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Levi ben Gerson on the Principles of Cosmology

Introduction

The astronomical works of Levi ben Gerson (Gersonides: 1288–1344) have received considerable attention in recent years.¹ In this paper we focus on his cosmology rather than on his contributions to astronomy.² Medieval cosmology was concerned with the arrangement of the planets and their orbs³ in space, whereas medieval planetary astronomy was mainly concerning with finding the coordinates of a planet in celestial longitude and latitude at any given moment in the past or the future. The views of Ptolemy (Alexandria, second century CE) on cosmology are presented in the *Planetary Hypotheses*,⁴ whereas his better known

- 1 See, e.g., Bernard R. Goldstein, “Levi ben Gerson on the Sources of Error in Astronomy,” *Aleph* 10 (2010): 211–240; José Luis Mancha and Gad Freudenthal, “Levi ben Gershom’s Criticism of Ptolemy’s Astronomy,” *Aleph* 5 (2004): 35–167; Bernard R. Goldstein, *The Astronomy of Levi ben Gerson (1288–1344)* (New York: Springer, 1985).
- 2 Although *teḳunah* usually means “astronomy,” for Levi it can also mean “geometrical planetary model,” “physical planetary model,” and “cosmology.”
- 3 In certain contexts, Ptolemy’s term “sphere” (Ar. *kura*, Heb. *kaddur*), was replaced in the Middle Ages by a special term, “orb” (Ar. *falak*, Heb. *galgal*).
- 4 Bernard R. Goldstein, *The Arabic Version of Ptolemy’s Planetary Hypotheses*.

work, *The Almagest*,⁵ is restricted to astronomical matters. The first part of Book I of the *Planetary Hypotheses* is extant in Greek, but the second part of Book I and all of Book II are not. There is a complete translation into Arabic of Books I and II, as well as a complete Hebrew version, by Qalonymos b. Qalonymos (1317), based on the Arabic translation. The Hebrew version is extant uniquely in Paris, MS héb. 1028, fols. 54b–87a, copied in 1342.⁶ In Book I, Ptolemy presented his nesting principle; namely, that the minimum distance of a planet from the Earth is equal to the maximum distance of the planet below it, and the cosmic dimensions derived from it; Book II is devoted to what Ptolemy calls “physical arguments”⁷ and then to the physical configuration of the partial orbs that compose each planet’s orb.⁸ The orb of a planet is a spherical shell whose inner radius is equal to its minimum distance from the Earth and whose outer radius is equal to its maximum distance from the Earth. The partial orbs are the components of a planet’s orb; for Ptolemy they are the eccentrics and epicycles, but for Levi there are eccentrics but no epicycles.⁹ Moreover, in contrast to Ptolemy, Levi includes discussions of both astronomy and cosmology in his magnum opus on astronomy.¹⁰

In the *Almagest*, Ptolemy described geometrical models for planetary motion, but the issue of their physical reality was not addressed. However, in the *Planetary Hypotheses* Ptolemy made it clear that these models are to be understood as physically real; in particular, he stated the principle that the ratio of a planet’s maximum to minimum distance from the Earth in the model is the same as the ratio that applies in reality. Levi accepted this principle, although his geometrical models differ from those of his ancient predecessor. Similarly, Levi has a nesting principle, but it differs from Ptolemy’s, for he adds a fluid between each pair of adjacent planetary orbs, which has some special physical properties.¹¹ As far as I can determine, Levi is the only medieval Jewish astronomer to quote a passage from Book II of the *Planetary Hypotheses*.¹²

Transactions of the American Philosophical Society, 57.4 (Philadelphia: American Philosophical Society, 1967). For the Arabic text and a French translation of Book I, see Regis Morelon, “La version arabe du *Livre des hypothèses de Ptolémée*,” *Mélanges de l’Institut dominicain d’études orientales* 21 (1993): 7–85. For a German translation of the Arabic version (excluding Book I, Part 2), see Ludwig Nix, “Schrift des Ptolemaeus Claudius über die Darlegung des gesamten Verhaltens der Planeten,” pp. 70–145 in *Claudii Ptolemaei Opera astronomica minora*, ed. Johan L. Heiberg (Leipzig: Teubner, 1907).

