה] — and they have no connection or partnership [שום ענין או השתתפות] one with the other [?]; moreover, the configurations [מצבי] of the two examinations are the *reverse* [בהיפוך] of one another: in the first, the arc [קשת] of the instrument faces *upward* [כלפי מעלה] and its center *downward* [כלפי מטה] [?]; whereas in the second examination you find the reverse [בהיפוכו] — that the arc of the instrument faces *downward* and its center *upward* [?] —

nevertheless, know that both of them rest upon one and the same principle [מקום אחד] [?], and there is for them one root and foundation [שורש ויסוד אחד]. And although the practice [דרך] of the two examinations is alike [כא'], most of our words [discussion] will be [in terms of] the second examination [הבחינה השנית] — because it is the easier and quicker [הקל ומהיר יותר], by reason of being [carried out] in a fixed stance [בעמידין] [?]; only [take care] to level [ליישרו] the instrument [truly] to the horizon [לאופק].

Siman 247 [סימן רמ"ז]

The shapes and figures of the instrument of the quadrant, with all its constructions and rules

(צורות ותמונות כלי הרובע לכל חוקותיו ומשפטיו)

Before I begin to speak of presenting the figures of the instrument, I have said [to myself] [?] two things. Because it is hard — indeed all but utterly impossible [מן הנמנע הגמור] [?] — to enable [להשכיל] the students to grasp the rule [משפט] of this instrument and its operation [מעשהו] without a picture and figure [תמונה וצורת], therefore [I have included figures]. And so as not to multiply figures upon every

point [?] — for the sake of [ease of] study and learning [למוד ולמוד] [?] — I saw fit to set before you, at the very outset and head [בתחלה ובראש], the whole figure [תמונה] of the instrument and its form [וצורתו] in a single presentation [?], [showing] all the [parts] needed for this [הצריכים בזה]... [?]. From it [the figure] one will gain understanding [?]; and let every man [כל איש] discern and grow wise in all the workings [משפטי] of this instrument, according to what will be explained [?].

**** *(anticipates siman 248)*

Diagram. A quarter-circle (quadrant) observing-instrument, drawn as the wedge of a circle bounded by two straight radii meeting at the lower-left vertex (the center / pivot), with the graduated arc sweeping across the upper-right. The outer arc is divided into a band of **degree-cells in regular 5° steps, 90, 85, 80, 75, …, 15, 10, 5**, numbered (in the source) along the right and top margins. An inner, finer scale carries the identical 5° graduation (90, 85, 80, …, 10, 5). Two straight edges (the radii) run from the vertex; small square boxes (the two brass sight-pieces / the seat) are marked along the lower edge.

- Lower-left vertex: the center / pivot point (corresponds to **א** in the text; the pivot of the indicator-arm)
- Outer arc band: degree graduation **90, 85, 80, …, 10, 5** (regular 5° altitude scale)
- Inner/finer band: identical 5° graduation **90, 85, 80, …, 10, 5**
- Lower edge: square boxes = the two sight-pieces (ריח הבטה) and the seat (התושבת)

[Caption / explanatory note beneath the figure, p. 141, foot — Rashi-type:] *[Rashi script:]* The legend [כותרת] of the sights [or: of the boxes] of the inquirers and seers [החוקרים והרואים] and the measurers [?]... testifies [מעיד] to the motion of the stars... see [?] this... a line of altitude... the corner [קצה] [?]... in the days [?]... and they observed them [/ וישמרם וירשמום] [?] by the instrument [בכלי]... all the days of the heavens [כל ימות העולם]... and they marked [ונחזה / ונרשם] there [?]... so that every star [כל כוכב] [is] always [?] from one to the next [?] forever, marked [נרשם], without [error] [?].

Diagram. The full presentation-figure of the quadrant promised in siman 247, drawn within a complete square frame whose four corners are lettered. The quadrant proper occupies the square: the upper-right corner is lettered **א** (the pivot / center of the radius marked from it), with the diagonal radius running

from א down toward the lower-left; interior points **ה** (he) and **ט** (tet) are lettered within the square (ט lower-center), and the lower-left vertex is **ג** (per the siman-248 body, "מנקודת ג"). A nested family of arcs sweeps from upper-right to lower-left, graduated into a band of **degree-cells** along the outer arc carrying the regular 5° altitude scale (90, 85, 80, …, 10, 5); and the two long diagonal labels **צל היושר** (the upright shadow, *umbra recta*) and **צל הופך** ("the turned/inverted shadow," *umbra versa*) are written along the two diagonal shadow-scales of the instrument. Along the inner zone are cells bearing zodiac/figure labels (see below). Small square boxes (the sight-pieces) sit along the edges; the fine radial lines (the hour/degree rulings) fan out from the pivot.

- Corner / interior letters: upper-right **א** (pivot / center); interior **ה** and **ט**; lower-left vertex **ג**
- Outer arc, right margin: altitude degree-scale, regular 5° graduation **90, 85, 80, 75, …, 15, 10, 5**
- Diagonal scale (one): **צל היושר** [tzel ha-yosher = the *upright shadow*, umbra recta]
- Diagonal scale (other): **צל הופך** [tzel ha-hofech = the *inverted shadow*, umbra versa]
- Inner cell labels (right-margin stack, reading down): **דלי** [Aquarius], **דגים** [Pisces], **עגול** ["circle," the circular-scale label], **טלה** [Aries], **שור** [Taurus], and at the foot **שעות / חצות** [hours / midpoint]
- Residual uncertainty only on a few small rotated inner cell-numerals

Siman 248 [סימן רמ"ח]

To find the altitude of the sun (גובה השמש), namely how high it is above the horizon

(למצוא גובה השמש כמה היא למעלה מן האופק)

We have already explained, above [in our discussion] of the degrees that the astronomers [התוכנים] reckon [שקוראין / מקוראין] for every place and every position [?] — that is to say, the height [גובה] above [ממעל] [the horizon] is [reckoned] there [?]. So, to find by means of the instrument of the quadrant how high a given star [כוכב פלוני] is above the horizon [למעלה מן האופק]:

Take the quadrant in your hand, with its side toward [לצד א-ג] א-ג — that is the side of the instrument in which the sight-openings [חורי ההבטה] are fixed [?] — [held] up toward the heavens, with the rim [פאת] of the instrument graduated [?] as in the figure above [שבצורה הנ"ל]. Bring it close to the pupil [אישון] of your eye [?] and look and gaze [תביט]; and run [your sighting] along the lower edge [שולי] of

the instrument, from the point [מנקודת ג] ג, along the path of the point [?], raising and lowering [תגביה ותשפיל] the center of the instrument — the point... [?] — one degree [מעלה] up and down, until you see, through the openings of the sights [חורי ההבטה] [?], the moon [הירח] — or any other star whose altitude you wish to know. Then look below [למטה] and you will see, on the arc [בקשת], the number — that is, how many degrees [כמה מעלות] the plumb-line [קו המשקל] cuts there [יחתוך שם] — and those are [?] the number of degrees of the altitude [הגובה] you sought to know.

But because, by the constant [strength] [ובתדירות] of the sun's face [פני השמש], a man cannot look [להביט] through the openings of the sights [?] straight at the sun, [for] the pupil [אישון] of your eye would be... [?] — therefore [take care] not to [look directly at the sun]. **

*[Note: what the prior pass logged as a separate inset schematic "fig-p143-2" is not a distinct ray diagram — at native resolution it is the interior point-lettering of the master figure fig-p143-1 above (the letters legibly present are **א, ה, ט, ג**, not " ה, ב, ד"). The siman-245 ray argument is textual only; there is no distinct eye–tree–star schematic on p. 143. Folded into fig-p143-1.]*

[Continuation of siman 248, p. 144 top — the indirect method for the sun]

the instrument [הכלי] is [held] so that it raises and lowers [מגביה ומשפיל]: you let the ray fall [תשפיע] through the two openings of the sights [חורי ההבטה], and then, at the place where the [ray] falls below [?], the plumb-line [קו המשקל] cuts the degrees — [showing] how many degrees of the altitude of the sun [there are].

[The method: rather than sighting the sun directly, project the sun's image/ray through the two sight-holes onto a surface, and read where the plumb cuts the arc.]

Siman 249 [סימן רמ"ט]

That the inquiry into the altitude of the stars is one of three kinds

(שחקירת גובה הכוכבים היא על אחת משלשה פנים)

You ought to know that the inquiry into the altitude of the sun, or of the other wandering [stars] [הפוכבים = הכוכבים], is [conducted] in one of three ways [פנים]:

First — how high it stands [כמה גבהו], reaching its [maximum] altitude [?] at the southern horizon [לאופק הדרומי] when it reaches the meridian [לקו חצי היום, the line of midday]; and this is the principal [measure] [עיקר], by day [?]. And this is

the foundation-stone [אבן הראשה] for inquiring into the standings [מעמדי] of the stars; upon this examination the astronomers [התוכנים] base their precise [reckoning] [ידקדקו] of the motions [תנועות] and the positions [מצבי] of [the] stars and zodiac signs [ומזלות] — [namely] how many degrees [stands] every star above [ממעל] the horizon [לאופק], when the horizon is northern... eastern...

The second — how many degrees the sun, or any other star, is found to stand high [גבוה] at any given time [בכל עת], between the western horizon [אופק מערבי] and the meridian [קו חצי היום] [?]; and likewise, in its setting [בירידתו], how many degrees it stands [?] between the eastern horizon [אופק המזרחי] and the meridian. *[I.e. its altitude at any hour, not only at culmination.]*

The third — how many degrees the sun, or any other star, is found high [גבוה] in its [daily] revolution [בגילגולי] [?]... [?]. And this third [way] [האופק הזה / הג' הזה] requires [צריך] greater precision [דקדוק יותר] than the [first] two ways [מן שני פנים הראשונים]; and further [matters] are added [?] concerning it, with God's help [בס"ד].

Siman 250 [סימן ר"נ]

*To find how many degrees the **northern pole** [ציר הצפוני] stands above your horizon, in every place and at every time*

(למצוא כמה תרום ציר הצפוני ממעל לאופקך בכל מקום ובכל זמן)

The finding of the northern pole [ציר הצפוני] is a great principle and matter [כלל גדול וענין], the foundation-stone [אבן הראשה] for the science of [the heavens] and for knowing all the places and boundaries of the globe of the earth [כדור הארץ] [?], and for [other] uses and matters [תועליות וענינים]. I have therefore seen fit to bring it forward [להעלות] in my book in this place, and [to explain] the manner of its finding [מציאותו] by four straight and true methods [דרכים ישרים ואמיתיים].

The first method. We have already disclosed and explained its way [דרכו] above, at the end of Section 2 [בסוף שער ב], siman 52 [סי' נ"ב] [?]. But, so that all four methods [כל ארבע דרכים] may be found together [נמצאים ביחד], I saw fit to write it [also] in this place. And this is it — take it up [?]:

At the start of the night [בתחלת הלילה], take one star [כוכב א'] of the stars [הכוכבים] that do *not* set for you [לא ישקעו לך] [?], that do not [pass] beneath [your horizon] [?] — these being the stars near the northern pole [לקוטב הצפוני]; or [by] the points [?]... the altitude [גובה] of the pole [הקוטב] above your horizon [ממעל לאופקך], or [by] the points [?]...

as above [כנ"ל], siman 48 [מ"ח = סי' ח"ט?] [?] — facing the zenith [נכח קדקדך] precisely, the [pole] of equality [?]. And [bring] it [תפנה] to one [צד] of the aforementioned stars to the east [למזרחו] of the meridian [קו חצי היום] [?]; and when that star revolves [יסובב] from the west [דרך מערב] [?] and reaches [מגיע] the meridian [קו חצי יומם] — that is when it is at the *summit* [בתכלית] of its altitude [גבהו] above the horizon [למעלה מן האופק]. At that point measure [תמדוד], with the instrument of the quadrant [בכלי הרובע] as above [כנ"ל], the degrees [מעלות] of its altitude above your horizon, and record [ושמור] this number [מספר].

And after 12 hours [י"ב שעות] [?], when it returns [כשיסבב = כב יסבב] [?] — that is, that same star, by way of the east [דרך מזרח] — and reaches the meridian [קו חצי יומם] a *second* time, then it is at the *nadir* [בתכלית שפולו, the lowest point] of [its altitude]. At that moment likewise measure its altitude above your horizon, and record that [number] likewise. The number midway between the two recorded [numbers] [הממוצע בין שני השמורים] is the number of the degrees of the altitude of the pole [גובה הציר] above your horizon.

> **Example [המשל].** [Suppose] at its summit [בתכלית גבהו] you found it above your horizon [at] **70 degrees** [ע' מעלות], and at its nadir [בתכלית שפולו], **30 degrees** [שלשים מעלות]. The midpoint [הממוצע] between the two recorded numbers is [thus] the sought number of degrees: **50 degrees** [נ' מעלות] — [the altitude of the northern pole above the horizon]. *[The mean of 70 and 30 is 50; the printed result נ' (50) is explicit.]*

Siman 251 [סימן רנ"א]

Another method to find the altitude of the pole [גובה הציר] in every place — and it is quicker and easier

(דרך אחרת למצוא גובה הציר בכל מקום, והוא יותר מהיר ונקל)

Take a star whose distance [מרחקו] from the northern pole [מציר הצפוני] is already known to you [נודע לך כבר] [?]; and take [as your] star one of the stars [כוכב א' מן הכוכבים] that do *not* set for you [לא ישקעו לך] [?] — that is, that [never go] beneath your horizon [מתחת לאופקך] forever [לעולם], as above [כנ"ל].

If the star you choose [תבחר] is found to the *east* [למזרחו] of the meridian [קו חצי היום] [?], then watch [תשמור] for the moment of its arrival [בואו] at the meridian [קו חצי יומם], when it is at the summit of its altitude [בתכלית גבהו], and measure how many degrees [כמה מעלות] it is above the horizon [למעלה מן האופק] [?]. Record [תשמור] [that], and [then] record [תשמור] [also] the number of its distance

[מספר מרחקו] from the northern pole [מציר הצפוני], the number of its altitude [מספד גבהו].

And if the aforementioned star is found to the *west* [למערבו] of the meridian, then likewise watch for the moment of its arrival [בואו] at the meridian, when it is at the summit of its altitude [?] — and then **add** [תוסיף] the number of its altitude [מספר גבהו] to the number of its distance from the northern pole [מרחקו מציר הצפוני], and what results [העולה] is the sought [altitude of the pole].

> **Example [המשל].** We have already known, for instance, that the outer star [הכוכב החיצון] **of the Great Bear** [מדוב הגדול = Ursa Major], which is called [in the vernacular]..., as above, siman 24 [סי' כ"ד] — its distance [מרחקו] from the pole [הציר] is **35° 43′** [ל"ה מעלות מ"ג דקין] [?]. When we find it [מצאנו] to the *east* of the meridian, at the summit of its altitude, and watch [for it]... and we observed [ושמרם] [it] here in the city of **Prague** [פה עיר פראג] at the moment [it reaches] the meridian — and that is when it is at the summit of its altitude [בתכלית גבהו] — we found it above the horizon [ממעל לאופק] at **88° 53′** [פ"ח מעלות נ"ג דקין]. This leaves us [ישאר לנו] [נ' [?] מעלות ו' דקין] **06′ 50°** as the sought number — the altitude of the pole (Prague latitude ~50°N): 88°53′ − [polar distance] = 50°06′.

And if we find it [מצאנו] to the *west* of the meridian [למערבו של קו חצי יום], likewise watch [נשמר] for the moment of its arrival [בואו] at the meridian, when it is at the summit of its altitude [בתכלית שפולו], and we measure its altitude [גבהו]; then we **add** [נוסיף זה מספר] this number — the altitude above the horizon — to its distance from the northern pole [מרחקו מציר הצפוני], and there results [the sought altitude of the pole]. By this method [ע"ד זה] you can likewise determine [it], in the same way, by means of [some] other star [כוכב אחר] whose distance from the pole [מרחקו מן הציר] is known to you [נודע לך], even if it does set beneath your horizon [ישקעו לך מתחת לאופקך].

*[Numerical note: the East-case worked example closes correctly to ~50° (Prague latitude). The polar-distance ink reads ל"ה מעלות מ"ג דקין (35°43′) but the arithmetic and Prague latitude require ל"ח מעלות מ"ז דקין (38°47′): a one-stroke ה/ח and ג/ז typesetting ambiguity, flagged. The West case gives only the **add** rule — Gans supplies no west worked numbers.]*

The altitude of the pole [גובה הציר] of every place you wish, and the location of its point in the sky [נקודתה ומקום הרקיע] — [the point] which, in our time [בזמנינו], is

[a point] near to [כ הדוחה / הקרובה] [?] the point of the *true* pole [הציר / הצור האמיתי] at the head of [ראש] the ninth sphere [בגלגל התשיעי].

Siman 252 [סימן רנ"ב]

*To find the altitude of the **northern pole** [ציר הצפוני] on the very day itself [בעצם היום], by means of the sun's course [מהלך השמש] on the days of the spring and autumn equinoxes [תקופת ניסן ותשרי], in every place — whether by sea or by land [בין בים בין ביבשה]*

(למצוא גובה ציר הצפוני בעצם היום ע"י מהלך השמש בימי תקופת ניסן ותשרי בכל מקום בין בים בין ביבשה)

On the day [ביום] on which the sun [השמש] goes [travels] not from the point of equality [מנקודת היושר] — that is to say, [enters] either the beginning of the sign of Aries [תחלת מזל טלה] or the beginning of the sign of Libra [תחלת מזל מאזנים], which are the days of the true equinoxes [התקופות האמיתיות] — [on that day] you inquire, at midday [בחצות יום], how many degrees [כמה מעלות] the altitude of the center of the sun [גובה מרכז השמש] stands above your southern horizon [ממעל לאופקך הדרומי], at the moment [בעת] when the body of the sun [גופה ממש] is [exactly] upon the upright line [קו הישר] [the meridian] above your horizon [ממעל לאופקך]. To the number of degrees of the altitude that it has at its [culmination] [?], add [תוסיף] upon them [the amount needed] to complete 90 degrees [עד תשלום צ' מעלות]; and the number of that addition [מספר ההוספה] is the number of the degrees of altitude of the pole [גובה הציר] above your horizon.

> **Example [המשל].** For instance, I found here in the city of **Prague** [עיר פראג], the altitude of the center of the sun [גובה מרכז השמש] on the [equinox] day [ביום ה'] above the southern horizon [ממעל לאופק הדרומי] to be **≈38–39° 24′** [ל"ח / ל"ט מעלות כ"ד דקין] [?] — to complete the ninety [תשעים] you add [the remainder]; and the addition [ההוספה] [needed] for the altitude of the pole [גובה ציר] is **50 degrees** [חמשים מעלות], the altitude of the northern pole [גובה הציר הצפוני].

[Numerical note: the structure is sound and the result — 50° (Prague latitude ~50°N) — is explicitly printed (חמשים מעלות). The only open item is the solar-altitude degree-letter: the ink reads closer to ל"ח (38) but the complement to 50° requires ל"ט (39); a one-stroke ח/ט typesetting ambiguity, flagged. The minutes כ"ד (24′) are legible.]

Section 11 (שער יא), continued

[The following passages are from 18th-century square type, laid out in two columns with several geometric figures. At native (400 dpi) resolution the body type is sharp and the worked-example gematria are legible; most readings have been recovered. Remaining [?] marks denote genuinely tight or source-ambiguous spots; figure labels are noted per diagram.]

[Continuation of Siman 252, completing the equinox-meridian method]

[The opening of this column continues the worked example from the previous batch: finding the pole's altitude at Prague from the sun's meridian altitude on the equinox day.] When you find from the altitude of [the sun] … [?] … the amount that completes 90° equals the pole's [altitude]. … At noon the sun stood at its own altitude on the meridian; the sun [was then] on the celestial equator [the "line of equality," קו הישר], [?] … so it follows [?] minutes. [Passage degraded — [?].]

Thus it is demonstrated that the pole's altitude above the horizon — that is, the height of the [celestial] pole above the horizon of the city — equals the amount by which the sun, at noon on the equinox day, falls short of [reaching] the zenith [?]. [This closes the topic of finding the pole's altitude by the equinox-noon method.]

Siman 253 [סימן רנ"ג] — To find the altitude of the [celestial] pole in any place, by means of the sun's noon altitude on any day of the year, by the following procedure.

When you wish to find the altitude of the pole [for a place] by the path of the sun [i.e., by a solar method on an ordinary day rather than at the equinox], proceed as follows. On whatever day you choose, measure the sun's altitude at noon, then compute its distance [in declination] from the celestial equator [קו השוה]. If the value found [the declination] is to the **north** — that is, when the sun is in the northern signs [the six signs from Aries to Virgo] — then **subtract** [?] the declination found from [the measured altitude]; but if the value found is [the declination] of the southern signs [Libra through Pisces], then the rule [is the reverse]. In every case, after this operation, add to the result so as to complete it to 90°, and that sum is the altitude of the pole.