- 5 Gerald J. Toomer, *Ptolemy’s Almagest* (New York and Berlin: Springer, 1984).
- 6 In H. Zotenberg, *Catalogues des manuscrits hébreux et samaritains* (Paris: Imprimerie impériale, 1866), p. 186, Qalonymos’ translation is dated 1317, although the colophon has only 8 Nisan without giving the year. Moritz Steinschneider explained that this date was based on the colophon of the previous item in MS 1028 (fol. 54a: [50]77 A.M., corresponding to 1316/17 CE); 8 Nisan 5077 corresponds to 22 March 1317. See *Die Hebräischen Übersetzungen des Mittelalters* (Graz: Akademische Druck- und Verlagsanstalt, [1893] 1956), p. 538.
- 7 Ar. *al-qiyās al-ṭabīʿī*; Heb. *ha-heqqeš ha-ṭivʿī*: Goldstein, *Arabic Version*, p. 36:14; Paris, MS héb. 1028, fol. 71b:20.
- 8 In the secondary literature there are several discussions of the contents of Book II but, for the most part, they are based on the inadequate German translation of the Arabic version: see, e.g., Otto Neugebauer, *A History of Ancient Mathematical Astronomy* (Berlin: Springer, 1975), pp. 922–926. The only detailed account based directly on the Arabic version is found in Andrea Murschel, “The Structure and Function of Ptolemy’s Physical Hypotheses of Planetary Motion,” *Journal for the History of Astronomy* 26 (1995): 33–61.
- 9 For the argument against an epicycle for the Moon, see Levi’s *Astronomy*, ch. 20, translated in Goldstein, *Astronomy of Levi ben Gerson*, p. 117; and ch. 75, translated in Bernard R. Goldstein, “The Physical Astronomy of Levi ben Gerson,” *Perspectives on Science* 5 (1997): 1–30, on pp. 23, 27. In ch. 43, Levi extends the argument against a lunar epicycle to the planets, invoking the principle that “one individual provides evidence bearing on all the individuals of the species”: see Mancha and Freudenthal, “Criticism,” p. 132.

This paper is concerned with chapter 29 of Levi's *Astronomy*, where the principal claims are that the lowest partial orb of each planet moves with the daily rotation and that each planet lies on the highest of its partial orbs. Levi offers a variety of arguments, but I will focus on just two of them. One argument is based on the principle that the surrounding orb is moved by the orb it encloses (§§4, 12).¹³ Levi finds support for this principle in a passage in Ptolemy's *Planetary Hypotheses* (§43). This principle leads Levi to the conclusion that each planet lies on the highest of its partial orbs (§18).

Another argument is based on the observed motion of meteors (*'otot*),¹⁴ that is, some meteors move with the daily rotation, which is otherwise associated with celestial motions (§§19ff.). In the medieval view all meteors are sublunary, and natural motion in the sublunary realm is supposed to be either towards the center of the Earth or away from it.¹⁵ Hence, these meteors must acquire the daily rotation from a rotating celestial body, namely the lowest orb of the Moon, which is adjacent to the sublunary realm. This implies that the lowest partial orb of the Moon moves with the daily rotation. Levi extends this argument (initially applied to the Moon) to the other planets: the lowest partial orb for each planet moves with the daily rotation (§§29–30), implicitly drawing on the principle that what applies to one individual of a species applies to all the other individuals of that species as well (see n. 9, above). Elsewhere, Levi dismisses the argument in Aristotle (see, e.g., *De caelo* II 10, 291a33) that the motions of the planets diminish according to their distances from the outermost celestial sphere of the daily motion.¹⁶

In Aristotelian meteorology, many phenomena seen in the sky for a limited period of time are called "meteors." From Levi's argument, it is clear that he has in mind "meteors" that move with the daily rotation. The best candidate for a "meteor" with this characteristic is a comet (Heb. *koḳav mezunnav* or *koḳav ba'al zanav*; lit. a "tailed star"). Some comets, however, have been observed without tails,¹⁷