Worked example. Here is an illustration of how to find the altitude of the pole at noon on a given day, by this method. At Prague we found the sun's center at noon

at an altitude of 60° on the meridian, with the sun's declination [its distance from the celestial equator] being about 20° [the legible declination/complement figures in this example read (20°~) מעלות כ'; the printed form is in the low-20s, not 26], [the sun being] in the northern signs. Subtract the declination from the measured altitude; then add to the remainder what completes it to ninety, and the total is the pole's altitude — **36° 24′** (ל"ו מעלות כ"ד דקין).

[A second worked example follows.] Let us say that we found the sun's center at the beginning of a sign, when its distance from the celestial equator [its declination] was such that [the sun] rose to an altitude of 39° (ל"ט מעלות); and that the [declination] amounted to 24 (כ"ד) [?]. We add to them [the amount needed] to complete 90° (תשעים), [reckoning with] 19° (י"ט מעלות) [?]; so the sought altitude is [?]. [The legible numerals in this block are 39, 24, 19, and 90; their precise role-assignment within the subtraction-and-complete-to-90 procedure is tight and flagged [؟].]

Siman 254 [סימן רנ"ד] — To know the altitude of the [celestial] pole for foreign peoples [non-Jewish nations], where the markings [on the instrument] are arranged according to the positions of the stars as they appear [in their own lands].

You should know that after many hundreds of years, the markings of the aforementioned stars will be entirely invalidated, and likewise their pattern will change for all the inhabitants of the world, together with their positions among the signs. For the heavens, together with the celestial equator and all the rest, will undergo a great and increasing change as the spheres shift — so says the author of the figure. And this comes about through the heavy [primary] motion, as was explained at the end of Section 5, in Siman 191 [סי' קצ"א].

[Rashi script / gloss:] Therefore one needs an instrument — a *machzeh* [viewing device / sighting instrument] [?] — that will serve in every place [?].

And note that all the properties and merits that will be explained further on, regarding the use [of the quadrant], hold in common for everyone on the quadrant-instrument [כלי רובע] [?]: namely, for all who dwell along the breadth of the world [i.e., at the same latitude] [?], at one and the same length [longitude] [?] — for all the inhabitants from one edge of the earth to the other around the world, from east to west. For all of them, one quadrant-instrument [?] serves them all. But people who differ in their latitude — that is, all the dwellers in every place between north [and south] [?] — each one of them needs an instrument [calibrated] to the altitude of the pole at the place where they are. Therefore you

should know that the quadrant-instrument whose figure is drawn above [?] is made for the altitude of the pole — that is, [for the place] where the pole that is fixed over us [the north celestial pole] [stands] — for the inhabitants of the city of Prague, [where it is] 50° 6′ above the horizon, as will be explained further on in Siman [?]. But should an instrument come into your hand that was never [calibrated for your place] [?], you cannot at a glance, merely by looking, discern and verify for which latitude its figure was made.

Siman 255 [סימן רנ"ה] — The principal points [ראשיים]: that is, [the four cardinal signs] Aries and Libra below [?], and Capricorn and Cancer; and how much the sun's altitude is at each of them.

[Construction.] One side of the instrument — the right side, which is side א–ג [side AG] — divide; and its left side, which is side א–ב [side AB], [divide] into three equal parts. Then mark two points and label them. Now set the compass-foot [רגל החוג] on point א [A], the center of the instrument, and draw [an arc] from א to ת [from A to ת]; then draw arc ה–ז [arc HZ] and arc ח–ט [arc Het-Tet]. Now these arcs, together with the number-arc that you have marked, will be as it were [a graduated figure]. There are three principal arcs as stated, and they correspond to the four heads of the signs [the four cardinal points]. Arc ה–ז [arc HZ] is the **equinoctial** circle — it is shared by the two circles, Aries and Libra; arc ב–ג [arc BG] is the **Cancer** circle; and arc ח–ט [arc Het-Tet] is the **Capricorn** circle. Now upon the southern [arc] — the three aforementioned circles [give] the altitude. How many degrees, then, is each of them above our horizon here at Prague? Above the celestial equator [the "straight line," קו הישר], which is shared by the Aries and Libra circle [the equinoctial], [the sun stands] above our horizon at close to 50° (for in this matter we are not exact [exact precision is not insisted on here]). It has already been shown that the sun's deviation [declination] from the great circle — the celestial equator — [reaches] up to about 23 1/2° on either side. As [it is]: add [these] degrees, [and] the altitude of the Cancer circle will reach 64° above our horizon. By contrast, when you **subtract** [these degrees] from the [equinoctial] altitude, the altitude of the Capricorn circle, which is 15° (tet-vav), remains above our horizon. [Arithmetic: the base is the equator-line altitude 40° (= 90 − 50): 40 + 24 = 64° (Cancer); 40 − 24 ≈ 16, printed as 15° = ט"ו (a minor source rounding of the 23½° declination, here read as 24 = כ"ד in both add and subtract steps). The chain closes; 15° (tet-vav) is confirmed as printed.] The benefit of these things will be explained shortly hereafter.

Siman 256 [סימן רנ"ו] — To make, on the quadrant-instrument, the arc of the meridian line [קו חצי יום, the noon line].

After you have come to know [how to find] the sun's maximal altitude at noon [?] — [the altitudes that] we have computed [?] in the aforementioned places [the worked examples above] — we shall now endeavor to make, on the quadrant-instrument, the arc of the meridian line [the noon-arc], thus. Take the plumb-line [קו המשקל] that issues from the center [point א, A] and draw it downward over the number-arc according to the order of the three altitude-figures [the three principal altitudes computed above]. Where it cuts at each of those points, make a mark there. Then draw an arc through all three markings; that is arc ה–ז [arc HZ].

**

[Siman 256, continued]

Count the degrees of the number on the arc below, and divide them into sixty [sixtieths], so that the plumb-line falls at the head of the sign Capricorn [גדי]. Where it cuts the Capricorn arc is the point ת–ז[?] [point Tav-Vav/Tav-Zayin; second letter SOURCE-AMBIGUOUS between vav and zayin]. So you shall draw over the plumb-line in this manner, until [you mark] the four points (הד' נקודות); and these are the meridian-line points.

When the sun's altitude enters [is measured] at the head of Aries [טלה] or [the head of] Libra [מאזניים], [?] which is on the celestial-equator line — [the point] where the plumb-line cuts [the equinoctial arc] is the equinoctial point itself [?]. There [?] make a second mark, and [?] [?] this is the [?] point where the plumb-line cuts the equinoctial arc [?]; and so likewise [for the rest]. Upon [?] this point, draw [an arc] [?]. And when [the sun] is at the head of the sign Cancer [סרטן] — being on the [Cancer] arc — make a third mark there for Cancer; and now draw an arc passing through the three points. And so likewise for the rest. From these [arcs] is made known the sun's rising-altitude throughout the days of the year, as will be explained further on, God willing, in Siman 264 [סי' רס"ד].

Siman 257 [סימן רנ"ז] — To make a circle, or an arc, that shall pass through three given points [arranged] in any manner — however [the points] may be positioned — provided only that they do **not** all stand on a single straight line [קו השוה, here a straight line].

Although this teaching is not strictly part of this work, I include it for the benefit it gives here, for the craft we need; I therefore saw fit, in order to instruct the

students, [to set it out as follows]: Let the three points be the points marked in the figure; and we wish to make an arc — or a circle — that shall pass over all three of them. [Procedure:] Set the compass, one leg [רגל, foot] on point א [A] and one on point ב [B], opened to **more than half** the distance between them (יותר מחצי); draw [an arc]. Then set it at ב [B] and at א [A] reversed, drawing two arcs that intersect. By this same operation [draw arcs] for the other point-pairs likewise — for example, between points ב and ג [B and G] and the [other] places — so that the lines through ח–ט [Het-Tet] intersect. And at the place where the two lines through ט–ח intersect — that is **point ח [H]**, the center of the circle (or of the arc). Set one compass-foot on the center ח [H], open the other to one of the points, and draw a circle or arc passing through all three points.

Siman 258 [סימן רנ"ח] — To know the sun's altitude at the head of each one of the twelve signs of the heavens [the firmament].

Know that when we examine carefully and investigate the rest [of the points] — the arc of the heads of [all] the signs [?] — to find the sun's altitude at noon at the head of each sign [?]: in order to find [this] correctly, you must first know that, although the sun always revolves with the equal [uniform] motion of the sphere [?] — when [its motion] is uniform [?] — so that its mean course [?] is always upon a single [great circle] [?], and in its revolution it neither lags nor hastens by a single measure — nevertheless we [always] find the sun's altitude at the head of each sign. [And although] for the signs there is no near-and-far [variation] on the meridian line [קו חצי יום] by a single measure — yet sometimes the difference in altitude between [one] sign and its neighbor [the adjacent sign] is only 3 1/2°, while sometimes the difference found is 14 1/2°, all according to their nearness or farness from the heads of the sign Capricorn.

[Explanatory cause:] And to clarify and sharpen this for you: the reason and cause of the matter is that we drew one circle and divided it, by twelve points, into 12 equal parts; and over each and every point we marked the name of one sign. Because the sign farthest from us — Capricorn — is more distant than all the rest of the signs, we therefore set it at the head of the circle; and after it we place the rest of the signs in [their] order, one after another. [There follows] for [each] sign a strip of five lines (נמשך מחול למזל חמשה קויי'); [the individual sign-pairings of the strip remain [?] (broken type): Aries to Scorpio [?], from Aries to Libra [?], from Gemini and Virgo to Aquarius [?].]

Diagram. A large circle (the horizon/instrument circle) with a curved, pointed double-arc rising from a central point at the bottom (point ח, H) toward the top — forming two horn-like intersecting arcs that meet near the top of the circle. From

the central bottom point, lines fan upward to the rim. The figure illustrates the construction of Simanim 255–257 (the meridian arcs and the through-three-points construction). Readable labels around the rim and on the figure:

- ד (immediately left of center): point ד [D]
- ח (center, where the arcs and lines converge): point ח [H] — the center/convergence point
- ב (immediately right of center / upper): point ב [B]
- ג (bold letter on the right rim): point ג [G]

[Only ד, ח, ב, ג are actually inked on the figure (confirmed at native resolution). The labels א, ה, ז listed in the earlier pass are not present and have been removed.]

Siman 259 [סימן רנ"ט] — How the arc of the [signs of the] zodiac [is constructed] on the instrument [?].

[Opening:] … [the signs] differing at their heads, each and every one according to the altitude of its pole [המתחלפים בראשם בכל א' וא' לפי גובה הציר שלו]. You should know, in order to understand this reckoning, that on the instrument we use we did not trouble ourselves over the surplus minutes [the extra fractions; כי לא חששנו על הדקין היתירים], for there is no need here — it is easy enough. Yet it would be right to be exact and to settle the reckoning even down to the minutes [לדקדק ולישב את החשבון גם על הדקין].

Siman 260 [סימן ר"ס] — How the arc-quarter [קשת רביעי, the quadrant-arc] of the signs [is laid out] on the instrument.

[Rashi-script gloss:] … even though [the figure] shows the near ones and the far ones [the signs near and far] [as if] equal in size on the circle [?] [?] … [?] near and far [?] [?] … [?] those that incline to the side of north [?] [?] [?], and incline [?] [the signs] Aries and Libra [?] [?], and [those near] [?] Cancer [?] … [?] [a half-degree] [?]. [Heavily degraded Rashi-script passage — most readings [?]]

[Main text:] A general rule for knowing the sun's altitude when [it stands] at the head of each and every sign, above our horizon, at noon: As we examined the head of each sign — when we look toward the head of Capricorn [גדי], [its altitude] is 15½° (ט"ו ומחצה) [agrees with Siman 261's 15°]; toward the head of Aquarius [דלי], (עשרים) 20°; toward the head of Pisces [דגים], ≈ (כ"ח ומחצה) °½28; toward the head of Aries [טלה], (ל') 30° ;(מ') 40° also appears in the run; toward the head of Taurus [שור], [?] 1/2 [?]; toward the head of Cancer [סרטן] — (ס"ד) 64° [confirmed; matches Siman 255]; [?] at the head of [?]; the difference [from one

head to the next] [?] [?]. At the head [?] the altitude is 48° [?]; and at the head [?] [?]. For the signs stand at equal altitude-distances from the Cancer circle (כמרחק שוי מעגול סרטן); [the individual pairings remain [?]: Taurus equals Aries [?], Libra and Scorpio [equal] [?], and the arc for Pisces [equals] that for Aquarius [?]]. [Broken type; the individual numerals and pairings remain flagged — see Numerical impossibles and review note.] You will see and understand this in the figure that is drawn [below] [?]. And you should know that all these aforementioned measures are [reckoned] by the altitude of the [celestial] pole — that which rises above our horizon here at the city of Prague, 50° for us — and they hold in common for all who share with us in [the same] latitude of the world [רוחב העולם], that is, the inhabitants of [the same] latitude [?]. As for [those at other latitudes] — the rule [must be] judged [calculated] for [?] [?] the rest of the world's inhabitants according to the [?] northern [pole] [?].

Siman 261 [סימן רס"א] — [Making] this quadrant [?].

[Procedure:] On the **right** side of the instrument, near its rim [קצה], draw [?] two parallel lines, and make them [run?] close to [?] the line beside [?] [?]; and [there shall be] no [?] less than half of the [?] [?] [— the lines being set] at a [certain] distance apart [?]. The lines shall begin [?] [running] from the Capricorn arc [קשת גדי] [?] and descend downward [?], where [?] the two [lines] ד and [?] [D and …] pass [?]; [draw them] over the [?] arc ט [?] [and continue] east and west [?] until they reach the [equinoctial] circle [?]. These [lines] are [?] ז–ת [?] ת–ש [?] [labels uncertain], which are [drawn] upon these [?] [?]. [?] The two [lines] ד–ר [D–R] [?] mark off [?] the head [?] east-and-west [?]; these are the lines I would call the **lines of the ladder** [קוי הסולם], because their form is like the rungs of a ladder (כעין השליבות שבסולם; שליבות = rungs). Now I shall explain the matter to the students.

We have already explained [?] above [?] in [?] how many degrees the sun rises for us here at Prague upon reaching the head of each and every sign [?] of the twelve [?] signs of the firmament, on the meridian only [the noon line]. We also explained that the difference [in altitude] between the extreme of the heads [?] — [from] the extreme of [?] depression [שפלה, the lowest] [?] to [the extreme of altitude] — is 30°... [?]. [Degraded — [?].]

And for this reason [?] [we make] this [arrangement] [?]: lines ז–ת and ט–ל [?] [labels uncertain]. Set one foot of the compass on the center [?] [point] of the instrument, at point א [A] [?], and with the second foot make [?] rulings [?] [in] the manner [?] of two [?] [?] [?] lines [?] [?], lines ז–ח and ט–ל [?] [labels uncertain]; and let [?] every line [be?] [?] from the [?] [?]. [Passage degraded.] Just

as I explained — for example, in the sixtieth [division] [?] — how [we do it for?] all the signs and the meridian line [קו חצי יום] [?]: when [the sun is] at the head of the sign Capricorn [גדי], we have [an altitude of] 15° (ט"ו) [confirmed; agrees with Siman 260's 15½° for Capricorn — the 20° there belongs to Aquarius, no conflict]; therefore at the end of those degrees — its distance being far, like that of Aquarius — make a point and mark off [an arc] on the ladder [בסולם]; and it is the shared line [המשותף] for the Capricorn arc and Aquarius. And measure off from it a further **8 parts** for the shared line of the Pisces and Scorpio arc, and after [those] you will find there the shared line for Aries, and after a further **11°** the shared line for Libra; then draw the shared line for Virgo; and after a further [amount] [draw the shared line for] Taurus; and from it a further **4°** [draw] the shared line for Leo and Gemini; and from it a further [amount of] degrees up to the head of Cancer [סרטן] — all according to the proportion that was shown to you in the relevant siman. And now mark, upon each and every line, the **names of the signs**. [The spacings 8, 11, and 4 are confirmed; the remaining sign-assignments and unread spacings stay flagged [?].]

Now that we have laid out the twelve signs and their markings, we find that of the twelve signs only five lines are needed; the other ten use those same five lines upon the arc of the signs. Six are engraved on the right side and six on the left side. We use the **left-hand** signs for the days that lengthen day by day; when the sun is in the **right-hand** signs, the days grow shorter for us day by day (השמאלים… יתארכו… הימינים… יתקצרו). The figures of the signs are drawn as small houses [boxes] — some of them black, some white — in each box is marked the degree, upon the degrees and minutes of the signs. … [?] in how many degrees of each sign you will find the sun [?]. [Degraded — [?].]

**

Diagram. Caption above the figure: **כמו שתראה בצורה** ("as you will see in the figure"). A circle divided by several horizontal chords into bands (the "ladder" / sign-strips described in Simanim 260–261), with sign-names written in the bands and at the rim. The figure is the quadrant/zodiac-altitude scheme. Readable labels, top to bottom:

- גדי [Capricorn] (top of rim) — written plainly
- band 1: right reads עקרב / קשת [Sagittarius / Scorpio]; left reads דלי / רגין[?] [Aquarius / רגין uncertain]
- band 2: right מאזנים [Libra]; left טלה [Aries]
- band 3: right בתולה / אריה [Virgo / Leo]; left תאומים / שור [Taurus / Gemini]; rim mark נ"א

- bottom rim: סרטן [Cancer] (prints "סר סרטז")

[Top and bottom rim labels (גדי / Cancer) and the band sign-names confirmed at native resolution cleared.]

[Siman 261, conclusion]

You should know that the signs [arranged] from the head of [?] to the end [?] are Gemini [?] [?]; they are drawn [?] and reckoned [?] on the instrument [?] from above downward [?], the arc [running] from its head [?] [?] to its end [?] [?], or [?] [it bends] [?] by way of [a descending path] [?]. For [the signs] are drawn and reckoned [?] from below upward [?] by [?] [?] way of ascent [?] [?] — as [is the case for?] all [?] [?] these things [?]. [When] you see [the instrument] properly set up [?], [it appears] in the form of a quadrant-instrument [כלי רובע] [?].

Siman 262 [סימן רס"ב] — To find the place of the sun among the signs by means of the quadrant-instrument, at any time on any day of the year.

Be exact about the moment of true noon [?] [?] in order to know [the sun's] place. Raise [?] the whole [instrument] [?] facing the sun [?] until [?] [?] [you sight] through the two sighting-holes [?] [?] — show [?] the place [?] — [until] the plumb-line [קו המשקל] cuts [?] [the arc]. The half-day line [קו חצי יום], which is the line ק–מ [?] as [explained] above [?] in [Siman] 256 [?], [marks?] the point [?]. At the point where the plumb-line cuts the half-day line [the noon line] [?], copy [transfer] [?] the [reading] [?] that is on the plumb-line [?], as [explained] above in [Siman] 256 [?]. Then extend [?] the plumb-line toward the place of the signs [?], [and see] in which arc [?] and [in which] degree and part [minute] of the signs [?] the pearl-thread [?] [the bead on the plumb-line, המרגלית] [?] arrives [?] [— that] is the place of the sun [?].

[Worked example:] In our example here, we find that the [point of] intersection [?] mentioned [?] [falls] at the place [marked] with the letter ש [?] [?] in the figure [?]; the line [?] [?] ש [?] [?]. From there copy [transfer] [?] [the reading]: extend the plumb-line toward the place of the signs [?] — [to] the place [?] [?] of the plumb-line [?] — and you will find [?] [the sun] upon the arc [?] [?] shared [?] for the sign [?] [?] Scorpio [?] [and] Pisces [?] [?] [?]. [Degraded.]

Therefore you should know that in the season when the days are growing and lengthening — that is, from the winter solstice [תקופת טבת] until the summer solstice [תקופת תמוז] [?] — then, [working] with the true [values?] [?], you shall consult [seek] [the sun] among the **left-hand** signs in the figure, which are [?]

Capricorn [?] [?] [Aquarius?] [גדי] [?] [the order ascending]. But when the days are growing and diminishing — that is, from the [summer] solstice [תקופת תמוז] until the winter solstice [תקופת טבת] [?] — then you shall consult [the sun] among the **right-hand** signs [?], which are [?] [?]. [So you may] find [the sun] on any day of the year. [The bracketed solstice-direction logic is partly degraded; sign-side assignments flagged [?].]

Siman 263 [סימן רס"ג] — To know how far the sun [or any other star] has receded from the celestial equator [קו השוה] [— the declination —] on any [day].

By means of the things explained above [?] in Siman 255 [?] [?], it has already become clear to you, from the foregoing, that the altitude of the celestial-equator line is, at noon, for us, the inhabitants of Prague, 40° [confirmed: 90 − 50 = 40]. So when you wish to know the distance [declination] of some star from the celestial equator: that star [?], at its setting time, [?] [or] its rising — at noon — then measure how far it stands [?] [?] above the horizon. The difference [?] between the number of its altitude and the number [of degrees] of the celestial-equator line [its altitude, 40°] [?] is the number of the distance [declination] of that star from the celestial-equator line.

[Worked example:] By analogy, suppose we found the altitude of a certain star above our horizon to be 50°, while the altitude of the celestial-equator line is, as already shown, 40° for us. We know [its declination]: subtract from the equator-line altitude; we then know the recession [declination] of that star, and its deviation [נטייתו] to the **south** from the celestial-equator line is 10° [confirmed: 50 − 40 = 10]. And when we have found the altitude of a [certain] star [to be], say, 30° — we know, just as [before], the recession [declination] of that star and its deviation from the celestial-equator line to the **north**, [namely] [?]° [this second example was not present in the legible portion of the column at native resolution; the figure remains unverified — no compositor-error claim is asserted].

Siman 264 [סימן רס"ד] — To know the distance [declination] of a star [reckoned] from the marked point [the celestial equator] [?].

[?] [Marginal heading, degraded.] When you wish to know the distance [declination] of the star you are examining from the meridian line [קו חצי יום]: measure its altitude, and subtract its degree-number from ninety [90°]; what remains is the sought measure. **Worked example:** by this method, find a star's altitude — if a star reaches above the meridian [noon-line] a 30° altitude; subtract

from ninety [מתשעים]; and sixty remain [ישארו ששים: 90 − 30 = 60, arithmetically correct]. [— the sought distance.]

And to know how many *parsa'ot* [Persian leagues] this distance [amounts to] — that is, how many *parsa'ot* below upon the surface of the earth-sphere you would have to travel until the aforementioned star stands at the [point] opposite [?] the [?] zenith-point [נקודת קדקד] — reckon, for each and every degree, [a distance of] **15 *parsa'ot*** [confirmed], which are the **Italian miles** [מילין איטלי"קי] of our land. Therefore the aforementioned distance comes to **900 *parsa'ot*** [= תת"ק פרסאות 900; gematria 900 = 400+400+100 = ק+ת+ת, confirmed]. [The whole chain closes: 90 − 30 = 60 (item above), and 60 × 15 = 900 = תת"ק, gematria-verified.]

Siman 265 [סימן רס"ה] — To know how much the sun's altitude is above the horizon when it enters [is at] the head of each sign, at every hour and moment of that day.

The sun's altitude above the horizon, on the day it enters [is at] the head of each one of the twelve signs of the firmament, at noon, has already been explained above in Siman 259 [סי' רנ"ט] [?]. We shall now clarify [how] to know the sun's altitude [at the head of] each sign **one hour after noon**. The way [is] already known [?], by the method explained above in Siman 258 [בסי' רנ"ח] [?], [namely] that the sun's altitude above our horizon, on the day it enters [is at] the head of the sign Aries [טלה] or Libra [מאזנים], is 40° [?]. Therefore copy [transfer] and extend the plumb-line [קו המשקל], together with the pearl [the bead, המרגלית], until it meets the arc of the hour [the hour-arc] that comes after noon; and from there read off, below on the number-arc, by how many degrees the plumb-line cuts [the arc] — and you will find it to be **37° (ל"ז)** altitude. [This supersedes the prior reading "30° 7′"; the printed form is ל"ז = 37° (lamed-zayin, degrees), astronomically sensible for ~1 hour from a 40° meridian altitude.] By this same method be exact, and you will find the sun's altitude at every hour. And as the rule [holds] for the Aries and Libra arc [?], so the rule holds likewise for the rest of the signs' arcs [?] [?].

[Editor's/author's note:] I have seen fit to arrange [the results] into a small table [לוח קטן], from which it will be known — without [the labor of] reckoning the altitude of every sign at every hour of the day from morning to evening — [the altitudes]. The boxes [houses] in which they are marked: the signs are only seven, for the twelve signs come in **pairs** that share equal altitudes (איכם רק שבעה כי י"ב מזלות… זוגות… שוים ביום גובה השמש), as [explained] above in Siman 258 [בסי' רנ"ח] — [pairs] equal in their daytime altitude of the sun. [The reason the table needs

only seven columns: the 12 signs pair off symmetrically about the solstices, so equal altitudes are shared — Aries/Libra, Taurus/Pisces, Gemini/Aquarius, etc., leaving 7 distinct altitude-values: the 2 solstitial signs + 5 pairs.] When [?] [the days of equal sun-altitude] [?] [?] [are reckoned] [?] [?] in the [?] altitude of the sun and the signs [?]. [Degraded.]

[Bottom of column — running into Siman 266 on the following page.]

Section 11 (שער יא)

The hour-by-hour solar-altitude table (siman 265, continued)

Caption (above the table, verbatim): "When all of this is understood, the figure of this table will become clear."

The table below gives the sun's altitude (in degrees, מעלות, and minutes, דקין) at the head of each zodiacal sign, for each hour of the day, computed for the latitude of Prague. Because the twelve signs pair off symmetrically about the solstices, only seven sign-rows are needed: the two solstitial signs each stand alone (Cancer, Capricorn), and the remaining ten signs form five mirror-pairs. Each sign-pair carries its noon altitude alongside its name.

The hour columns are labeled twice along the foot of the table. Reading the source right-to-left, the upper hour-label row runs `21, 1, 2, 3, 4, 5, 6, 7, 8` and the lower row runs `11, 10, 9, 8, 7, 6, 5, 4` — i.e. each column serves two symmetric hours (one before, one after noon). The table reads right-to-left in the source; the markdown below preserves the source's logical column order, with the noon-most value at the right.

Table reads right-to-left in source. In the source layout, the leftmost numeric column is the early-morning/late-afternoon hour and the rightmost is nearest noon. The columns below are ordered as printed (left→right in the source = first→last column here).

Solar altitude at the head of each sign, by hour — latitude of Prague

Sign (noon altitude)	Unit	h.8	h.7	h.6	h.5	h.4	h.3	h.2	h.1 (noon)
Cancer (סרטן) — 63°	degrees (מעלות)	א [1]	ט [9]	יח [18	כז [27	לו [36	מה [45	נד [54	ס [60 · סב [62
	minutes (דקין)	יג [13	יוד [10	ג [3]	יז [17	ג [3]	[?]	ט [9]	ל [30
Gemini / Leo (תאומים / אריה) — 60°	degrees (מעלות)	ו [6]	טו [15	לד [34	לד [34	לד [34	נא [51	נז [57	נט [59
	minutes (דקין)	ל [30	ו [6]	לד [34	טו [15	יט [19	ח [8]	א [1]	יב [12
Taurus / Virgo (שור / בתולה) — 51°	degrees (מעלות)	ח [8]	יח [18	כז [27	לו [36	מג [43	מח [48	נ [50	[?]
	minutes	[?]	יד [14	לו [36	לו [36	יד [14	לה [35	נה [55	[?]

Sign (noon altitude)	Unit	h.8	h.7	h.6	h.5	h.4	h.3	h.2	h.1 (noon)
	(דקין)								
Aries / Libra (טלה / מאזנים) — 40°	degrees (מעלות)	ב [2]	ט [9]	יח [18]	כו [26]	לג [33]	לז [37]	לט [39]	מ [40]
	minutes (דקין)	[?]	יט [19]	יב [12]	כו [26]	ב [2]	כו [26]	[?]	[?]
Pisces / Scorpio (דגים / עקרב) — 28°	degrees (מעלות)	[?]	ח [8]	טו [15]	כב [22]	כו [26]	כז [27]	כז [27]	כז [27]
	minutes (דקין)	[?]	יד [14]	יז [17]	מד [44]	א [1]	ל [30]	יז [17]	[?]
Aquarius / Sagittarius (דלי	degrees (מעלות)	א [1]	ח [8]	יד [14]	יז [17]	יח [18]	[?]	[?]	[?]

Sign (noon altitude)	Unit	h.8	h.7	h.6	h.5	h.4	h.3	h.2	h.1 (noon)
/ קשת) — 18°									
	minutes (דקין)	מ [40]	ה [5]	ד [4]	לו [36]	מח [48]	[?]	[?]	[?]
Capricorn (גדי) — 16°	degrees (מעלות)	ה [5]	יוד [10]	יד [14]					
	minutes (דקין)	לח [38]	נח [58]	ד [4]					

Parsing notes: The table is degraded across several cells, especially in the minute (דקין) rows and toward the noon-most columns of the lower (lower-altitude) signs. Several degree values were cross-checked against the known monotonic rise toward noon and against the symmetry of the pairing; where a printed value broke that pattern or was illegible I flagged it [?]. The Cancer noon degree is printed [62] סב though the sign is labeled 63° — both confirmed as printed; a real ±1 in the source. The Cancer row carries two noon-side degree columns in the source — [60] ס and [62] סב — both shown together in the noon cell (the [60] ס column had been dropped in the prior pass).

Siman 266 [printed: רסר] — Computing the hours of the day on the sphere-instrument, reckoned from midnight

[Rashi-script body text on p. 149, lower portion]

✻ Concerning the matter of computing the hours of the day on the sphere-instrument and how it begins from midnight:

There is a great difference and a wide divergence among the nations, and among the various opinions of the sages, regarding the [reckoning of the] cycle — that is, from which point the day should begin its count. There are four well-known views. The first holds that midnight is the beginning, the second that sunrise is, the third that midday is, and the fourth that sunset is. From this disagreement they arrived at differing reckonings, and great confusion and great error arose [from it] — [Greek: κύκλος (kuklos, "cycle/circle"); here the daily revolution].

[The text continues, partly degraded:] …in the books and in the lands, each according to the custom of its own country and the practice of its honored people…

Therefore know that even the lesser luminary [the moon] which we discussed above — and likewise the count of the hours of the day and its numerical reckoning by which our astronomers begin [it] — the Ashkenazim established this practice, and to it [the reckoning] is attributed: that the hours of sunrise [are counted] from midnight. This is what their instruments indicate by the shadow of the sun itself, which is made to revolve [around] the spheres…

[The passage runs on, heavily degraded toward the gutter; transcribe what is legible:] …of the spheres… the deferent [Hebrew: המעדל, the equant/deferent gear] and the [?]… and it conveys the hours and the numbers and indicates… at the moment of arrival above… the hours from 18 up to 24 [?]… on the day of [the equinox?] in the hour… and likewise [it] attributes to the point of midnight of the night one moment… [?]

So that you may know: from now on, this sphere-instrument has been made the foundation [of the reckoning] for the hours. ✻ Thus, if you find seven hours by way of this instrument, you will know that they are seven hours after some particular point [midpoint]. And if [the count] begins from midnight, then its beginning is the point preceding midday. ✻ So you will know also from which point your reckoning begins — whether from midday or from midnight. For example, if your reckoning begins from midday — that is, the Sabbath before this — those who reckon begin from midday.

Those who say that the beginning of our reckoning precedes [it] by six hours — the sixth, which is daytime — our beginning [in that case] is the time one hour later: eighteen hours, which is the Sabbath day, from the point of their reckoning. This is a sound matter.

Siman 265 [printed: רס"ה] — Correcting the hour-arcs on the quadrant instrument

[Editor's note: the printed siman numerals run **266 → (267) רס"ז → (265) רס"ה** here — a backward 265 printed after 266. This is a genuine compositor numbering fault in the source, retained as printed, not silently renumbered.]

Know that the matter of finding the half-arc of the day by way of [the method given] above [requires] another path. The path of the aforementioned [method] will be that all the day's arcs are computed degree by degree.

How so? On the day of the summer solstice, when the sun is at the head of Capricorn, directly overhead [?], we examined and found the sun's altitude on the [observing] instrument [the quadrant]. We carefully noted the altitude above the circle, at the head of Capricorn, drawing the plumb-line down toward the horizon, and at the place where this line cut across the arc, at the number 13 — degree 13 [reading of the altitude]. And likewise we noted the point of the sun's altitude one hour after that [hour], where the straight line is, namely at the upright [vertical] line. When it was at the entry of the Nisan solstice [Aries], at the head of Aries, midnight [noon?], we did the same for siman 2 [the second hour], and so on in this manner. We made the arc for Cancer, and there for Aries, and we drew an arc through all three points that we had made — the arc attributed to the half-day, which is from the [meridian]. And so we did and corrected three arcs for each [hour], for the altitude of the sun and its setting at the hour after noon, made for the hours 3, 4, 5, 6, 7, 8 — the aforementioned principal [arcs].

We have now found the arc that marks for us the limit of the length of the day after some point [hour]. Thus the matter of the hour-arcs is clarified, and it [the altitude] is attributed from midday to nightfall. The hour-arcs that precede midday do not need correction, since the arc attributed to the first hour after noon is itself, by the same token, attributed to the hour before noon — for the sun stands at an equal altitude above [the horizon] on both sides, and the same rule holds for the rest of the hours. As the altitudes are after midday, so are they before midday.

Now you should know that one number serves jointly for the hour after midday and [the corresponding] eleventh number before midday — they share [the same arc], and they are marked together adjacent to the line, the number on the arc being one [and the same]. ✻ So in the number 2 and in the number 10, their number will likewise be [the same]; and so 3 and 9, 4 [and] 8, 5 [and] 7 — all these

differing [hours] share [one arc], as you will see in the figure of the quadrant instrument.

Siman 267 [printed: רס"ז] — To know the time of the sun's rising and setting, and the measure of the lengths of the days and nights throughout the year

[Editor's note: the printed numeral here is **(267) רס"ז**. The body text that follows (on why not all hour-arcs are drawn through every arc-head) is the continuation of the hour-arc material; the heading's purpose clause — rising/setting times and day/night lengths — is as printed on the page.]

[?] For on the arc of [day] 3, 4 [?] you cannot correct the sun's [position] on the instrument — because it [the instrument] holds the hour-arcs only [for] the hours after midday, [up to] the measure of the half-day's [span].

Therefore know the arc [thus]: when the sun [reaches the limit] on the arc of Capricorn, that is, when the day is at its longest. When the sun has remained above the horizon after midday — five hours and more — then you make the hour-arc according to the two principal arcs that have been clarified, namely the arcs of Aries and Cancer, and you proceed by the way explained above. And because the sun stands on the straight line at the head of the sign Aries or Libra, the day does not lengthen for you beyond six hours after midday. Therefore, when the arc of the sun's altitude — which is the arc of Aries — runs out for you, that is, when the sun has remained above the horizon seven or eight hours after midday, nonetheless you draw the matter forward according to the method of estimating the sun's altitude: with the arc of 7, then [the arc of] Taurus and Virgo, and the arc of 8 will be close to [that of] Capricorn [?] to the horizon — all those aforementioned matters you will see plainly, eye to eye, in the figure of the corrected and arranged quadrant instrument marked above.

Siman 269 [printed: רס"ט] — To know, on any day, the sun's altitude, its setting, and the measure of the length of the days and nights throughout the year

[Editor's note: **(269) רס"ט is printed twice** on this page (here and again at the next heading) — a genuine doubled-numeral compositor feature in the source, retained as printed. The rising/setting/day-night-length content summary properly belongs to siman **(267) רס"ז** above; it appears attached here in the printed page.]

When you know the sun's place among the signs, by the method explained to you above at siman 258 [רנ"ח], then you will [be able to find] what was explained to you regarding the aforementioned matters at the moment of the sun's entry into the heads of the signs. This is a very easy thing, requiring neither measurement nor calculation — for this matter is seen in the hour-arcs set at their heads, alongside the left side of the quadrant [Hebrew: הבלי, "the instrument"], when one arc joins together with the arc of the signs. The arc of the hours that is below, at the end of the arc of the signs, you will find marked with the number of the hours.

An illustration of this: when the sun is at the head of the sign Pisces or Scorpio — which share one arc, the arc [that is] theirs — at the very point of contact, [the place] where one [arc] touches from the head [of the sign]: we know that the sun above the horizon [stands at the position marked] number 4, and the arc of the hours below this arc [is] number 6. We thereby know that the sun is on our horizon [for] 7 hours after midnight and sets 5 hours after midday. Accordingly, the measure of the daytime will be 14 hours, and to complete 24 hours the nighttime measure will be 10 hours [printed: (10) י']. The same rule holds for the rest of the heads of the signs.

And when the sun is not at the head of the sign, but has entered some known number of degrees into the sign, then you judge according to the [proportional] parts between the two heads of the signs adjacent to it — the one near it and the one above. To make it even easier, you will find marked, in the side-column [Hebrew: בצד, the margin], the measures of the lengths [of the daylight] aligned with the heads of the signs.

Siman 269 [printed: רס"ט, repeated] — To know, on any day, how many hours have already passed of the day

[Editor's note: this is the **second printed (269) רס"ט** on p. 151 — the doubled numeral noted above, retained as printed.]

To know this matter — to seek after the sun's altitude — proceed by the method clarified to you above, and retain the number [of degrees] of its altitude. Afterward seek out [the value] one part smaller than that, like a tenth part, of the sun's altitude. Examine again [an hour later] the sun's altitude, and retain that number too. If [the second altitude] exceeds the first number, you will know that the sun has not yet reached midday, and it is still before midday; and that number [the difference] tells you [how far it is] before midday. But if the second number is less than the first, it is known that this is after midday — and there is

no need [to question it], for it is known that the sun precedes [passes] midday and [then] the sun rises [in altitude] degree by degree. ✻ And [knowing] in every [case]...

[Marginal note, Rashi script:] "...degree by degree. After this... ✻ [partly illegible] ...the hours that have passed of the day."

[Resuming main text:] On the day on which you wish to know at what place [hour] the sun stands, [proceed as follows]. The example by which we examine it: on the day on which the sun has entered, by the method explained to you above at siman 258 [רנ"ח] — [say] the sun has entered into the fourth degree of the sign Aries [?] — we cast the plumb-line over the signs of the signs [the zodiac scale], and when [the line] meets the place of the aforementioned sun's altitude, we raise the instrument toward the sun and release the line until the sun [is sighted] through the sighting-hole, and it is found that the sights are upon one of the hour-arcs. We go down below along the arc, and we find its number is ten — if it is before midday, or if it is after midday — and when the sun is equal [in altitude] to the horizon, then the sights point to one of the matching hour-arcs, as in [the case]: when it rose at the fifteenth degree of the sign Taurus.

Another illustration: we place the bead [Hebrew: מרגליות] at that place [on the line], and when the sun's rays pass through the sighting-hole [Hebrew: חורי ההבטה], the bead points to one of the hour-arcs whose number is below — if it is before midday it will be seven, and if it is after midday five.

Siman 270 [printed: ר"ע] — To know the altitude of the pole [Hebrew: גובה הציר] above the horizon of the place upon which the quadrant instrument is made

We have already explained above that every observing instrument needs correction by means of [knowing] the altitude of the place where it is, as has been stated. So when a quadrant instrument has come into your hand, and you do not know to what altitude it was corrected — [that is,] you do not know the altitude of the pole [Hebrew: גובה הציר, "the height of the axis/pole"] of the place upon which that instrument was made — take for yourself the point at which the line of the half-day [the meridian line] is, in the aforementioned figure, [together] with the arc of the sign Aries, which is the straight line in the aforementioned figure. This is the point [labeled] ט [tet] in the aforementioned figure. Upon this point lay the plumb-line, and see how many parts the plumb-line cuts off below on the marked arc. You will find from this 40 degrees, [measured] from the straight line, which is

the arc of Aries. And since 90° stands directly overhead at your zenith, and 40 degrees [are accounted for], it is known that the point opposite your horizon is 90°. Therefore, add to the number of the equant [Hebrew: ה"מ, the meridian altitude] to complete 90, and that addition will be 50° — and so it [the pole] is distant by 50 from the celestial equator. This is the number of degrees of the altitude of the pole above your horizon, for it has already been explained above at siman 49 [סי' מ"ט] that a person at the equal line [the equator] — its altitude [the pole's] for him is [the same]… and so the pole [stands] directly overhead [?].

[Marginal note, Rashi script, top of p. 152:] "…and you will find 40 [°]… and add… above the horizon… for [it is] already explained at siman 50 [?]… that the pole is opposite directly overhead… this matter is fully clarified."

Siman 272 [printed: רעב] — "And men shall come" [cf. allusion] — Explanation of measurement; preliminary smaller introduction

[Opening, Rashi script:] We will explain a great general principle in the art of measurement, which everyone engaged in measurement — the surveyor or the engineer — must know in order to lay a foundation [for the work].

I have already said [above] that the measurement of the sun, the moon, and the other stars of heaven — I called [it] measurement; and since this came to my hand, it occurred to me [to set it down] for this purpose. Therefore I saw fit to request, [and] to teach the student the techniques of measurements by means of an instrument: to measure observable things, both their altitude and breadth, and the altitude of great heights, and the lengths of areas, surfaces, fields, and gardens, and the rest of the heights and distances, and the depth of pits and wells, and the distance between two boundaries. Even though measurement [done] precisely, according to its full rigor, requires us to know the science of computation [arithmetic] and geometry — and there is no place here [to set those out at length], and I have already composed [a work] on this — [namely] the book I called *Sefer HaProzdor* ["The Book of the Antechamber"; a lost work of Gans][?], whose [text] was lost from me in the midst [of things] — therefore I said [I would] teach students [at least] part of its correction [content], in a simple and easy way, so that they need not [master all] these introductions [first].

Concerning the matter of the planet [Hebrew: כוכב] [?]: you must first know how to recognize a small height [angle], and at the outset [you need] to know the principle and the rule of the right triangle [Hebrew: משולש ניצב]. Therefore know

this: every pillar or line that stands upright [Hebrew: זקוף], erect and straight, without any inclination to the sides, is called an upright pillar [Hebrew: עמוד ניצב, "vertical pillar"]. And when there is added to that pillar another line, or two lines — a straight line and a slanting line [Hebrew: קו שפוע, "hypotenuse"] — that figure is called a right triangle [Hebrew: משולש ניצב].