- 10 For a comparison of the table of contents of Levi's *Astronomy* and that of the *Almagest*, see José Luis Mancha, "Demonstrative Astronomy: Notes on Levi ben Geršom's Answer to *Guide* II.24," pp. 323–346 in Resianne Fontaine et al., eds., *Studies in the History of Culture and Science: A Tribute to Gad Freudenthal* (Leiden: Brill, 2011), on p. 330.
- 11 Bernard R. Goldstein, "Levi ben Gerson's Theory of Planetary Distances," *Centaurus* 29 (1986): 272–313. See also Ruth Glasner, "The Early Stages in the Evolution of Gersonides' *The Wars of the Lord*," *Jewish Quarterly Review* NS 87 (1996): 1–46, on pp. 35–39.
- 12 See §§42–43, below. Levi cites Book II of the *Planetary Hypotheses* in ch. 43 of his *Astronomy* and then quotes a passage from it: see Mancha and Freudenthal, "Criticism," pp. 163, 166. He rejects the physical models that Ptolemy described there, but adds (pp. 164–165): "However, it would be wrong for us to fail to express our gratitude to Ptolemy for all his innovations and discoveries in this art [i.e. astronomy] on these grounds [i.e. that his astronomy is false]. Indeed, he has helped us enormously and, as it were, directed us toward its [astronomy's] truth." Other references to Ptolemy's *Planetary Hypotheses*, Book II, are found in Levi's *Astronomy*, chs. 45 and 123, translated in Bernard R. Goldstein, "Levi ben Gerson's Preliminary Remarks for a Theory of Planetary Latitudes," *Aleph* 2 (2002): 15–30, on pp. 18–20, 25; see also Goldstein, "Planetary Distances," p. 277.
- 13 For a profound discussion of this principle and Levi's interpretation of the relevant passages in Averroes and Aristotle, see Glasner, "Early Stages," pp. 23–27, 34. Levi argues in favor of this principle at greater length in his *Astronomy*, ch. 43, where he insists that Aristotle's views, properly understood, do not contradict his own astronomy/cosmology (*tekunab*) or that of Ptolemy: see Mancha and Freudenthal, "Criticism," pp. 156–158.
- 14 In Antiquity, the term "meteor" referred to a range of phenomena observed in the sky, including some that in fact are astronomical. As we will see, the current meaning of meteor (or falling star) is not relevant in the context of the chapter under discussion here. The Hebrew *'ot* means "sign"; the corresponding Arabic term, *athar*, means "trace."
- 15 For Levi's views on this issue, see Ruth Glasner, "Gersonides's Theory of Natural Motion," *Early Science and Medicine* 1 (1996): 151–203, especially on pp. 190–195.

for which the general term *meteor* (Heb. *’ot*), would have seemed more appropriate. At the time, comets were believed to be sublunary because they appear for only a limited time interval, in contrast to celestial bodies, which are eternal. In chapter 17 of his *Astronomy*, Levi refers to a comet that he observed: “The comet [*kokav mezunnav*] ... continued to appear for more than three months.”¹⁸ Here Levi introduced a cometary observation in an astronomical context, despite the strict distinction between the superlunary and the sublunary realms in medieval cosmology.¹⁹ In §21 we are told of a “meteor” that Levi observed for ten days near a fixed star, which is probably a report of a cometary observation.²⁰ In §§32ff. Levi alludes to the Aristotelian theory of the formation of meteors/comets.²¹ For example, Aristotle says:

When therefore the material gathers in the lower region, the comet is an independent phenomenon. But when the exhalation [rising from the Earth] is formed by the movement of one of the stars—either of the planets or of the fixed stars—then one of them becomes a comet.... When therefore the formation of matter occurs in connexion with a star, the comet must necessarily appear to follow the same course as that on which the star is moving.²²

Levi’s argument, based on “meteors,” is most unusual, and it is a significant departure from the arguments in Ptolemy’s *Planetary Hypotheses*. It is equally significant that Levi does not report Ptolemy’s analogy of the motion of planets through the heavens with the motion of birds in the air.²³ In Sabra’s translation, the passage reads:

If someone takes the observable behavior of birds as an analogy for the motion of what exists in the heavens, then such an analogy would not be objectionable. For the proper