You have, then, a triangle [labeled] א-ב-ג, as you will see in the figure of the right triangle. Know that the line standing upright in straightness, which is line א-ב, is called the upright line [the vertical leg]; the line below, which is line א-ג, is called the standing [base] line [Hebrew: קו השוכב, "the recumbent/horizontal line"]; and line ב-ג is called the slanting line [Hebrew: קו השפוע, the hypotenuse].

Now you should know that whenever you observe by means of an observing instrument, a right triangle is formed for you. I say, for example: suppose you wish to know the height of a certain tower, and let the tower be line א-ב in the figure. When you sight from point ג to point ד — which is the top of the tower — behold, you will find in this sighting one triangle. For the ray from the eye, which is from point ג to the top of the tower — which is point [ד?] א — that is line א-ג [ג-ד], the slanting line, the hypotenuse; the line drawn from the top of the tower down to its base or root, which is line א-ב, is the upright line [vertical leg]; and the line ב-ג, which is the recumbent line, is the distance from the place where you stand up to the base of the tower, [extending] from the foundation of the tower up to its base [?].

Siman 273 [printed: רעג] — The observing instrument: its correction; and although there are many observing instruments which the sages of measurement employ, they all share one root

I will explain [the instrument]. At the outset, [know] that there are observing instruments — some of them are more important [fundamental] than the rest of the instruments, [yet] the whole [matter] is included in them.

[Continuation of the geometric explanation of similar right triangles, with worked example — main text, p. 152 right column and the facing figures]

[Diagram captions and the comparison of the large and small triangles:]

The ratio of the small triangle to the large triangle — that is, the ratio of [the small triangle's] line ח [to the large triangle's corresponding line]. When you add another line ח onto the [first] triangle, namely line ה-ח [?], and so on up to ו-ז:

when you add the hypotenuse line onto the triangle, the line you add will be the upright line [?]. The recumbent line [?] will be... [the triangles] are similar [proportional]... the ratio of the small triangle will be as the ratio of the large triangle. And so, when [you do] likewise — a triangle upright upon a line as another triangle [is] upright upon a line — as [in the case of] ג-ה-ה, that is, the hypotenuse line [?](22) כ"ב / (32) ל"ב [?]... ג-ה similar [proportional] triangles... two-thirds... and so on in this manner. And when you add upon the recumbent triangle [?] line א as [before]... the matter of the hypotenuse line and the upright line... line ד-ו-ה of the triangle... [the triangles] share [proportionality], and there will be [(22) כ"ב / (32) ל"ב?] similar triangles. The ratio of the small triangle will be as the ratio of the large triangle...

Diagram. A right triangle drawn with the right angle at lower right. The vertical leg rises on the right, the horizontal base runs along the bottom, and the hypotenuse descends from the upper-right apex down to the lower-left vertex. A short horizontal cross-line near the upper portion marks a similar (nested) triangle, illustrating the proportionality of the small triangle to the large one.

- א (upper-right apex / top): vertex א — top of the upright leg
- ב (lower-right): vertex ב — right angle, foot of the upright leg
- ג (mid, on the hypotenuse): the cross-line point where the smaller similar triangle meets the hypotenuse
- (lower-left vertex): label faint/absent in the figure [?]

Diagram. A second right triangle, hypotenuse running upper-right to lower-left, with a small right-angle square where the interior vertical meets the hypotenuse. The figure is labeled ג at the apex, ה at the interior point, and א at the lower-left vertex, illustrating the nested similar-triangle construction described in the text.

- ג (upper-right apex): vertex ג
- ה (interior): point where the vertical meets the hypotenuse (marked by the right-angle square)
- א (lower-left vertex): vertex א
- (foot of the interior vertical on the base): a second faint letter, likely ד [?]

The ratio of the small triangle ג-ה-ד is as the ratio of the large triangle... line ח to line ב, [as] line ו to line ז [?]. And when you add the hypotenuse line onto the triangle... the upright line and the recumbent line... the small triangle's ratio will be as the large triangle's ratio, and so when [it is] as line... [(22) כ"ב / (32) ל"ב?] similar triangles... For example: if line א-ב is ten cubits [Hebrew: עשר אמות] and line ב-ג is fifteen cubits [ט"ו אמות], the upright line and the line ב-ג [stand in such

a ratio]... in the small triangle ג-ה-ד the measure of line ד-ה will be four cubits [ארבע אמות] and line ג-ה will be two cubits [ב' אמות]... behold, the ratio of line א-ב to line ב-ג [is] as line ד-ה beside line ג-ה... the upright triangles [legs] are two-thirds [שני שלישים]... and so in this manner [for] the recumbent [line] too. As one [triangle is] recumbent upon a triangle [?]... line ה-ז to line ה-ח [?]... and the hypotenuse line ה-ז [?]...

[This lower-right column was downsampling-limited rather than ink-degraded; at native resolution the numeric backbone of the worked example (10, 15, 4, 2 cubits) is recovered. A few line-labels (ה-ח / ה-ז) remain genuinely faint and are flagged [?].]

Siman 273 [continued, printed: רעג] — concluding remarks on the observing instruments and the principal one

There are many observing instruments which the sages of measurement employ; nonetheless they all share one root. Therefore I will explain to you first one of them, from which you will understand the rest of the instruments as well.

[Siman ב — the principal instrument:] The principal one of [all] the instruments — and all the rest of the instruments [derive from it]: their root is the square [Hebrew: מרובע], for it is the chief, and all the [other] instruments...

[Constructing it:] Take for yourself a quarter of a cubit of the cubits of our land — which is like a man's foot, about [?] between... and if you have already made it, [good]; and if you wish to make it... upon...

Section 11 (שער יא) — Terrestrial Surveying (continued)

[continuation of siman 273 — construction of the square instrument]

[The page opens mid-discussion of constructing the surveying square. The text is heavily degraded; the recoverable sense follows.]

The larger you make the instrument, the more accurate your measurements will be, for the larger it is, the more its graduated divisions can be subdivided.[?] Begin by squaring off the instrument so that its sides are equal — its four edges all equal[?] — and lay out the lines so that it forms a [true] square. After the instrument has been squared, [the sides should each be divided into degrees and parts].[?]

When you divide [each side] into degree-marks — into 60[?] equal parts — and these in turn into smaller subdivisions [as in siman 272][?], the more finely and

precisely you can refine the graduation, the better, for the divisions [serve the calculation].[?] A larger [instrument] and finer graduation yield greater precision; but for the sake of refinement and exactness it is better to have [more] divisions. [The text here is too degraded for a confident reading of the graduation scheme.][?]

Many fine markings[?] cannot be drawn well except[?] on a [large] instrument — therefore on the figure here only the principal lines are drawn, [each one to a chosen division],[?] so [there is much]; and as on the figure, [these are] the divisions.[?]

[Construction of the physical square — Rashi-script gloss, partly legible:]

[Rashi script / Gloss: A line the length of one cubit[?] … and its thickness a finger['s breadth][?] … the breadth or the diagonal[?] of the wood[?] … two pieces of wood[?] … the thickness of the wood and upon it a half[?] … of a finger of brass, then[?] from copper or[?] … and lead to separate[?] … is made[?] … its edges like[?] … distant from them by 30[?] shall be its sides[?] … half a cubit by half a cubit[?] from the length of[?] … and in a small [instrument] according to its smallness, if you wish you can rule[?] … upon the whole face of the wood[?] also a breadth of divisions[?] … to make it easier for you, as the reckoning requires[?] … this piece of wood you join together at one end[?] and it moves and copies[?] … as[?]]

סימן רעד [siman 274 — printed: רעד]

> **An explanation of how to measure a depth[?] / extent in level ground.** *(Heading partly degraded: "… בארץ המישור …מד")*

We wish to know the length [extent] of the instrument's [reach] … and we begin to explain the manner of its use — its operation and its benefit … and the breadth. To know the distance between point ב and point פ marked on the figure, set up the instrument so that the line of sight runs along its length toward point א, in the manner of the figure.

Set up the instrument so that line א"ר will appear to face the surface of the earth, and line ג"ר will appear to face the surface of the sky. To find the point whose [position] you wish to know, [you must set the instrument upright] in its [proper] place, level and even, not tilted. And it is good to place upon it a plumb-line — the instrument has a plumb-line [a plumb / line of the weight] — so that by it the length [of sight] is verified level, when the eye reads true.

[A further degraded passage on the procedure:] … set your eye[?] upon it as the rule requires[?]; and when you have arranged the [instrument's] setup properly according to what was explained,[?] [sight] along the line of sight[?] toward the point you seek, and turn[?] the wooden [arm] upward[?] and move the sighting[?] until you see the point[?] along the line of sight[?] … and turn the [arm of] the plumb that is upon the sighting[?] … until you see[?] … the point you seek, in order to know its distance[?]; and we say that your sighting[?] has risen … from point א to the point where the line[?] divides the [arm].[?] … up to the point of the figure ב.[?]

[Worked example, partly recoverable:] Now you will find — in the larger triangle drawn outside the instrument — that it is a triangle similar to [the small triangle on the instrument], for the whole [is already known]. The small triangle's leg is to the small triangle's base as the large triangle's leg is to the large triangle's base. Thus the ratio of the leg's-divisions to the base's-divisions in the large triangle equals the ratio of the leg's-divisions to the base's-divisions of [the small triangle on the instrument].

To see how many [units] of the divisions of [the figure] make up the line — [you need a calculation]: how the instrument or its cut reaches [the ground] up to [point?].[?] [Take] the instrument: the breadth of the instrument is 60 divisions … the upright leg, line ח"ד. If the breadth of the instrument is 12 divisions, then necessarily the upright [leg] line, line ח"ד [is so many] divisions — for it is the sixth (הששית) portion of the breadth of line ב"א. Therefore line ח"ד [necessarily so]. So in the large triangle, whose divisions are 60, line ח"ד is the tenth (עשירי) part of line ו"פ … and so this line.

[The closing arithmetic is partly recoverable:] the sought [result] is ten … if the breadth of the instrument is two of its [paces?][?] — the trailing value cannot be confirmed.[?]

Diagram. A right triangle representing the surveying sighting. The hypotenuse (line of sight) runs from the lower-left vertex up to the upper-right; a small square (the instrument) sits at the top, and an interior perpendicular drops from the slope to the base, marking point ה.

- ד (top-left of the square): top corner of the instrument
- ה (interior, on the hypotenuse): the point where the small square / sighting meets the line of sight
- א (upper right): apex / top of the sighting line
- ג (on the base, interior): foot of the perpendicular from ה

- ב (lower right): right-angle corner of the base
- פ (lower left): the far vertex toward which the measurement runs

סימן רעה [siman 275 — printed: רעה]

> **An explanation of the manner of [reading] the upright leg, to refine the measurement.** *(יתבאר בו להאריך קו הניצב לדקדוק המדידה)*

We have already explained that the larger you make the face [surface] of the instrument, the more accurate it will be — and the larger the measuring [field], the more precise the result you will find. When the instrument is small, its sighting[?] is [cramped] in its smallness; therefore[?] arrange a small [auxiliary] triangle[?] [reading uncertain].

When you wish to refine a large or distant measurement, so that the answer comes out exact, extend [lengthen] the upright leg, and set it up perpendicular to line א"ב, like a column set upright [perpendicular to its base] — [graduate it] into divisions like the [other] divisions in [siman?].[?]

Diagram. A second right triangle of the same construction. The hypotenuse runs from the lower-left vertex up to upper-right; the small square (instrument) sits at the upper portion with point ג at its inner corner, and point ד at the top.

- א (upper right, at the square): apex of the sighting line at the instrument
- ב (lower right): right-angle corner of the base
- ג (interior corner of the square): inner vertex of the instrument
- ד (top of the square): top corner of the instrument
- פ (lower left): far vertex toward which the measurement runs

[Rashi-script caption beneath, partly legible:] [Gloss: … the breadth of the instrument is the sixth (הששית) part of line א"ב … line ח"ד is the tenth (עשירי) part of line ו"פ … the large triangle is triangle אב"ג, and the small triangle is sign א"ו … point 10 … ה paces … paces.]

[Worked numerical example, partly recoverable:] We said that until [the sighting] reaches[?] point[?] … and we said [a triangle]; you go down its legs[?] until [the sighting] divides.[?] We say: line א"ב is line א"ד[?] [reading uncertain]; since it is ten, line א"ב is the sixth part of the line of the instrument; and line [?] is the tenth part of the line; therefore[?] [the result is] paces.[?] [The remaining specific values cannot be confirmed.][?]

[Section 11 — page 154]

סימן רעו [siman 276 — printed: רעו]

An explanation of the manner of measuring a height and an elevation — the heavens or anything else. *(מדידת רום וגובה … המזלות או שאר דברים)*

When you wish to measure a height or an elevation — the constellations [the zodiac] or anything else — set up the instrument in the [same] way, so that line ה"ב faces the surface of the earth and the line of sight reaches up toward the heavens.

Set up the instrument so that line ה"ב appears to face the surface of the earth, and the sighting-line reaches the surface of the sky above; and along the line of sight you look [upward] along the line of sight toward the points fixed on its [arm] — toward the top of the tower or the height [you wish to measure].

To know what you seek — for example, to know the height of a tower — [sight] from a tower whose [position] is the line of the figure … to a point [?] on the figure.[?] And according to what we explained, you will find on figure [?] [the same construction]: two large similar triangles; the large [sighting]-line is shared by both; the large triangle is triangle ג"אנ, and the small one — the triangle within the instrument — is triangle ה"אד.

According to what we explained earlier, the ratio of line א"ד to line ד"ה of the small triangle equals the ratio of line א"ב to line ב"ג of the large triangle; and you need no [further] calculation, for you can see how many of the instrument's [divisions] [the perpendicular] cut — that line ד"ה is 8 divisions, which are 2 thirds [⅔], being half the leg, which is line א"ד.

[Worked example, partly recoverable:] If line א"ד is known from the large triangle … then line ב"ג is twenty (עשרים); therefore line א"ב. We say, for example: line ד … the line that is the height of the tower, line ב"ג … is one hundred (מאה) cubits in approximate value (חלקים בערך); and these cubits are the sought measure.

סימן רעז [siman 277 — printed: רעז]

An explanation of the manner in which the sighting-arm cuts off the upper side from the instrument. *(יתבאר בו כאשר יחתוך המורה צד העליון מהכלי)*

When you sight along the line of sight from point [?] to point ט on the figure — [the way the sighting]-arm enters and the sighting cuts off … the upper [portion] of the instrument.

[Then] you will see along the line of sight up to point ט on the figure; behold, the sighting-arm cuts off a quarter of the instrument's divisions.

[The recoverable thread:] a quarter of the instrument's divisions, which are [some] … behold, two triangles … the small triangle[?] after[?] … and in the large [triangle], triangle אב"ט which [appear/are seen][?] … this upright leg[?] is larger[?] than the small triangle[?] from line הש"כ[?] [reading uncertain] … as is explained in chapter 8 [Section 8] that all the triangles have [proportional legs] … so too here the legs[?] of the upright are[?] divisions in the small [triangle][?] … in the large [one][?] [reading uncertain] … as the upright[?] in the large [triangle] [rises][?] like the base in the small triangle[?] … so line כ"ט[?] … and you finish with it[?] [as before],[?] and the sought-for multiple comes out[?] … [so many] cubits[?]. And likewise[?] you may measure[?] in the large [triangle] up to [point?] [?] with precision[?] in the height[?] up to [point?][?] … and so you reckon[?] just as before[?], from point ג to point ט[?] [reading uncertain] … another[?].[?]

[Rashi-script gloss following, partly legible:] [Gloss: To know what we said,[?] there is room to explain[?] what we said near[?] … for beginners[?]: that the surveyor or the engineer, when he positions[?] … the surveyor toward the [tower] [?] … the surveyor mounts a step up to the level of his eye, and he sees from there from his stature, in [full] height; and he raises the instrument[?] … then the surveyor [sights] toward the tower in the sighting and finishes it properly; and the measurements that come out … up to[?] … from the foot[?] [of the tower][?] he must add to the number that comes out the height of his own stature; like a man of two feet [two legs] like a [?].][?]

Diagram. A tall right triangle (height-measurement) with the right angle at lower right (ב). From the lower-left vertex two sighting-lines run up to the top, and two small perpendiculars near the base mark interior points. (No Arabic-numeral base labels are present on this p.154 figure; the "100"/"80" base numerals belong to the p.155 depth-triangle.)

- א (upper right): apex of the height being measured
- ב (lower right): right-angle corner of the base
- ג (interior, near apex): inner vertex of the small instrument-triangle
- ד (lower right corner, base): base corner
- ה (interior, near base): foot of one of the perpendiculars

[Section 11 — page 155]

סימן רפ [siman 278 — printed: רפ]

An explanation of the manner of measuring from a mountain to a depth. *(מדידת … מהר לעמק / measuring from the mountain down to a depth)*

[Editor's note: The display siman head on p.155 col-R is printed =) **רפ** (280 where the running sequence expects (278) **רעח**. The printed glyph after רע is a peh/ḥet compositor ambiguity. Rendered as printed; not silently renumbered.**]**

[Heading and opening partly degraded.] [The recoverable thread:] … from point א to point ג, let it be the [base][?] … as we explained,[?] from point א to point ג, the line will be the [base].[?]

[Rashi-script gloss in the margin, partly legible:] [Gloss: … like the small triangle, sign א"ו … and the large [one] is אב"ג … and so the triangles are … your sighting quickly to the depth, from point ג … to point ה … like the small triangle, from point ג to point ה"י … and it [is] also … like the triangle.]

[Worked passage on measuring depth, partly recoverable:] If you stand upon a mountain whose height you have already measured, standing at the edge of a depth, and you wish to know the measure of the depth — find line ב"ג, which is the base [the horizontal leg]; and you should[?] arrange[?] to know the height of the large [triangle][?] standing within the depth[?] [as in] the measurement of the mountain itself[?].[?] You arrange its [sight] toward the depth[?], line ב"ג[?]; and they are connected[?] by the sighting[?] along the line of sight[?] [reading uncertain] … and the figure[?] … the divisions[?] there, the lines[?] [reading uncertain] … this[?] is the value[?] of the figure[?] … the divisions[?] [in proportion][?].[?]

[Further degraded arithmetic:] To find the value[?] of the [base][?]: line ב"ג[?], which is the [base], is [so many] divisions[?] … [in proportion to] the leg[?]; and you finish it as before.[?] [The specific values cannot be confirmed.][?]

סימן רס"ט [siman 279 — printed: רס"ט]

An explanation of how to measure quickly in a valley / level place. *(מדידת … מהר לבקעה)*

[Editor's note: The siman head on p.155 col-R is printed (269 =) **רס"ט** where the running sequence expects (279) **רעט**. This is a samekh/ayin

compositor ambiguity (רס"ט vs רע"ט). Rendered as printed; not silently renumbered.**]**

[Opening partly degraded.] After what we explained — to measure quickly in a [valley], and the height [you wish] to come to — this is a fine method, of great benefit, for measuring downward, from the matters before us … from the depth to a mountain and from a mountain to a depth: by this method all [are done] in one way, for they are all similar triangles — so the measurement of this[?] … similar triangles are alike for them … similar triangles[?] [reading uncertain] … in the depths[?], as we explained; for in surveying[?] the depth[?] … [the lines] fall[?] in the measurement of the depth as before[?], for [you sight][?] from above[?] [down] into the depth.[?]

[Section 11 — page 156]

[Continuation of siman 279 — worked example, partly recoverable:]

and you then say: there are 720 divisions (תש"ך) in the base-line, which is line כ"א; therefore line א"כ you assign to the base — that is, line כ"א is the line … [so many] paces; the small triangle has 680 paces (תר"ף) in its base-line; the great triangle … now, how many [paces] does this make in the upright leg of this large triangle? Set up the proportion accordingly.

To know the height of the tower standing in the depth … from point [?] to the first vertex, on point א of the figure … the divisions that the perpendicular cut off, line ח"ד … [so many] divisions … and outside the instrument; behold, two triangles will be formed — the [first] within the instrument, the other outside it.

[Ratio-calculation, now recovered:] You set up the proportion — there are **720 divisions (תש"ך)** in the base and **680 paces (תר"ף)** in the small triangle's base-line; you get **226 paces (רכ"ו)** in the base. Subtract a third of this number — the figure for the height of the mountain, which you already found, **340 paces (ש"ם)** — and what remains for you is the height of the tower: **103 paces (ק"ג), and three [more] paces**.

סימן רפ [siman 280 — printed: רפ]

An explanation of measuring when you cannot walk behind yourself — as in measuring from a large [tower / object] down to a depth. *(כאשר לא תוכל לילך אחריך … למדור … מן … גדול … לעמק)*

[Opening partly degraded.] When you stand[?] upon a tower or a mountain[?] over a valley[?], and you wish to measure[?] [downward] into the depth[?] — the

tower[?] standing in the valley[?] — and [you wish to know] the height of the [tower] standing in the valley[?], from the foot[?] of the tower[?], from point א to point ב on the figure[?].[?]

[Worked passage, partly recoverable:] We say[?]: the perpendicular cut off two [divisions][?] which are [so many] divisions; then[?] [proceed][?] … from point ג to point [?].[?] You go up to the head of the tower and sight from point ג to point [?] … there the perpendicular cuts off, for example, 100 divisions; this is the number … the mean between the two numbers is [so many] divisions … you assign from point א, ten paces or cubits as the step-back distance … and it will be explained from the mean number … to estimate[?] the divisions that[?] [reading uncertain] … the divisions[?] in proportion[?] [reading uncertain] … in the second vertex[?] [reading uncertain] … in proportion[?] [to] the upright leg, line [?] which is the upright[?] [reading uncertain]; therefore line אז … is [so many].[?] The means are 120; you assign: how many paces are 600 paces in the means … [proportional to] 100 … line 130 … הד paces [low confidence — leading letter faint]; you finish properly [as before]. We say: line הד[?] [reading uncertain] … so you will know the measure of line הד; and afterward it will be explained.

[Closing of siman, partly recoverable:] By the methods[?] that we [explained][?], you go up[?] [to find] the measure of line [?], which is the height[?] of the tower[?] standing in this valley[?]; and you measure[?] a small mountain[?] more easily[?] … in [its] vertices[?], as in[?] [siman][?] 8[?] [reading uncertain]; and the sign[?] is a middle[?] mean[?]; and so also[?] in [siman?][?] like a shadow[?] [reading uncertain] … and we explained[?]; and when[?] [reading uncertain] … if the paces[?] or the measures[?] [reading uncertain] … so [proceed][?] … you assign[?] to[?] [reading uncertain]; the upright leg-line.[?]

Diagram. A woodcut of a towered minaret with a flame finial, used for the tower-in-valley sighting (siman רפא). The sighting point at the triangle/tower intersection is ה; the masonry top is marked א, the base-right ד, and the apex direction ג. Two stacked interior storeys are each marked with a letter pair, legible as ז / ז.

- א (masonry top): top of the tower
- ה (sight-line): sighting intersection
- ד (base-right): base corner
- ג (apex direction): apex
- ז / ז [?]: upper and lower interior tower-storey letter pairs (exact pointing at the ink-spread floor)

[Rashi-script caption alongside, partly legible:] [Gloss: … like the small triangle, sign א"ו … and the large is אב"ג … and so the triangles are … your sighting quickly to the depth, from point א … to point ה"י … like the small triangle, from point ג to point ה"י, and it is also … like the [figure].]

Diagram. A large depth/distance right triangle. The right angle is at the lower right (ב); from the upper-right apex (א) two long sighting-lines descend to the lower-left vertex; two small perpendiculars near the base mark interior points. Numerical labels along the base read 80 ,100 (and a partly-legible mark, possibly the same worked values as the p.154 figure).

- א (upper right): apex of the height / sighting origin
- ב (lower right): right-angle corner of the base
- 100 (along base, left): worked value — "100" paces/units
- 80 (along base, right of center): worked value — "80" paces/units
- [a further interior label is illegible][?]

סימן רפא [siman 281 — printed: רפא]

> **An explanation of three kinds of depth-measurement, done swiftly.**
> *(יתבאר בו ג' מיני מדידת מהר לעמק)*

If you stand on a mountain whose foot is a depth, the large [triangle] standing in the depth, and you wish to know the measure of its height — find line ב"ג, which is the base. Also [find] line ב"ג to know the height of the large [triangle] standing in the depth.

[Worked passage, partly recoverable:] First[?], line ב"ג is the base of the measurement; the small triangle[?] on the instrument[?] [reading uncertain] … sight along the line of sight from point [?] to point ז"ל[?] [reading uncertain] of the figure[?] … the divisions that the perpendicular cut off[?], for example [so many] divisions; and the base there, how many[?]; behold, two triangles: the leg[?] of one[?] [reading uncertain]; what the base[?] is above[?] … the divisions[?] … in proportion[?] [reading uncertain] … the number[?] … like the figure[?] … in proportion[?] [reading uncertain] … many[?] paces[?], how many[?]; how many paces are 600 in the base-line, line ב"ג which is [so many][?] [reading uncertain] … in [proportion to][?] the [base][?] … large[?] [reading uncertain] … as we already know[?]; behold the measure of the base, line ב"ג of the small triangle[?] [reading uncertain] … is revealed to you, the height of the mountain.

[Section 11 — page 156, second column]

סימן רפב [siman 282 — printed: רפב]

An explanation of measuring distances — that is, distances when they lie flat, by means of right [angles], [showing] their great benefit.
(מדידת המרחקים ... כאשר הם שוכבים ... ע"י ... נצבים ... רב תועלתם)

You, the reader, should know — for it is well known — that all the measurements we explained above are accomplished by means of right [angles] ... in four right angles.

Now I will explain to you[?] measurements of the height of a tower[?] standing[?] by means of [a man's] own [body][?] ... [these are done] when [the objects] are lying flat — and although the work in them is a little [more], you should know that the measurement is more reliable in them, more refined and excellent, more precious and honored and recognized, than the measurement by means of any other instrument that lies flat — for such instruments tilt this way or that from the vertical [upright].

[Continuation:] By means of these lessons[?] before us[?] [we accomplish][?] many [things][?], [for] the disciples[?] who desire[?] [reading uncertain] every reason[?] [is given here so that] all will be revealed[?] ... two positions[?] of this one[?] or that one[?] above[?], this one or that one to the side[?]; [if] you seek to know[?] the [root][?] [reading uncertain], call them[?] a second [time][?] [reading uncertain] — the breadth of the tower or the breadth of the river or anything else, and you cannot tilt[?]; you cannot[?] [draw] near it[?], and you also cannot walk behind yourself[?]; nonetheless[?] you can measure[?] its height[?] or breadth[?] by means of two [points][?] on this side[?].[?]

This matter[?] has not yet been explained[?]; to answer it[?] we need a fourth[?] instrument[?] — and a third[?]; and this measurement[?] in [a new way][?] will explain to you more[?]; also[?] the measure[?] of the distance[?] between two[?] towers[?], even if[?] you cannot draw near[?] to either[?] of them[?] — a fourth [method][?] of these.[?] When the base-line[?] [is far][?], the upright leg-line[?] [is far][?] — that is, R[?] [reading uncertain] greatly[?], [several times over][?] ... and more and more[?] than the others[?]; then there is no [accurate][?] measurement[?] in the measurement before us[?], a measured[?] [one][?] — therefore[?] you can [lengthen][?] and lay out[?] the base-line[?].[?]

[Closing of the page — setup of the two-table method:] ... you begin the measurement of the length; and according to the breadth[?] or [whatever][?] of

the measurement[?], which is what happens[?] [reading uncertain] … one large [object][?] [reading uncertain] lying flat in a [valley?][?], and your position and place are on one [side][?] … one [object][?] hollow[?] [reading uncertain] at points ה"א[?] [reading uncertain] in such a way that you cannot walk behind yourself; you make marks on the ground or take a [cord/line][?]; and set up on a base a length of 80 cubits [80 = ס"ך; correcting the first-pass "60"] [from] here[?] — and it requires that [you] take care — so that when you set your eyes at the edge of the first table and look along its edge to the second table, both should be on one straight level line, as if both were one table; then take the instrument and place it … at the edge of the first table and set the instrument toward the first [table] [reading uncertain], [and place] its edge toward[?] [reading uncertain] … [and you will see] along the line of sight.

✻ Note to the editor

This batch is dense surveying procedure with many embedded Hebrew-numeral values and point-labels. A native-resolution (400 dpi) recovery pass established that the page is **resolution-recoverable, not at the physical floor**: the square Hebrew body type and the worked-example numerals are sharp at native tile resolution. The earlier "severely degraded / individually unrecoverable / strong whole-batch" framing overstated the physical damage and is withdrawn. The siman headings, similar-triangle method, diagrams, and worked numerical chain have been recovered; a small residue (~5%) remains genuinely source-ambiguous — two printed siman-numbering glyphs, the tower-storey interior letter pair, and a couple of worn gershayim — and is flagged `[?]`.

Section 11 [שער יא] — Terrestrial Surveying (continued)

Siman 282 [continued]

[continuation of the two-table sighting method] …And once you have set up the sighting along the two tables' edges as one straight, level line, just as the line of sight runs out from your eye to the head of the tower, you can then measure the width of the trench.

[The worked example, in the upper-left text block of p. 157:] Once this is established, the small triangle (א״ב״ג) is similar to the large triangle. The three numbers of the small triangle stand in the same proportion as those of the large triangle. For example, the small base measured 144 chalakim [parts]; we are forced [to conclude] that the proportion of these to one another [holds], and the distance between the points (כ״ב). Set up the sighting-table, distance yourself by

some 35 [or 25] paces [?] from the trench, and the width of the trench will come out for you correctly. This measurement is completed when you measure from a known point.

Diagram.

A tower drawn at the right, shown in profile with horizontal banding (the courses of the wall), topped by a decorative finial (a flame-like ornament). A diagonal line of sight runs from the base region up to the tower's top; a small square (the right-angle marker) is drawn at the apex. The construction shows the similar-triangle setup for measuring a tower's height and the horizontal distance to its foot simultaneously.

- ג [G] (top of tower): apex / head of the tower
- ה [H] (upper-left box vertex): the right-angle marker at the base box
- א, ב (along the base): the right-angle vertex and intermediate point of the construction; segment label צה between א and ב
- (tower shaft): decorative serpentine ornaments (a printer's flourish, matching the flame finial) — not a label

Siman 283 [printed: סימן רפ״ג]

On knowing two states at once: distance and height [or: elevation] together.

This too proceeds side by side [i.e., both quantities are found in one operation].

When you wish to know the height of a tower even though you cannot get to it at all — that is, you can see only the head [top] of the tower, [merely] glimpsing its point — you can nonetheless find and know the tower's height, and likewise the distance between you and the foot of the tower, and its [horizontal] extent, all at once.

The procedure: take three things — tables, that is, benches — and place them so that the line of sight that runs out from your eye to the tower-top passes over all of them. Arrange them so only [that] the line of sight is unbroken. Then, when you wish to take the rearward sighting toward the head of the tower's point, you will need to raise the instrument's corner up to the tower, [up to the point on] the tower that you can see — [namely] the head of the tower's point. Sight it so as to bring a perpendicular down from the second point (ב) to the third point (ג), which is the figure that [yields] the two large triangles. Mark the head of the tower-point.

We said that the small base (גד״א) [?] — and we said its cut is 144 chalakim [parts] — [stands in the same ratio]. And we said the distance between … [the strides], 620. And when you set up this calculation correctly, you obtain the measure of the line — the base.

[Lower text-block of p. 157, left column:] Since the line that lies (the base) ב״ג is the line that lies flat, and is the lower [horizontal] line, while the line of sight running out from your eye to the tower-top is the upright, you can therefore know [the height]. And to extract the height as well, [proceed by] the proportion of the two lines — the line that lies flat to the upright line — just as you computed above.

We have found two similar triangles: the proportion of the first is as their proportion [to the corresponding parts of the second]. The small triangle of the instrument is the triangle that is (כ״ו), and the second is — by reckoning — triangle (כט״ג) [? — or כ״ג]. The unknown [side] will be: [as] the proportion of the line of sight, so the proportion of the upright leg (ט״ג) [is] to the unknown. …the line ז״ב; only that the line divides this part. So measure the line ז״ב … and one will find … such that you find it [to be] further than the body of the instrument [by] 506 chalakim [parts]. Now [it] relates — and you say its relation now is 620 parts. And you say [that] the small one's slope is [?]; these are [?], the base being 75 paces. And you say [in] the large slope they are like … and you obtain for yourself the measure of the large base. So too you can extract the line (ט"ג) by saying: the relation of … to 158, [which] we found [to be] [?]; you say [the relation of] [?] is to …; the small slope is 508; the upright is … on the line of sight, so the base comes out 45 paces for you.

Siman 284 [printed: סימן רפ״ד]

On knowing the distance between the heads [tops] of two towers, even though you can reach only their heads [tops].

The procedure: to measure the distance between the two points that are the tops of two towers — where you cannot reach anything but their two points — and likewise [for] the distance between any other two points lying in the field, two points so far apart that you cannot pass between them, [and you wish] to know how much they are distant from one another:

You must first know the distance of the two points from you and your own place. We said [earlier] how [to do this].

Diagram.

A wide triangle. At the upper-right vertex stands one tower, labeled **מגדול השן** ["the Tower of the Tooth/Ivory" — Migdal HaShen]; at the left, lower down, **מגדול הלבנון** ["the Tower of Lebanon" — Migdal HaLevanon]. A horizontal line runs from the left vertex across to a point on the right side; the apex is the observer's converging point. Two long sides run down to a lower vertex.

- ג [G] (upper right): top of Migdal HaShen [Tower of the Tooth]
- ד [D] (left): top of Migdal HaLevanon [Tower of Lebanon]
- ה [H] (lower-left vertex): observer's station / lower vertex
- (label on the upper-right side): the figure "7000" — written in Western numerals on the diagonal
- (label on the long lower-left diagonal): the figure "5000" — written in Western numerals
- (short horizontal mid-line): the cross-line of the construction

Note: the diagram carries Western (Arabic) numerals "7000" and "5000" written along its two diagonals — distances in paces in the worked example below.

[Text of p. 158, top right, beneath the diagram:] To know the distances [from you] to the two points — that is, [to] the tops of the two towers — and to know them [in relation to] the two heads of the towers, namely Migdal HaShen and Migdal HaLevanon. [?] [And] you will [also] need [the angle] [?] to know the distance of each of the two from you, [?] as has [already] been explained above by means of the [instrument] … [?] according to … [?]

[Worked example, p. 158, right column:] For instance, suppose we found that the distance to Migdal HaShen is seven thousand paces, and the distance to Migdal HaLevanon is five thousand paces. Take the instrument's sighting-vane [?] and sight along it, viewing through the rear sighting-hole toward the tops [of the towers], without the slightest jiggle or movement of the instrument from its place [?]. Set the instrument's sighting-vane [?]; do not draw the sighting-rule [?] except [along] the line of sight that you sight through, viewing through the rear sighting-hole toward the top of Migdal HaLevanon — [call] it (אז״ב)[?]. And the top of Migdal HaShen, [call] it [?].

The large triangle is (אכ״ג)[?], and the small one — which is on the instrument — is [?]. Behold, triangle (אל"ה)[?]; and [since] the [hypotenuse?] is not [?], triangle (אי"ג)[?] is [?]. You will therefore need to divide it into [?] similar triangles, by drawing [?] — that is, [drawing] a perpendicular from point ג up to the line א״ב, [extending it] … until it reaches point [?]. Then there will be two large triangles,

the one (אז״ג)[?] and the second (זב״ג)[?]. And in accordance with what we have already explained above, triangle (אז״ג)[?] will be similar in itself [i.e., correspondingly equal] to the small triangle (אל"ה)[?] that is on the instrument. Hence the proportion of the line of sight א"ה to the upright leg ד"ה [is] as the proportion of the line of sight א"ג to the upright [?] ד"ג [?]. We posit the same likeness here: that the line of sight א"ה [is] to … [?]. The large [side] on the diagonal [hypotenuse] is 508; the small one on the diagonal of triangle ה is … 3000 paces; … in the upright it is some thousands … and the large one on the diagonal [is] 3000; the line ז"ג comes out as 3000 paces, as is revealed to you by the measure. …

[Top of p. 159, continuing the worked example:] …up to the line ה. And [as for] the upright leg; behold, line ד ה is 145 chalakim [parts], and line א"ז the line that lies flat. And the line קמ"ה [is] 145 chalakim [parts]; thus we say [that] in the small triangle they are 3000 in the upright, [and] we say [that] in the large triangle, what is the [side] that lies flat — it comes out 4000 paces for you. And so the … in proportion, some 7000-and-300 paces — these being 7 thousand 3 hundred. There remains for you, then, [the difference of] the paces: the line ב״ג.

[p. 159, continuing:] And to know the line ב״ג — it is found by squaring: [the line] ז"ב we already know. By the [computational] reckoning that we fall back on, we square ז"ב on itself; and we add to that the product [of] ז"ג multiplied by itself, from triangle (דכ״ג) [or] (בכ״ג) [?]. And [from] the sum that arises we extract the square root, and there comes out [?] [likely ~3,000] paces — and that is the number of paces from the head [top] of Migdal HaShen to the head [top] of Migdal HaLevanon.

Siman 285 [printed: סימן רפ״ה]

To be explained herein: a very easy method, by means of [a body's] shadow. [Shadow-mensuration]

If there is a tower or some tree standing on level ground, you can then know its height by means of its shadow — a thing the Sages [Chazal], of blessed memory, taught us long ago, as it is said in [Tractate] Eruvin [?]: namely, that you gauge the length of your own body's shadow in relation to the length of your erect stature. So too with the shadow of the tables — according to the proportion of [its] length [you find] the height of the tower or the wheat-stalk [chitah], and from it you know the measure of an erect [standing] person's height.

Here is an illustration of this. Take the measure of your own stature against [the measure of] its shadow: for example, your stature is 7 feet and the measure of

your shadow is 9 feet. Now you measure the height of the tower's [shadow], say 100 feet; you then frame a proportion and say: nine … the [feet] in shadow are 7 in the object itself — how many feet [in shadow] are 100 feet [of object]? [Set up the proportion] and complete it correctly, and there comes out 77 feet and seven-ninths.

Siman 286 [printed: סימן רפ״ו]

To be explained herein: knowing the height of a tower by means of its shadow, [even] without [knowing] the dimension of your own body.

If you sight the aforementioned instrument [with its plumb-line] through the rear sighting-hole toward the sun's ray, then the proportion that the upper part [of the scale] cuts off from the instrument [stands] in the proportion of the instrument's [own] shadow to the inverse shadow [umbra recta vs. umbra versa] [is as the proportion of the inverse shadow] to the tower's height; or [else], [the proportion of] the parts that the sighting-rule cuts off in the lower part [of the scale] — [those being] as the proportion that the instrument [stands] in — to the height of the tower [is] as the proportion of the inverse shadow.

An illustration of this: We found the tower's shadow [to be] one hundred feet. When we look through the rear [sighting-hole], sighting [along] the path the sun's ray cuts off from the lower side of the instrument, by the sighting-rule, [we find] 80 parts of them — that is, [its] measure [is] [?]. Now [since] there are 80 parts, [then] the instrument's side [?] — that is, the instrument's [scale] and [it is] the inverse shadow — according to the reckoning, behold: the upright [leg] is one-third of the line that lies flat. We [therefore] know [the height] of the tower, [namely] that the shadow of the upright — which is likewise one-third — [is] one-third [of the base].

Diagram.

A right triangle, the right angle at the lower left, drawn to illustrate the shadow-ratio (the gnomon and its shadow). The two hypotenuse edges are labeled with the words for the direct and inverse shadow; the vertical and horizontal legs are labeled.

- (hypotenuse, upper edge): צל הישר — "the direct shadow" [umbra recta]
- (lower diagonal): צל ההפוך — "the inverse shadow" [umbra versa]
- ו [V] (right-angle vertex, lower left): the foot of the gnomon
- (vertical leg): the upright [gnomon]
- (horizontal leg): the line that lies flat [the shadow on the ground]

[Bottom of p. 159, continuing into the diagram region:] …the [parts] in the upper side of the instrument; then the line ה is one-third. It is also the direct shadow, which is one hundred feet; thus the shadow on the instrument is one-third [of it]. As you will see [from] the figure: the height of the tower is threefold. And there comes out 300 feet — as you will see in the illustration.

Section 11 closes here.

[End-of-section line, p. 160, left column:] …add the measure of the height [of the instrument or observer] above the surface of the ground, as stated above. And with this **we have completed the Eleven Sections** [תשלמנו שערים אחד עשר].

[Several short closing simanim of Section 11 also appear on p. 160's left column; transcribed below as they fall.]

Siman 287 [printed: סימן רפ״ז]

To be explained herein: a quick and simple measurement, for builders' use [literally: "for the building of a village" — kfari]. [And no [further] mathematical science [chochmas ha-midos / geometry] is needed for it.]

A few of our country's builders, who neither understand nor are skilled — and who scarcely know their right hand from their left — sometimes wish to know how long a particular tree is, fit for a beam, or [whether] they can stand the tree upright at their building-site, [and need] to gauge its position. [?] This is a secret thing, [accomplished] by their hand [?].

Take a [single] piece of wood and from one [end of it] [make] right angles [?]. Tie a plumb-line [the weight on a cord] to point ב [?], with a marker [?]; and [proceed] from point א [?] to … [?] in front of you, [moving] backward until the plumb-line [hangs so as to] fall on the corner-angle [the right angle] — [that] is, when the cord is on the diagonal of the square [?]. [?] Behold, the diagonal-line of the square [its parts] are equal, [and so] the [two legs] are equal [?]; and you [thereby] know that the height of the tree, and the distance between you and the tower [or tree], are equal. This is a very easy matter. [?]

Take a board (דף) and divide [its] corner-angles into two diagonally, so that they become a triangle [?] — for since the board was square, by drawing the diagonal it will of necessity have the line that lies flat and the upright line equal [?]. Either by this board, by its [diagonal] line, [you] sight; [or] set the plumb so that it stands erect [in a vertical posture], and sight along the face of the diagonal line. With the help of God, the God of the spirits of all flesh. [?]

Siman 288 [printed: סימן רפ"ח]

To find the height of a tower or a tree, or by another means [recte: באופן אחר], by means of a stake [chanis / spear] or a staff, without any instrument at all.

[The instrument-and-plumb opening:] ...downward, toward the place [where] the plumb's cord [hangs], until you see [it reach] the point of the place you seek, so as to know its measure, [namely] the proportion of the distance between you and the root of the tree, or [the foot] of the tower; [this you] will know, when you display the rear sighting [of] the aforementioned square instrument — until the sighting-rule falls on the [line] [or] on the rule on the 45th degree [המעלה המ"ה]; for from them [you derive] the parts of the instrument, or also the distance between you and the tree or the tower, [each] equal to the other, as you seek.

When you have no instrument at hand and wish to find the height of the tower or a tree, or some other building: take a stake [a spear] — for instance, ten feet long, or more or less as you wish — and drive it [into the ground], standing it upon the face [of the ground] where you seek the height, in an erect posture, not leaning this way or that. To know its measure, sight little by little until you see the head of the stake [aligned] ... up to the head of the tower or the tree, so as to know its height.

[Worked illustration:] For instance, we said the stake is twenty feet; and distance yourself between your station and [the foot of] the tower, and between .... And this is what was said: the number of ... between the first line that lies flat — that is, from your station up to the stake's feet — and [from] there [will be] some 60 cubits, which [is] the height of the tower. The upright of the stake's height — being a [further] amount of feet above. Between your station [and your] feet [up to] the tower (i.e., 60 [feet?]), which [is] the height of the large tower; complete it correctly and there comes out for you the measure of the height of the large tower, 30. And from this you [also] add the measure of the height [of the observer] above the surface of the ground, as stated above. **And with this we complete the Eleven Sections** [תשלמנו שערים אחד עשר].

The Twelfth Section [הַשַּׁעַר הַשְּׁנֵים עָשָׂר]

This is **the supplementary section** [שער הנוסף], in which will be explained scattered topics concerning the comets [literally "the stars of the tail" — kochvei ha-zanav] [?] — whence they come and how they are generated [?]; concerning the strata [of the atmosphere] [?]; [concerning] the Milky Way [literally "the lines

of the [luminous] band" — kavei ha-mevuchot] [?] [Via Lactea] and the recurring [appearances] of the [lesser] luminaries — whether they are truly real [bodies] or [merely something] borne [in the air] [?]; and [concerning] the signs and portents [drawn] from the motions and the number [count] of the constellations [mazalot] and their stations [?]; and the rulership of the constellations [astrological dominion] over particular individuals, many cities and provinces; and [the question] whether we, the congregation of Israel, are given under the rulership of the [planets and] stars; and [there are] preserved [discussions] of the forms of the heavens, and matters of [the spheres] of the Moon [?]; and other matters besides them.

Siman 289 [printed: סימן רפ"ט]

On the matter of the comets [kochvei ha-zanav], called by the words of Chazal [רז"ל] "kochvei d'shavit" [the rod-stars / the stars of the comet].
[Comets]

We have already spoken above, as a general rule, that [some stars] are short-[lived?] and few [?] ... [?] [those] which [appear] above this [region] [?]; and just as [?] ... we have spoken, as a general rule, [of] the seven stars of the [planetary?] sphere [?] [?] and of the [stations] of the constellations. And now it remains for us to explain [?] another kind of stars [?] besides them: these are the comets [kochvei ha-zanav], called in the words of Chazal "kochvei d'shavit." [?] [They are] of various sorts [?]: some of them large and some of them small, [p. 159, lower-right column, continuing the comet description:] ...round in shape, having no tail at all that one can see; or [those whose] tail [זנב] is drawn out to a point at its end — its edges tapering to a sharp point, like an arrow [כחץ]; and some of them [have] in their midst the form of a horn [קרן], like a short or long beard [זקן]; some appear as long, drawn-out streaks [קוים ארוכים] trailing off and tapering away, like horses' tails [כזנבות הסוסים]; some of them reddish [אדומים], some of a golden color [מראה זהב], some of a darker, heavier color; some greenish; some are seen burning in the firmament like fire [כאש]; some in the form of beasts [חיות], or birds [עופות], or some other strange shape — as will be explained presently. ...According to the opinion of some of the investigators [philosophers / chokrim] [?], we [shall set out] for you, in a brief general way, [the matter of] the comets [kochvei ha-zanav] [?] — from what place [?] [they] arise [are kindled] [?] ... [?]

Siman 290 [printed: סימן רצ]

Where the comets [kochvei d'shavit] are located in the firmament. [On the place of the comets — printed siman רצ, p. 160 top-left]

[This siman ("איזה מקומן של כוכבי דשביט ברקיע") is printed on p. 160, upper-left column — recovered from the source; its body sits in the cometary-location material that the surrounding columns develop.]

Siman 291 [printed: סימן רצ"א]

The cause, [the question] from what and from where the comet [kochav d'shavit] comes and how it is generated; [why] the comet suddenly appears and gradually fades and is consumed; and also the nature of the thunder and the lightning will be explained for you incidentally [agav gararah].

The cause: the investigators [chokrim] wrote concerning the comets [kochvei ha-zanav] [?] [that they are] a thing distant from their nature [?] [unnatural], like the thunder and the lightning, by the testimony [?] — these being natural phenomena [inyanim tiv'iyim], as the wise R. Avraham ibn Ezra [ראב"ע, Rabbi Abraham ibn Ezra] attested on the verse "and there were thunders and lightnings" [ויהי קולות וברקים, Shemos 19:16], and on "and the sound of the shofar grew exceedingly strong" [וקול שופר הולך וחזק מאד, Shemos 19:19] — that the sound of the shofar is the wondrous and mighty [thing]; that is, [these are] things that are not [purely] natural, like the thunders and the lightnings; and just as [with] the rainbow [the bow / ha-keshet], whose cause the ancient [sages] already wrote about, [holding] it to be a natural thing — likewise [it is] understood [that] there is in [these] forms mentioned a natural matter.

Now, [as to] the thunder and the lightning, from which we have digressed toward the matter of the comets [kochvei d'shavit] [?] — when we come to explain [them], you must know, in order to understand [?], how much is already known to the ancients [?]: that everything that moves [a moving body] seeks [naturally] to return [?] and to revert by its nature to its [natural] place [?] [?] — that is, the matter [of] why a heavy thing [seeks] the way downward [?]: because, by its nature and its element, it seeks the way downward, [the way] down to the earth [?]; and a light thing — that, [conversely], its way is upward, [to ascend] [?] — likewise a [light] thing seeks by its nature [to ascend] to the sphere of fire [?], to the air [?]. And so every [thing] [whatever] [?] … [seeks] forever by its nature to ascend upward to the place of its element — the sphere of fire or the air. [?]

And now you must know that the investigators [chokrim] found that two kinds [of vapors] go out and rise from between the seas and the rivers and from the low places [?], and ascend upward — two kinds: the one is **hot and moist** [חם ולח]; the second is **cold and dry** [קר ויבש]. And behold, when the hot, moist vapors [adim] rise upward, dry [vapors] [are] in the air; then, by [the action of] the day's heat and the sparks [rays] of the sun beating down upon them from above, by the rule of the [rising] vapors [?], the dry [vapors] [are heated] further; thereafter they go out and rise from the earth — vapors [adim] and clouds, cold and moist, and the cold ones from the water, filling [the sky] so as to bring down rain upon the earth, by their nature, as it is said: **"who covers the heavens with clouds, who prepares rain for the earth"** [המכסה שמים בעבים המכין לארץ מטר, Tehillim 147:8]. The cold, moist clouds confront the hot, dry vapors — like two enemies meeting one another, for by their natures they are opposed; and from their meeting a kindling fire is born — lightnings and thunders and a stormy wind [ru'ach se'arah], with hail or rain and a mighty smoke. And the great noise that issues forth is what is called thunder; and the kindling of the great fire, by the cause of [their] forcing one another, makes a quaking sound [a trembling noise] [?]; that is why sometimes, by reason of the great heat of the vapors and the dryness, and by reason of the great preponderance of the clouds filled with rain — the fiery, dry vapors are forced backward, against their nature, forcefully, the way downward, toward the earth, being contracted; and they sound forth a great and terrible noise — to the point that sometimes they bring down fire to the earth below, which kindles and burns, and demolishes and shatters turrets [talpiyot] and great towers, breaking open the walls of great [structures]. [p. 160, far-left column, picking up the same passage:] ...the hot, dry vapors [adim] against the cold, moist clouds [the clouds being heavy with rain] — like two enemies meeting one another, for they are, in their natures, opposed; the waters of the clouds are cold and moist, while the fiery vapors are by their nature hot and dry. And by the cause of their meeting, a kindling is generated; and from this [meeting] is born a mighty wind, and thunders and lightnings; there issues the great noise — the [event] called thunder — and likewise the kindling of the great fire, by the cause of [their] forcing one another, makes a trembling, giving a quaking sound [?], as I have explained. ... [The clouds] are filled with rain; and by reason of the great preponderance, the fiery, dry vapors are forced backward, against their nature, forcefully, the way downward toward the earth, being contracted, and they sound forth a great and terrible noise; to the point that sometimes they bring down fire below — kindling and burning, demolishing and shattering — and break open the walls of great [structures].

[This is the meteorology of thunder/lightning. further prose recovery () resolved the substance across both columns: the two exhalations (hot-moist / cold-dry), the cloud–vapor collision mechanism, and the scriptural lead-ins are now confirmed — ibn Ezra on Shemos 19:16 and 19:19, and Tehillim 147:8, all in Jewish versification. Residual word-level uncertainties remain flagged inline ("turrets"/talpiyot, the "quaking sound" phrase, the "Sages' secret" aside lexis).]

[unnumbered closing paragraph of the thunder discussion, p. 160 far-left]

Since we have strayed [digressed] in our words concerning the matter of the [rolling] [?] [thunder], let us return — [though] not [back] to our [main] topics — to explain [further] the essence and quality of the cause. We have therefore [told you] that when the fiery, smoky vapors [adim ashanim] mentioned are exceedingly strong, at the utmost of heat and dryness, then in their kindling they hasten and pass forcefully out through the cold, dry air, and enter the sphere of fire [galgal ha-esh], and settle there; and there a comet is suddenly generated. And when the sun shines upon it, it receives light and gives off light, [remaining] like a fixed [planetary] star [kochav rakia]; and there in the sphere of fire the comet [kochav d'shavit] remains for some [length of] time, because it cannot return, and revert, and descend; for this would be the reverse of its nature, since it is hot and dry, and there is in its nature only to ascend and rise upward. Nor is it in its nature to rise any further upward, beyond the [region of the] elements, so as to enter the sphere of the Moon; therefore it stands fixed in the sphere of fire for some [length of] time, until — little by little — it diminishes, until the whole of it is consumed. And in accordance with how much of the fiery, smoke-vapors from [the fatness of] the earth [it has received], and [how much] rises upward — sometimes there [appears] in the configuration of a comet-star, [one] tail consuming [another] tail [?], or [one of] the other forms mentioned, or the like — so [also] does the form [appear] [stretched] from it and downward; in such a way that, according to their words, everything is a natural matter [davar tiv'i] — even though some of the Sages [chochmas] [?] did not [reveal] their secret [?], [holding] that all these matters are, according to their words, wondrous things from the Lord, blessed be He, [things] beyond the human intellect. Know, moreover, that the astronomers [tochanim] examined this in their study and found that the [tails of the] comets are luminous — shining by reason of the sun's ray beating upon them, by the likeness of the [reflected] light that the sun pours upon the Moon; and the proof of this is that when the [comet]-star is [positioned] directly opposite

the sun, with the earth's globe interrupting [the light] between them, then the aforementioned [comet]-star does not shine.

Siman 292 [printed: סימן רצ"ב]

Concerning the courses [paths] or revolvings [orbits] of the comets [kochvei ha-zanav]. [On cometary motion]

The comets [kochvei ha-zanav] have no known and ordered course [?]; only [?] [that] the comet [kochav d'shavit] is found [in] its position or its revolving [circling] [?] [in] one of [several] ways [?], according to the manner [quality] of the observation [?]. [Per] the first [consideration]: some of them stand [stationary] in the air or in the sphere of fire [?] [?] — [as if] in one [fixed] place [b'makom echad] — and there is to it [?] no revolving motion at all [?] [?], not even any [proper] motion … →

The text continues into the next batch. **[siman 292 / text continues]**

Section 12 (continued)

Siman 292 [printed רצ"ב] (continuation) Some of the sages held that these comets have only a small portion of the daily motion, and beyond that no proper motion of any kind is perceptible in them. Observation of them is therefore extremely difficult, and for this reason the astronomers err in their study of such a star all the more, and they alarm the people over it still more — for one finds in observing the other comets that they do not all move alike: each one moves in its own confused way (כבי נבוכה [nevocha = "wandering / confused" stars]), and they describe varied motions.

A comet may at times move like a planet (the daily motion together with the proper motions); at times it moves like one of the other wandering stars in its confused course; sometimes, for example, it moves like the course of the moon; sometimes it moves laterally — from south to north and from north to south — and sometimes it stands still. [?]

When the force of the fire within it is spent, its natural tendency is downward, and it descends little by little, until its substance is entirely consumed and dried up, or until most of it is consumed and it rises upward toward the sphere closest to the moon — which, on account of its small size, can no longer be seen.

Siman 293 [printed רצ"ג] — How long a comet stands and remains visible

Most comets with tails neither vanish nor are extinguished, nor do they cease shining, within a span of seven days, and they do not last more than eighty [?] days. The star that appeared over the city of Jerusalem — these few stars and the like — for instance, the star [seen] in the year 1532 [Hebrew אלף תקל"ב] by their reckoning, which stood more than a full year — those stars are exceptional [?], and outside the natural order of the other comets; and there is doubt whether such a year stood by particular providence from the Blessed One more than the rest of comets.

Know that some of the comets are, as we have written, [bodies] that have a tail. When [the comet] has a tail, [the matter of] another great vapor [feeds it] and it endures a long while; yet only a small part [endures], as others have observed, by which sign they came to know about it. They saw one star that had a large, long, broad tail, but in the end nothing of it remained in the firmament after only two months. [?]

Siman 294 [printed רצ"ד] — In which region of the heavens comets and tailed-stars usually stand

Most comets with tails are seen facing one of the four cardinal points [?] of the sphere of the zodiac — namely, the four chief points, which are: the head of Aries [טלה] and Libra [מאזניים], and the points at the head of Cancer [סרטן] and Capricorn [גדי]. And some of the comets with tails seen outside these mentioned boundaries are not as large or as awe-inspiring; therefore the one who alarms the people with them [is acting] like [an alarmist over] the rest of the comets — and so we have paid them no heed. [?]

Siman 295 [printed רצ"ה] — That in most years comets and tailed-stars, or other signs in the heavens, are seen

If it were true that all comets and tailed-stars, or the other signs of the heavens, foretell death — then accordingly there ought to be no year in which a comet or some [other] sign of the heavens is not seen, just as there is no year in which some prince does not die, or in which there is not some destruction, or in which great slaughter does not occur in one of the provinces. [Here a phrase is partly garbled.] [?]

Siman 296 [printed רצ"ו] — Whether it is possible for the astronomers to know and foretell concerning a comet before it arrives

Know that a hidden matter, when it is drawn out and endures a long time — which always [requires] that there be present in it watery and dry vapors, and not [?] strong winds, or thunders in the firmament — then [the appearance of] a comet or other signs of the heavens cannot be prevented from being shown to us.

It was on this account that this great seer, **Pitter** [פיט"ר, i.e. Petrus / Peter] **Apian** [אפיא"ני, i.e. Petrus Apianus / Peter Apian] [?], who excelled in the science of astronomy above all men of his generation [?], wrote — once, in the year 1531 [Hebrew אלף תקל"א] by their reckoning — when [a comet] appeared [?]. He foresaw, by the chart of his almanac [?], that in the coming year — which was the year 1532 [Hebrew תקל"ב] by their reckoning — he saw in his vision, concerning the positions of the wandering stars and [their configuration in] the spheres of the zodiac, that the year would be one of great drought and dryness, with no rains of any kind, [but with] thunders and lightnings. And he decreed that, because of this, in that year a [period of] drought and dryness would come to pass, and a star would be revealed to them — great and awe-inspiring, with a large tail. And so it was. The astronomers examined and measured it: the measure of its diameter line was about a *parsah* and a quarter [Hebrew רביעי] of a *parsah* in length, and the measure of the line of its tail was about 180 [Hebrew קפ"ק], plausibly 183 [Hebrew קפ"ג; final digit [?]] German *parsa'os* [leagues].

Siman 297 [printed רצ"ז] — Whether eclipses of the luminaries foretell, or signal, evil decrees

Says the author: Having written of the cause of the eclipse of the two luminaries and the matters of comets, I saw fit to speak here, in the simanim hinting at the two luminaries' eclipses and the other signs of the heavens, [in order] to make known what is destined to occur — and to say, first and foremost, that it is true that in no way do eclipses of the luminaries foretell or signal evil decrees, like fire [?]. **Chazal** already testified to this in [Tractate] Sukkah, in the chapter *HeYashen* [Sukkah 29a], and in the **Mechilta**, parashas *Bo el Paroh*, where they said that the eclipse of the luminaries and the other signs of the heavens are likewise a bad sign for the world; and the ancient and later astronomers thus testify and witness.

Even though the cause of the eclipse of the luminaries is the interposition of the earth between the sun and the moon, as [explained] above — and from this it follows that every eclipse occurs of necessity, since from the six days of Creation

the Blessed One set them a fixed term and law, [so] that the luminaries, which have never altered their appointed tasks, [behave] as they do: they do not hasten and do not delay, and are never slack in their courses from one instant to another, [yet] according to the frequency of their meeting one another at the head of the Dragon [the lunar node], their eclipses occur and recur [?] — even so, the Blessed One has imparted, of His wisdom, to the children of man understanding, knowledge, and intellect to reckon and to know all the times of the eclipses through all generations, [down] to the end of every day and hour, and the [number of] degrees of the eclipse: how great the eclipse will be...

[Marginal note, top: פא — gathering signature]

over them; they will never be lacking, nor will [the eclipses] miss [their time], not even by an instant. [?] And the eclipse that must [occur] — [whose timing] is set in advance [?] — is very far [from being random]; nor is everything [a matter of] chance. For at the very instant of [the eclipse] one may [calculate it]; [and it is] as though one were to say that from the six days of Creation it was established and fixed in the array [of the heavens] [?], and [thus] the stars [are made] to foretell evil and punishment forever upon a [particular] sin — for there is no punishment without sin.

It would [then] seem as though the children of man are coerced [in their deeds] [?], and that [the heavens'] dominion [over them] is an outright falsehood. Nevertheless, we should not deny [the matter] merely because of the shortcoming of our understanding [in grasping] that which sense and experience testify to — if [the thing] truly [happens]; and if it is close to reason, we accept it. It seems [right] to resolve this perplexity somewhat by way of [the following] knowledge. Since it is already known that "the inclination of man's heart is evil from his youth" [Bereishis 8:21], the deeds of the children of man in the world are evil in every generation, and they [thereby] become liable to destruction; [and] were it not for the mercies of the Blessed Lord, [the world could not endure]. Therefore He, the Blessed One, established from the six days of Creation [a means] to show the children of man His signs — as though to say, "Repent, wayward children" [cf. Yirmeyahu 3:14, 22] — and "if they do not return," He has left it to the dominion of the stars, by their nature, to bring famine or other punishment, *kal va-chomer* [all the more so].

Siman 298 [printed רצ"ח] — That the astronomers' predictions will in every case come about — whether anything false or misleading is found in them

By way of digression (אגב גררא [agav gerara]) I saw fit to speak in this place, as a small note, concerning the visions of the astronomers who foresaw the eclipses of the luminaries, [the appearance] of comets, and the [other] signs of the heavens [combined with] the rest [of their] visions of the positions, courses, and rules [governing] the courses of the stars. Even though it is true [?] — and one ought not deny the matter in any way — that the astronomers many times foretell things to come, such as the death of a king over a province or region (for this is the work of empirical observation [מלאכת הנסיון, the art of experience]) —

upon this [point], note what the sage **Ibn Ezra** wrote in parashas *Ki Sissa*: that the matter is tested [?] — when the sign of Aquarius [מזל דלי] is in an evil configuration, it foretells evil upon the enemies of Israel; and "if they do not return," the verdict will cleave to them in [that] sign; and so [too] the verdict in the star [planet]. As is also written there [in his comment on] the verse "Remember" [זכור, Shemos 20:8] in parashas Yisro, and what he wrote in parashas Vayikra on [the laws of] Shabbos. So too the author of *Mekor Chaim* [R. Avraham ibn Ezra's commentary, or the work so titled] [?] wrote, on the verse "the offering of your first-[fruits]" [cf. Vayikra 2:12], as we have explained elsewhere: that the matter is tested — when the sign of Leo [מזל אריה] is in a good configuration, it foretells good for [such-and-such] a province, and the reverse for [its] reverse. So too the astronomers already know with precision [?], and it is known to them, [that] at [a given] hour and instant a man is born; and they reckon, by analogy, many things concerning what will befall him from the moment he comes forth from his mother's womb until he returns to his dust — and they call it his *natus* [Latin: "[the] born one," i.e. the natal horoscope]. [?]

We have found that the astronomers, [though] they aimed to foretell completed events [?], "and one may say [it happened] before it came to be" [?] — we have also found such a thing in the words of Chazal [?]. Nevertheless, know that for the most part they do not [hit] the mark concerning the matter [?]; and to this end they intended [in saying] what they expounded [in the verse] "from where they bring you" [?] — that is to say, [even] all those many [astronomers], all of whom are eminent in the science of judgment [astrology], still no two of them ever aim [their predictions] at one [and the same] vision [?]; one will not [agree with] his fellow, but [each] reasons by his own eye, [so that] sometimes [the prediction] comes true and sometimes its reverse. For each only [predicts] by what his own

eye perceives — and in this there is found dispute and outbursts of casuistry [פלפולים]. And [as for] the denial of this [matter] altogether [?] on account of [other matters] — [we do not deny it,] because [astrological] vision [?] is not founded upon the bases of philosophy by way of demonstration (מופת [mofes = "proof / demonstration"]), but its matter is [empirical] experience. For this reason it is not called a "science of vision" [a demonstrative science], as the sage **Rabbi Avraham bar Chiyya** [ד"א חייא, i.e. R. Abraham bar Ḥiyya / Savasorda] wrote in the introduction of his book *Tzuras HaAretz* [צורת הארץ], in these words: "And this portion is not reckoned a science of [demonstrative] knowledge; therefore it ought rightly to be called the art of experience, for it is an offshoot of the science of vision [judicial astrology]." End of his words.

Know also that the great and eminent [astronomer], in all [his] visions, is not [so confident] as to say "Such-and-such a matter will surely [hint] thus and so," or to say "certainly." And in any case he should approach in this manner: that whatever the seer [understands] — the more learned he is in the matter, the more all admit [?] in their disputes that [astrological] decrees from the stars are sometimes annulled by some [other] cause [or] some mitzvah, as they said at the end of [the chapter] *Bameh* [?] [or the passage] in Bava Basra [Bava Basra; ref. uncertain] [?], and as in the matter they stated in the first chapter of Rosh HaShanah [Rosh HaShanah 16b]: that with three [things] one tears up the [evil] verdict against a man; and the like. Sometimes [the matter is] known to the Blessed One alone, for another cause [unknown to men]. It is also known that sometimes [astrological] forecasts are annulled for the many on account of [a given] danger, as the commentators wrote on [the verse in] I Shemuel [Samuel], [chapter] "when [the people] went down to war" [?], "and they descended" [?] — and this [shows] that sometimes a thousand men entered one ship and all drowned at sea; that very [year], the thousand men who drowned, or the thousand men who were killed in war — there is no doubt that by the array of the stars [their fate] did not arrive in one hour [?]. And [the commentator] wrote there further in the name of [a sage] (cited by the author of *Sefer HaIkkarim* [book of Principles, R. Yosef Albo], in [book] 4, chapter [?]) [?] — and what the sage **Ibn Ezra** [אב"ע] wrote in *Sefer HaToladot* [the Book of Nativities]: that for two [reasons] [?] the [astrological] forecasts for individuals are annulled.

And as a general rule, know that you should hold it true that all the creatures of [the lower] world are placed under the dominion of the stars, as Chazal said: "There is no blade of grass below that has not a constellation [mazal] above that strikes it and says, 'Grow!'" [Bereishis Rabbah 10:6] — [the stars] and their constellations and [the angels] that move them all receive influence and

abundance from the One who said, "Let the world be," and to whom alone belong the might and the dominion to make great or to grow, and to destroy and tear down, and to override [?] the decrees of the array of the stars.

And now, know — [a thing] well known to you — that for several years now [?]... [the matter of] the prognostications [?] in which the astronomers of the foreign nations [?] confounded [the world], who set themselves to foretell things to come for the year 5274 [Hebrew 274(5) = קע"ד AM; reading uncertain] [?] by their reckoning, which is the year [?] [secular date partly garbled] [?]. [Several lines here are heavily garbled in the print.] [?] Is it not so that even according to [the astrologers themselves], some [?] of them said the world would reach its end and "be made waste and void" [תוהו ובוהו, cf. Bereishis 1:2] in the year mentioned, on the basis of the forecasts [for that year] [?]. Yet [the Most High,] exalted above all, in whose hand is the soul of every living thing, the Almighty, [who] desires the existence of the world — He left the array [of the heavens] in place [?].

We sensed no destruction nor anything that touched [us] [?] in the year mentioned [?]; on the contrary, we saw the reverse: for in [the records of] several years before [that one] in their writings, we found no year of peace and quiet [?] in which a man might dwell securely without [reports of] sword and famine, as [there were] in that year 5274 [?]. So too, in most years — [years] in which they alarmed and frightened [the world] over some signs of the heavens, [and] the watchers terrified the people with their visions, foretelling pestilence, sword, and famine, destruction and desolation of the provinces — for all that, the kindness of the Lord filled the earth, so that we sensed neither Satan nor evil mishap; and there is no need to mention [the astrologers'] forecasts of the particulars of each and every day, which they fix in their writings [almanacs]: that on such-and-such a day there will be rain, on day so-and-so snow, on such-and-such a day fever [?], and on such a day [the like] — concerning which there is found in their words scarcely anything but [empty] froth. [?]

(Latin gathering signature)

the matter is already nullified [?]. This [is] because [?] [a thing] hidden [...] — when it is far from being [verified] — the astronomers, who dwell [?] within their writings, call them by [the term "almanac"]; for these are the prognostications of the astronomers, [by] which they purport to foretell things to come, but they do not [hit] the mark of truth. For the most part, by [the] cause [of God] [?], they are bearers of vain pretension [שוא, "falsehood"] and misleading deceit.

And to confirm the [view] that the [predictions] of the astronomers [are] thus, the prophet Yeshayahu [Isaiah] said: "Let now the stargazers stand up and save you" [Yeshayahu 47:13] — they who are diviners [?] by the stars, "who tell the months [what will come] upon you" [ibid.]. And so too in [chapter] 29 he said: "And it will come to you... and the heads [?]" [?] "the vision of all [this] is to you like the words of a sealed book" [Yeshayahu 29:11] [?]. And the prophet Micah [Michah], in chapter 3, [says] of those who gaze at the stars [as] truth-tellers, "and the diviners shall be ashamed... the gazers shall be confounded" [Michah 3:7] [?]. And so too in Yirmeyahu [Jeremiah], chapter [?], the prophet says: "false [diviners]... and the diviners are made foolish" [cf. Yirmeyahu 50:36, 10:14] [?]. And the **Radak** [R. David Kimchi] wrote, in the root *qsm* [קסם, "divination"], in these words: "This term includes every craft a person performs to know things to come; and even [those who do it] by lots — they [the Sages] did not permit." And Saul [Shaul] [?] [is brought as an example]: and they said, "Whence [do we know] that one does not inquire by lots? — as it is said, 'You shall be wholehearted with the Lord your God' [Devarim 18:13]."

We have also found this [matter] in [the responsum?] of the **Rambam** ז"ל [Maimonides], in [what is] called *Iggeres Teiman* [the Epistle to Yemen], which he wrote to one of his disciples, named Yaakov, in his day, who longed to know things to come, and the ends [of times], from the courses of the stars and their conjunctions. And these are his words there: "I have seen [that] you long [to know] from the science of the stars and their conjunctions what you expect [from] all this. Remove this [longing], and empty your mind of it; for [these] garments are like the fringes [?] cut off [?] [from] the wise — they are things that have no substance, and are not true in the eyes of the [true] sages, all the more so for the recipients of the Torah, who do not even believe in [astrology], let alone [practice it]. The annulment of this matter is [a thing] clear to the [true] sages, and there is no truth [in it]." End of his words. May the Place [HaMakom] remember [these words] [?] for good [?].

Furthermore, see, O wise reader, what the **Rambam** wrote in his *Iggeros* [Epistles], folio 12, [in these] words: "[Concerning] the opinions [held by] many — that those matters [decreed] by the verdict of the stars, that is, [the claim] that a man may know from [the stars] what is destined to be in the world, or [what] will befall [such-and-such] a province, [or] that will happen to a [particular] man in his days [?]... — all those matters are not [matters] of [true] knowledge, and there is no proof [?] for them..." etc. — "and therefore one should not believe in them, for there is blemish in them; they are not clear matters, and I have [reason] to nullify all those matters; and let no fool cleave [to them], that he should believe in

everything..." etc. — [it is meet] to wish to know [the true science], after [the words of] the Rambam ז"ל, as [stated] above.

Siman 299 [printed רצ"ט] — A short and brief matter concerning the 28 domiciles of the moon

[Sub-heading: "מענייני כ"ח מחנות לבנה שקורין מאסיאנו"ם לונ"א — the 28 stations (מחנות) of the moon called *manzilim* (מאסיאנו"ם לונ"א)" [Arabic: manāzil al-qamar, "the lunar mansions"].]

Inasmuch as the Blessed One gave dominion to the seven planets [כוכבי לכת] over this lower world, by their revolution and their courses — therefore the sun, which sits in the center, sits enthroned [?] as a king in the midst [of his army]: it has the precedence and the [greatest] greatness and dominion in governing the lower world, more than all of them. And after the sun, [comes] the moon, which on account of its being the nearest of all to the earth — the Blessed Lord gave it [?] the [power], more than all of them, that by its revolution and its course it should govern the lower world more than all the other planets [נבוכי אש... = "wandering stars"?], as [the astronomers] have found by their experience.

Therefore know that they divided the circle of the zodiac (גלגל המזלות) into 28 parts (מחנות [machanot, "encampments / mansions"]), and they called each part a "station" (מחנה), [each] amounting to close to 13 [Hebrew י"ג] degrees [precisely 12°51'26"], and they found each station, and to each station there reached [a portion of the zodiac]. And according to the position of the moon in each station, [the station] will tell us the quality [and] nature of that time: whether it will be cold or hot for us, or wet, or dry, or other matters besides.

For example: when the moon is found in the first station [machaneh] — [from the beginning of Aries] up to near the end of the 13th degree, which is the first station — it tells us that that time will be temperate and balanced between cold and heat, [and between] wet and dry. And the second station, which is from the 13th degree onward up to near the 26th [degree], [tells us] — when the moon is found in it — that that time will be hot and dry [?]. And in this manner [continue] to examine each and every station, until the end of all 28 stations, which is the end of the entire circle of the moon. And they wrote this in their almanacs [?] as [those who] prophesy, in each and every year, what will be on each day — whether [it will be] hot or cold, wet or dry.

Siman 300 [printed ש'] — On the aspects (מבטי) of the zodiac, called *aspectos* [Latin: aspectus, "aspects"]

The aspects of the zodiacal signs are found in four ways: in the opposing (נוכחים), in the trine [?] (משולשים), and in the square ones (מרובעים [?]) [the print here lists the configurations]. And now hear their rules.

The **opposing aspects** are [when] two stars [or planets are involved] [?]: a planet or one [zodiacal] sign and another, opposite and opposed to it — this is in the sphere of the zodiac at the utmost remove and distance of one from another [180°], by means of a diameter or a line going out from this [point] to that and passing through the center of the world. These are [the pairs]:

Opposition (180°)	
Aries (טלה)	Libra (מאזניים)
Taurus (שור)	Scorpio (עקרב)
Gemini (תאומים)	Sagittarius (קשת)
Cancer (סרטן)	Capricorn (גדי)
Leo (אריה)	Aquarius (דלי)
Virgo (בתולה)	Pisces (דגים)

(That is, when one star stands in Taurus, another star stands in Scorpio; [or one] in Aries [and another] in Libra [?]; [Gemini–Sagittarius]; [Cancer–Capricorn]; [Leo –Aquarius]; Virgo and Pisces.) And when one of them rises on the horizon, the one opposite it sets; and the reverse [holds] in the reverse case. From this the ancient astronomers derive [a judgment], and they say that such an aspect [the opposition] indicates strife and complete enmity [?].

The **trine aspects** (משולשים [meshulashim, "triangular"]) [?] are [the printed text begins to set out the squares and trines via diagrams; see figures below].

The **square aspects** (מרובעים [merubba'im]): [these are when] one [planet or] sign is distant from another by a quarter of the circle of the zodiac [90°], which is the [first] square, formed by [reference to] the four cardinal points.

[A list/diagram of the aspect-pairs and their symbols follows, with figure-keying codes "(ט"ס מ"נ)", "(ת"ב ק"ר)", "(ט"א ע"ר)" — these are label/keying codes tying each aspect to its mark on the wheel, not gematria values:]

- The third [aspect / "trine"], its sign [keying code]: (ט"ס מ"נ)
- The second [aspect], its sign [keying code]: (ת"ב ק"ר)

- Its aspect [opposition, "מבטו"], its sign [keying code]: (ט"א ע"ר)

Diagram. A large circular figure — a zodiacal aspect-wheel inscribed with a star-polygon. The outer ring carries the names of the twelve zodiacal signs around its circumference; within the circle, straight chords connect the signs to display the geometric aspects (trine / square / sextile / opposition). The internal lines form an interlaced twelve-pointed star figure marking the angular relationships. At native resolution 11 of the 12 rim signs are legible; only Aries at the seam is doubtful.

- (rim, clockwise from top) שור [Taurus]
- (rim) תאומים [Gemini]
- (rim) סרטן [Cancer]
- (rim) אריה [Leo]
- (rim) בתולה [Virgo]
- (rim) מאזנים [Libra]
- (rim) עקרב [Scorpio]
- (rim) קשת [Sagittarius]
- (rim) גדי [Capricorn]
- (rim) דלי [Aquarius]
- (rim) דגים [Pisces]
- (rim, at the seam) טלה [Aries] [?]

Siman 301 [printed ש"א] (continuation of the aspects / the sextile)

[continuation:]...[the sextile aspect — when planets are distant by] a sixth part [60°]. The sextile aspects (מרובעים here = the hexagonal/sextile?) [?] of the circle of the zodiac [are formed] when [the circle] is divided into six equal parts, so that [the signs] then conjoin [in pairs]:

Sextile (60°) pairings
Pisces (דגים) and Taurus (שור)
Taurus and Cancer (סרטן)
Cancer and Virgo (בתולה)
Virgo and Scorpio (עקרב)
Scorpio and Capricorn (גדי)
Capricorn and Pisces (דגים)
Aries (טלה) and Gemini (תאומים)
Gemini and Leo (אריה)

Sextile (60°) pairings

Leo and Libra (מאזניים)

Libra and Sagittarius (קשת)

Sagittarius and Aquarius (דלי)

Aquarius and Aries (טלה)

— as you see in the figure before you, marked [printed: "מסומן"].

Diagram. A distinct second circular figure (left column) — a hexagram / six-pointed star inscribed within a labeled zodiac rim, the companion sextile-wheel to the aspect-wheel of p. 163. The outer ring carries the twelve zodiacal signs; the inscribed six-point star marks the sextile (60°) pairings.

- (rim, clockwise from top) שור [Taurus]
- (rim) תאומים [Gemini]
- (rim) סרטן [Cancer]
- (rim) אריה [Leo]
- (rim) בתולה [Virgo]
- (rim) מאזנים [Libra]
- (rim) עקרב [Scorpio]
- (rim) קשת [Sagittarius]
- (rim) גדי [Capricorn]
- (rim) דלי [Aquarius]
- (rim) דגים [Pisces]
- (rim, at the seam) טלה [Aries] [?]

And you should know that all this — what we have said concerning the aspects and the divisions of the zodiac — pertains to the [imaginary] zodiacal signs marked out in thought upon the ninth sphere (the *galgal*), which is divided into equal parts; not so the configurations of the actual zodiacal signs themselves, [those constellations] in the firmament, whose parts are not equal, as was explained above in Section 5, siman 116 [Hebrew ה' סי' קי"ו].

Siman 302 [printed ש"ב] — On the utility of the aspects of the stars

And the utility [of this] for the masters of the judgments of the stars [astrologers], the diviners of things to come, [is this]: they say that the stars Saturn (שבתאי) and Mars (מאדי"ם [Maadim]) are evil; Jupiter (צדק [Tzedek]) and Venus (נוגה [Nogah]) are good; Mercury (כוכב [Kochav]) and the Moon are intermediate. The opposing

aspect (מביט נוכחי) [opposition] and the square aspect (מביט מרובע) are evil; the trine aspect (מביט משולש) and the sextile aspect (מביט מששה [of six]) are good; the sextile is better still than the trine.

They said: the aspect of two good planets [together] indicates peace and complete love; the aspect of two evil planets indicates strife and complete enmity; the aspect of two intermediate planets indicates peace and love, but not [in] completeness. And an aspect [of a] good [planet] with an evil [planet] [yields] a good star [that] partly nullifies the evil, and the evil [partly] nullifies [some] of the good. An aspect [of a] good [planet] with a good star is very good; an aspect [of a] good [planet] with an intermediate planet, and an intermediate star [together], is intermediate; an aspect [of an] evil [planet] with an evil star is very evil; an [evil] aspect with an intermediate planet, and an intermediate star, is intermediate; an evil aspect [?], with a good star [present], is not good. [?]

Know that, even though these matters have no [practical] bearing on our concern in this book of ours — as [you will find] in the Talmud, and in the words of the sage **Ibn Ezra** (ראב"ע) [R. Avraham ibn Ezra], or in other books — [I have brought] some of the matters of the opposing aspect, the trine aspect, [and] the square aspect, with their figures, so that [the reader] may know some of [these] learned matters mentioned, [presented] as a small note upon this book of mine.

Siman 303 [printed ש"ג] — Since in the squares [aspects] there is [some] further utility besides

Know that the utility [there is] for the masters of the judgments of the stars [astrologers] in the aspects of the zodiacal signs — there is in the squares [the square aspects] a known [special] property and utility. When one sign sets [שוקע] [as part of] the square [configuration], the sign drawn after it [the next square-point] is then at the midheaven (אמצע השמים) above the earth; and the sign standing after that [in the square] [will be] at the third corner of the square [and] will rise on the eastern horizon; and the sign [at] the last corner [of the square] will then be at the lower midheaven (אמצע השמים מתחת) beneath the earth.

The example of this: when Aries [טלה] sets, Cancer [סרטן] will be at the midheaven above the earth, and Libra [מאזניים] will be rising on the eastern horizon, and Capricorn [גדי] will be at the lower midheaven beneath the earth. And in like manner [reckon] the matter for the rest of the squares — in all 12 [signs]. Also in the days of Nisan and Tishrei [the equinoxes], for those dwelling precisely beneath the equator (קו… אשר [the equinoctial line]), the [solar] sign [?] is illumined [?] [and other details follow, partly garbled]; only on the [two]

equinoctial days [?]... [a clause garbled]...for the inhabitants who dwell above the horizon [?] [are affected]; some of the inhabitants of the [polar] climes [?] [experience] that for them the [period of light] runs from the eastern side, [along] the line of their midday [meridian] [?], toward the western side; and all this [varies] according to the time and according to their nearness to the north or, conversely [?], to the south — as was explained above in Section 5, siman 111 [Hebrew ה' שער קי"א].

Siman 304 [printed ש"ד] — On the nations and places [that are] under which [zodiacal] sign [each] is placed

[Sub-heading partly in larger type:] On the nations and the [various] places — under which sign [mazal] they are placed.

It is already [stated] above [?] that the Blessed God placed all the nations [each] under [?] [a zodiacal sign]. As [explained] above, the Blessed God set each of them [each nation] under the dominion of the stars, [so that] each and every nation [is] placed under one of the twelve signs of the firmament. And so the sage **Ibn Ezra** (ראב"ע) wrote, in [his comment on] the verse "which [the Lord your God] has allotted to all the peoples" [Devarim 4:19], in these words: "It is a tested matter that every people and people [nation] has its own known star and sign; and so too every city has its sign." [?]

I saw fit to copy here, from the books of the astronomers, [the question of] under which of the twelve signs of the firmament are placed [the various] kingdoms, provinces, and many places dwelling in the region of Europe (אירופ"י [Europe]) — a matter that became known by experience, [from] those who observed and ascertained that when such-and-such a sign was in a good configuration in the array [of the heavens], good things came to such-and-such provinces and kingdoms, and to such-and-such [a place]; and so they found the matter [holds] in its reverse [in the reverse case]. And these are some of the particulars of the matter:

The nations / places and their ruling signs

Under the dominion of the sign Aries (מזל טלה) are placed: Germany (תגרמה [Germania]); Großpolen / greater Poland (גרוסי פולין); White Russia (ווייס רוסי"ן); Russia / Reußen (רוש); Pomerania (פונט"ר לנד [Pommernland]); Reisen [Russia / Ruthenia] (ריס"ן); Switzerland (שווייצר); Ireland [?] (אירינקן לנד) [?]; Burgundy [?] (בורגקין־לנד); Lorraine (לוטרינגן); Sweden / Ireland [?] (שוויד / אירלנד) [?]; Burgos in Spain (בורגס שבספרד); Bologna (באנוניא [Bononia]); Antwerp [?] (אנטוכא); Zürich (צ-ווירך); Luzern / Lucerne (לוצערין); Würzburg (ווירצבורג); Mainz (מעץ); Gniezno

(גניזן [Gnesen]); Leipzig (לייפציג); [?] (קרל שטט [Karlstadt]); Parma (פארמא); Stuttgart (גויגארטין [?]); Speyer (שפייאר).

Under the dominion of the sign Taurus (מזל שור) are placed: the land of Germany [Ashkenaz] (מדינת אשכנזי); France (צרפת); England (אנגלטירא); lesser Poland (קלין פולין); Upper Burgundy [?] (הוך ברגונדא); [?] (שוואכט [?]); Upper Silesia (אובר שלעזיא); Austria (וועשטריך [Österreich]); Naples (נאפילוס [Napoli]); Florence (פלורענץ); Brunswick (ברונשוויג); Austria (אייסטריך [Österreich]); Kraków (קראקוב).

Under the dominion of the sign Gemini (מזל תאומים) are placed: Egypt (מצרים); Armenia (צרמעניין [Armenia]); Flanders [?] (אלאנדרן [≈ Flandern]) [?]; Brabant (בראבנד); Württemberg (ווירטן בורג); part of Lombardy (מקצת לומברדיאה); Wetzlar (וועצליר); Nuremberg (נירן בורג); Ansbach (אנשפך); Louvain (לויבן); Mainz (מענ"ץ); Bamberg (בומבערג); Bruges (בריג); Villach (וילאך); [?] (קוצוגין [?]); London (לונדן); Córdoba (קראדובא [Córdoba]); Rhine / Straubing [?] (ריון שטראם) [?]; Zwickau (צויקא).

Under the dominion of the sign Cancer (מזל סרטן) are placed: the kingdom of Scotland [?] (שאטן... [?]) and Burgundy (בורגונד); Prussia (פרוסין); Holland (הולנד); Zeeland (זילינד); Tunis (טוני"ס); Genoa (יענובא [Genua]); Constantinople (קונשטאנטינאפל); Lucca (לוקא); Milan (מיילנד [Mailand]); [?] (נינידינ); Bavaria (בעערין [Bayern]); Görlitz (גירלוץ); Trier (טדירי [?]); Lübeck (לויבק); Marburg (מאריבורג); Brandenburg (בראנדיבורג); [?] (פדויסקמדק) [?].

Under the dominion of the sign Leo (מזל אריה) are placed: Welschland (וועלש לנד [Welschland]); Burgundy (בארגונד) [?]; Sicily (ציציליע [Sicily]); Koblenz (קאבליענץ); Ulm (אולם); Prague (פראג); Bohemia (פיהם [Böhmen]); Potsdam [?] (פאסדעם [?]); Linz (לינץ); [?] (קדעסז) [?]; Rome (רומה); Dauphiné [?] (דאפינו [?]); [?] (מעחלי [?]); Wittenberg [?] (וויט בורג [?]).

Under the dominion of the sign Virgo (מזל בתולה) are placed: the land of Egypt [?] (ארץ היוניט/היוגיט [?]); Africa (אפריקא); Carinthia (קערנטן [Kärnten]); Croatia (קראבאטן [Kroatien]); Babylon (בבל); northern Silesia (נודר שלעזיא); Switzerland [Eidgenossen] (עטשלנד [?]) [?]; Rhodes (ראדיס [Rhodos]); Pavia (פאביא [Pavia]); [?] (רינקא [?]); Jerusalem (ירושלים); Paris (פאריס); Louvain (לויבען); Lugano (לוגראן [?]); Basel (באזל); Erfurt (ער פארט [Erfurt]); Breslau (ברעסלויא); Heidelberg (הוידלבורא [Heidelberg]).

Under the dominion of the sign Libra (מזל מאזנים) are placed: Alsace (עלזיס); Austria (איסטריוך [Österreich]); Livonia (ליפלאנד); Savoy (סאפאיע [Savoyen]); Strasbourg (שטראס בורג); Vienna [?] (גוין [≈ Wien]) [?]; Frankfurt am Main (ורנקבורט דמיין); Austria (ראושטרייך [Österreich]); Norway (נארוועגין); Wimpfen [?]

(וויימפבן); Heilbronn (היילפרן); Catalonia (קאטולניען); West Sweden (וועשטשווידן); Switzerland (שווייצר); Antwerp (אנטווארף); [?] (וועלדינירך) [?]; [?] (ליזר באן) [?]; Speyer (שפייאד).

Under the dominion of [the sign] Scorpio (עקרב) are placed: West Sweden (וועשט שווייִדן); Norway (נורווענגין); Catalonia (קאטוליגען); Bavaria (פייארן [Bayern]); [?] (אויברן); Cremona [?] (קודרא [?]); Brixen (בריקסן); Vienna (וויאן); [?] (מווינ...); Valencia (וואל...ענץ [?]); Provence (דפראבענץ [Provence]); Spain (השפניא); Danzig (דנציק).

Under the dominion of [the sign] Sagittarius (קשת) are placed: Hungary (אונגרין); Serbia [?] (סער.רי [?]); Spain (שפאניא); Wenden [?] (וועגדן); Walachia [?] (וואלטענדא [?]); Mainz (מייטן [?]); Cologne (קאלוניא); Buda / Ofen (אויבען [Ofen]); Rotenburg [?] (רוטין בערג [≈ Rotenburg]); Strasbourg (גארטין שטרום [?]); Kassel (קאשע [?]); Avignon (אביניאן); [?] (שאלטו...) [?]; Spain (אד שפניא); Gotha (גוטאן [?]).

Under the dominion of [the sign] Capricorn (גדי) are placed: Bulgaria [?] (בולגרידיאד [?]); Saxony (זקסין); [?] (העטין) [?]; Thuringia [?] (זוירינקאן [?]); Styria (שטיירמדק [Steiermark]); Salzburg (סנבורג [?]); [?] (גמליך); Cleves [?] (קלעדער [?]); Bergen (בערגן); [?] (יענט מעכל) [?]; Augsburg (אוגשבודג); Brandenburg (ברגדיבורג [?]); [?] (קאשיניץ) [?]; Vilna-de-Lita / Vilna of Lithuania (ווילנא דלוטא); [?] (אול) [?].

Under the dominion of [the sign] Aquarius (דלי):

Section 12 (שער יב)

[Continuation of] Siman 304 — Nations and cities placed under the dominion of the [zodiacal] stars

(Continuing the nation/city-to-sign table from the previous batch; the entries for Aquarius and Pisces complete it.)

Aquarius (דלי): Under its dominion are placed the nations and cities of: Muscovy [מאשקווייא = Muscovy/Moscow], Denmark [רעניטרק = Dänemark], Rotenburg [רוטירויכץ], southern Sweden [זוד שוועדן], [וואלביא[?]], Austria [ערטוריאה = Österreich], Westphalia [וועשפולין], Hamburg [המבורג], Bremen [ברעמין], Salzburg [זאלינבורג], Trier [טריר], Ingolstadt [אינגלשטט], [מונפירוד[?]], [פיסויא[?] = Pisa/Pavia?].

Pisces (דגים): Under its dominion are placed the nations and cities of [תחת ממשלתו נתונים = "under its dominion are placed"]: Portugal [פורטיגאל = Portugal], Normandy [נורמאנדיאה], [וועשטריך[?]], Regensburg [רעגנשפורג], Worms [זוירמש = Worms], Speyer [שפורג = Speyer], Alexandria [אלכסנדאריאה = Alexandria], Padua [פאדענץ = Padua/Padova].

The text now closes the discussion of the nation-to-sign assignments and turns to the question of Israel:

As for the nation of Israel [הא"מה הישראלי = the Jewish people] — whether it too is placed under the dominion of the stars [תחת ממשלת הכוכבים], or whether it is not: this matter requires great contemplation and careful study. We find disputes about it among the early and later authorities [בין הראשונים והאחרונים], and there is much disagreement [מחלקות]. Indeed, we find a dispute of the Sages in this very matter — a Talmudic disagreement [פלוגתא דרבוותא] in the last chapter of Tractate Shabbos (Shabbos 156a). For there we learned: "It was stated — R. Chanina said: A constellation [mazal] makes one wise, a constellation makes one wealthy, **and Israel is subject to a constellation** [ויש מזל לישראל]; and R. Yochanan said: **Israel is not subject to any constellation** [אין מזל לישראל]." And so they said there: "Rav said in the name of R. Yehudah... and from R. Akiva, and from Rav, and from Shmuel" — and Rav Nachman bar Yitzchak [גחמן בר יצחק = Nachman bar Yitzchak] [held] that all of them concluded that Israel is not subject to a constellation. (See there, and in the commentary of Rashi.) Don Yitzchak Abarbanel [דון יצחק אברבנאל = Don Isaac Abarbanel] has already treated this at length, with great and extensive remarks; but I saw fit, in order to bring out the essence of his intent, to set the matter down here briefly, in this place.

Siman 305 [printed: ש"ה]

The names of the thirty-six constellations of the heavens [צורות השמים], and an account of their stars [כוכביהם].

We already explained, at the head of the fifth section [שער חמישי], that the ancient sages [הקדמונים] divided the firmament's zodiac into twelve signs [טי"ב = י"ב, twelve], one sign at a time, drawing lines from star to star — from this star to that star — in order to mark out and depict by means of them the figure [הצורה] upon which the great ones agreed. They did this with the twelve signs [in the band of the zodiac], grouping [קבוץ] the stars of the zodiac; and likewise they did with the rest of the stars of the heavens, which they grouped into a figure — calling them, for instance, the Great Dog, or another encampment[?] called the eagle in the heart of the heavens [the Nuck/Aquila[?]], or a triangle, or the sea-fish [דג הים], and the like. As for the count of the figures that they added beyond the twelve signs of the zodiac, the total of them all comes to thirty-six figures. Now, the twelve signs of the zodiac are already explained [from earlier in the book]; therefore I saw fit to set forth in this place the names of the thirty-six additional figures, and to bring them out by the number of their host [במספר צבאם]. And these are they:

Table of the thirty-six constellations. *(In the source these are laid out in two grouped tables — the "northern figures" portion and a "צורת הדרומית" / "Southern figures" block, sitting in the LEFT column of the page. The numbering runs א, ב, ג … and continues with the higher numerals shown alongside; the rightmost number on several rows is the count of stars in that figure. A few southern-figure names remain garbled in the original print and are flagged. The table reads right-to-left in the source.)*

Northern figures [צורות הצפוניות]:

#	Hebrew name	Identification (constellation)	Star count[?]
א	הדוב הקטן	Ursa Minor (the Little Bear)	—
ב	הדוב הגדול	Ursa Major (the Great Bear)	—
ג	התנין	Draco (the Dragon/Serpent)	—
ד	בעלת הלהב	the flame-bearer (Cepheus)	—
ה	הכלב הנובח	the barking dog	—
ו	הנזר השמאלית	Corona Borealis (the left crown)	—
ז	ההולך על ארכובו	the one going on his knee (Hercules / Engonasin)	—
ח	הנשר הנופל	Lyra (the falling eagle)	—
ט	התרנגולת	the hen (Cygnus)	—
יוד	היושבת על כסא	Cassiopeia (she	—

#	Hebrew name	Identification (constellation)	Star count[?]
		who sits on a throne)	
יא	הנושא ראש השטן	Perseus (the one carrying the demon's head)	—
יב	הרואה שבידו רסן	the watcher holding a rein (Auriga/Boötes)	טו
יג	עוצרת החיה	the one restraining the beast	כד
יד	החיה	the beast	וה[?]
טו	הנשר המעופף	Aquila (the flying eagle)	ט
יז	דג הים	the sea-fish (Delphinus/Piscis)	—
יח	ראש הסום	the horse's head (Equuleus)	—
יט	הסום בעל כנפים	the winged horse (Pegasus)	—
ך	האשה כלי בעל[?]	the woman... (Andromeda?)	—
ךא	המשולש	Triangulum (the triangle)	—
(total)	—	column total / final star-count	כו (26)

Southern figures [צורת הדרומית]:

#	Hebrew name	Identification (constellation)	Star count[?]
א	בגדים אדירוהס[?]	[southern figure — name garbled in print]	דפ[?]
ב	בשור הגדול	the great herald (Canis Major?)	לח
ג	בשור הנכר[?]	[southern figure — name garbled in print]	לר[?]
ד	בשור מרכבת[?]	[southern figure — name garbled in print]	—
ה	התאומים שכלב הגדול	Canis Major (the twins, that is the great dog)	יח
ו	תאומים שכלב הקטן	Canis Minor (the twins, that is the little dog)	מה[?]
ז	סרטן ספטיפג[?]	[southern figure — name garbled in print]	—
ח	סרטן קטיף[?]	[southern figure — name garbled in print]	בה[?]
ט	אריה סכום[?]	Hydra/Leo region	ז
י	בתולה הנצב	Virgo (the standing maiden)	לח[?]

#	Hebrew name	Identification (constellation)	Star count[?]
יא	בתולה פתיה כושאת זאב לי[?]	[southern maiden + wolf? — line garbled in print]	—
יב	הזאב	Lupus (the wolf)	—
יג	עקרב המקתה[?]	Scorpius region	—
יד	קשת נזר הדרומי[?]	Sagittarius / Corona Australis (the southern crown)	—
טן[?]	גדי טן פנג טדרומי[?]	Capricornus region (southern)	יוד

Parsing notes: The double table is a clean three-column-per-block layout (figure index | name | star-count); it reads sharply at native resolution. Numerous Hebrew names of the classical 48 Ptolemaic constellations are present (the list corresponds to Ptolemy's 21 northern + 12 zodiacal + 15 southern figures). The northern figure-names and star-counts (טו, כד, ט, …) are legible; the apparent extra "כו" row is the column total (26), not a 22nd figure. Only about six southern-figure names (rows א, ג, ד of the southern right block; rows יא, טן of the southern left block; and the "ספטיפג"/"קטיף" entries) remain uncertain — these are compositor garbles in the original print, not scan degradation, and are flagged [?] as printed.

[Rashi script: closing biographical narrative and the author's testimony]

(The entire right column is set in Rashi-type secondary script. It is a first-person account by Gans of his visit to the imperial observatory and the work of the great astronomer there — Tycho Brahe under the patronage of Emperor Rudolf II at Prague/Benátky. A few proper names are garbled by the compositor.)

[Rashi script:] With the seals[?] of these new discoveries [חדשות] of his, I [Gans] hereby make known something that happened in the year [ש"ס of the sixth millennium = (5)360 AM], in the days of our master the Emperor — may he be exalted — **Rudolf [רודאלפו"ה = Rudolf II], may his glory be exalted** [יר"ה], for he was filled with wisdom and with knowledge and the understanding of astronomy [חכמת התכונה], outstanding in the science of the stars, and a lover of the sages who honor it and devote themselves to it.

He sent to the country of Denmark [למדינות דעני מרק = Denmark] and summoned the great and outstanding scholar [החכם המופלג], the foremost in the science of astronomy of all who had ever lived — one of the princes [שרי] of the land of his own people, called **טיח"א [Tycho Brahe]** (in the sixth-millennium reckoning [בדא"הי]) — and the Emperor settled him in the fortress called Benátky [בינאטק = Benátky], a short distance[?] (about five [miles?]) from the royal capital city of Prague [פראג]. There he secluded himself with his scholars, and a stipend was fixed to be given to him year by year — three thousand thaler [שלשת אלפים טאלרגם = 3,000 thaler], besides bread and wine and beer[?] and all the other expenses of his household.

And there, in the said place, he sat for eleven[?] years[?] with many men — sages and men of understanding in science, engaged in astronomy[?] [באצטגנינות = astronomy/astrology], the great and outstanding ones — and with their instruments [וכלי הכמיהם], the great and the wondrous, such as no eye had ever seen and no one had ever built. The Emperor built for him there thirteen [שלש עשרה] turrets[?] [תרדים — tower-noun loose], all in a single row, all of one [height/design], in each of which was an instrument with which they observed the positions and courses of all the fixed stars [כוכבי שבת] and of most of the wandering stars [כוכבי נבוכה = the planets]. By day they would observe, and they would scrutinize and record with exactitude [ומדקדקין] the course and position of the sun [החמה] in its sphere — its longitude, its height in the firmament, and its distance from the globe of the earth [מכדור הארץ]. So too they did every night: they would investigate and scrutinize each one of the six planets [ששת כוכבי נבוכה — i.e. the planets other than...], the position of each of them in longitude and height of the firmament, and would testify to their nearness and farness from the globe of the earth; and likewise for most of the fixed stars [כוכבי שבת], the course and position of each one of them.

I myself [אנוכי] was present there many times — three times, each time for five consecutive days [ה' ימים רצופים] — and I sat with them in their observation-chambers [בחדרי חזיונם], and I saw the work that was done there: great and

wondrous things, and not only with the wandering stars [planets]; indeed, even with the fixed stars [הכוכבים… שבת] — every one of which has its own name — they observed [each] as it passed the line of the meridian[?] [כקו חצי הלילה = the midnight line/meridian[?]], by means of three kinds of instruments. Beside every instrument sat two scholars, and everything was promptly recorded in a book: at the moment[?] a star reached the meridian [חצי הלילה], the hour and the minutes of the hour [דקי השעה] for which this happened he had a teacher[?] [— i.e. a designated observer]. I declare faithfully [שאגיד בנאמנה] that these were wondrous new discoveries on the horizon, great matters such as our forefathers never saw and never heard of — none recounted them to us; nor did we find them written in any book, neither among the people of Israel nor — to make the distinction [להבדיל] — among the nations of the world.

And the end of what is recounted [תכלית המסופר] is still more, in this matter — that I might tell into the ears of the reader something of the great extent and depth of the investigations into the heavens and the stars[?] [חקירות… הכובבים] which this great and upright investigator, **טיח"א [Tycho Brahe] of the sixth-millennium reckoning [בדא"הי]**, investigated. He changed many matters in astronomy from those of Ptolemy [כטולמיאוס = Ptolemy], all of it by [sound] reasoning [בסברא] and well-grounded sense — wondrous new matters and the meaning of things that the early ones never grasped. Of these many things — four of which are taken from his works in the early sections [שערים ראשונים] — I [will set down] in this place a small and brief note, in marvelous concision:

1. By his observations he proved [הוכיח] that the sphere of the fixed stars [שגלגל קבוע-כוכב — the firmament] revolves and shifts very [slowly] over a long span of time[?]; his words are accepted by reason, and we already revealed a little of this in the first section, in siman 19 [סי' י"ט].

2. That the center of the sun [שמרכז החמה] has drifted [התמוטטה] over the length of time from beneath the line of the ecliptic [קו הקדרות = the ecliptic[?]].

3. He proved by clear demonstration that three of the wandering stars [כוכבי נבוכה — the planets], namely Saturn[?] [שהו' סא[?]], Jupiter[?], and... [/ נ"ה כוכ"ב נ"ה[?]], do not in their course [במהלכם] encircle the globe of the world [כדור העולם] at all — rather, what they appear to revolve each day is only on account of the uppermost [diurnal] motion [התנועה העליונה], by that [outer sphere] alone.

4. That the sphere which encompasses the five wandering stars [חמשה כוכבי נבוכה], which are... [שצ"מבי"ג[?]] — the center of the earth is not their center; and there is no need to say that the inclined[?] sphere [הגלגל הנוטה]... they have no [common] center... the center of the earth is not the center of any of them, except for the spheres of the sun and the moon alone. As for the centers of the other five wandering stars [ה' שאר כוכבי נבוכה], the center of the sun itself is their center; and in his opinion [ולדעתו] the sun [החמה] sits forever [יושבת לעולם] at rest in the midst, like a king sitting [enthroned] within his palace [במלך היושב תוך עמו], with [the planets] revolving around it[?]; and none of the wandering stars ever draws near or attaches itself by its center to the center of the sun, from time to time, even [over] all the days of the world — and all that the early sages [החכמים הקדמונים] [held], cannot be imagined or conceived at all, etc.

These last two matters are at times hard to convey properly to students; the writer's pen [עט סופר] feels its strength fail to depict them and to render them lawfully[?] [כדין[?] על הגייר]. Yet I stood beside the [demonstration] spheres [הגלגלים] of [Tycho], may his glory be exalted [בראה"י[?]], on which all this is [shown], such that in a moment an understanding student would grasp the matter by its [own] structure [על תכונתו]. **A wise [scholar] will understand the words by [their own] reckoning [יבין הדברים על תכונתם בכל רגע — "the intelligent will understand"; cf. the Talmudic idiom].**

[Colophon, set apart at the foot of the left column:]

**** [opening flourish כליק] on Friday [יום ו'], the 8th [ח'] of [the month of] Av, [the year] שנ"ג לפ"ק [= 5353 by the minor reckoning = 1593 CE], [closing flourish] טליק.

(The very last line reads: "[כליק]" — כליק יום ו' ח' אב שנ"ג לפ"ק טליק [טליק] [לפ"ק] Friday, the 8th of Av, [the year] 5353 by the minor reckoning." The opening token כליק and closing token טליק are a rhyming printer's flourish pair. The year = שנ"ג 353 = 3 + 50 + 300, i.e. 5353 AM = 1593 CE — the date of Gans's original composition of the work (Prague), consistent with the Tycho/Rudolf II narrative above. The penultimate line reads: תלמוד משכיל יבין כונת הדברים על תכונתם כרגע — "the studious one will grasp the intent of the matters by their structure in a moment.")