- 16 See Levi ben Gerson, *Wars of the Lord*, VI 1.9; Levi ben Gerson, *Milchamot Hashchem* (Leipzig: Lorck, 1866), pp. 323, 326–327; Seymour Feldman, *Gersonides: The Wars of the Lord* (Philadelphia: Jewish Publication Society of America, 1984–1999), 3:261, 266–269.
- 17 See, e.g., Amédée Guillemin, *The World of Comets*, ed. and trans. James Glaisher (London: Sampson Low et al., 1877), pp. 196–197.
- 18 Goldstein, *Astronomy of Levi ben Gerson*, pp. 107, 188.
- 19 For Aristotle (*De caelo* I 2–3; cf. *Meteorologica* I 3) the celestial realm is not subject to alteration, and natural motion in the heavens is circular. Moreover, the substance of the heavens, *aither*, is distinct from the four sublunary elements. Levi accepted the sharp distinction between the celestial and terrestrial realms, but had his own views on the nature of the celestial realm: see, e.g., Glasner, “Early Stages,” pp. 35–39.
- 20 For another report by Levi of this undated observation (where the object is called “one of these stars” in a context suggesting that a tailed star, i.e. a comet, is meant), see E. Meiron, “Gersonides’ Supercommentary on Averroes’ Epitome of the Meteorology” (Ph.D. diss., Hebrew University, 2003 [Heb.]), p. 21; Berlin, Staatsbibliothek, MS 110 (MS Or. Fol. 1055), fol. 203v, col. 1. One might also consider that this “meteor” was either a supernova or a nova (a “new” star), i.e., a faint star that rapidly increases in brightness and then fades into invisibility to the naked eye after a limited number of days or months. The supernova of 1006 CE was observed by ‘Alī b. Riḍwān; he called it in Arabic *athar* (pl. *athār*), which is equivalent to the Hebrew *’ot*: see Bernard R. Goldstein, “Evidence for a Supernova of A.D. 1006,” *The Astronomical Journal* 70 (1965): 106–114, on pp. 105, 112 (see also n. 21, below). However, supernovas visible to the naked eye are rare, and none was visible during Levi’s lifetime; indeed, I have not found any reference to a supernova in a medieval Hebrew text. Novas, which are not as bright as supernovas, occur more frequently, and were noted by medieval Chinese observers (generally called “guest stars”); it is not possible to exclude a nova as an explanation for the undated observation mentioned in §21. For an extensive list of Chinese observations, see Ho Peng Yoke, “Ancient and Medieval Observations of Comets and Novae in Chinese Sources,” *Vistas in Astronomy* 5 (1962): 127–225. For an astronomical interpretation of these records, see David H. Clark and F. Richard Stephenson, *The Historical Supernova* (Oxford: Pergamon Press, 1977), pp. 40–56.

motion of birds proceeds from the psychic faculty that resides in them, then the impulsion produced by this faculty goes forth to the nerve, then—in our example—to the legs or hands or wings, and there the process of being passed on from one thing to another comes to a stop. ... We should similarly imagine the situation with respect to the celestial animal (Ar. *al-ḥayawān al-falakī*, Heb. *ḥay galgalī*). We should, that is, consider that each of the planets has the rank of a governing power, and that it possesses a psychic faculty and that it moves itself.²⁴

This passage comes soon after the passage in Ptolemy's *Planetary Hypotheses* that Levi quoted in §43, so it is surely intentional that Levi did not mention it.²⁵ Clearly, Ptolemy's theory to account for planetary motion is completely alien to Levi's way of thinking; instead, Levi appeals to the relation of various crafts (§48). Levi's account of the movers of the heavenly bodies is the subject of much of his *Wars of the Lord*, Book V, Part 3, but a detailed examination of these passages would take us well beyond the astronomical and cosmological issues of primary concern here.

In sum, Levi took Ptolemy's *Planetary Hypotheses* as his point of departure for cosmology, but he developed his own theory, which displays considerable innovation while staying within a tradition that began in Antiquity.

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The edited Hebrew text is based on three manuscripts: Paris, Bibliothèque nationale de France, MS héb. 724 (ϕ); Paris, Bibliothèque nationale de France, MS héb. 725 (ϗ); and Naples, Biblioteca Nazionale, MS III F 9 (Ⓛ). Divisions into paragraphs and sentences are due to the editor; minor variants in spelling have not been noted.

- 21 See Aristotle *Meteorologica*, I 7, 344a34–344b13; Aristotle: *Meteorologica*, ed. and trans. H. D. P. Lee (Cambridge, MA: Harvard University Press, 1952), pp. 48–57; cf. Resianne Fontaine, *Otot ha-shamayim: Samuel Ibn Tibbon's Hebrew version of Aristotle's Meteorology* (Leiden: Brill, 1999), pp. 34–41; the Hebrew title means “The Signs of Heaven.” The Arabic title of Aristotle's *Meteorology* is *al-Āthār al-‘Ulwiya* (p. xii), meaning “The Upper Traces.”
- 22 Aristotle: *Meteorologica*, trans. Lee, p. 53. For a paraphrase of this passage in Hebrew, see Irving Maurice Levey, “The Middle Commentary of Averroes on Aristotle's *Meteorologica*: Hebrew Translation of Kalonymos ben Kalonymos, edited with introduction, critical apparatus and Hebrew–Arabic vocabulary (Ph.D. diss., Harvard University, 1947), pp. 28–29. The corresponding Arabic text is found in *Talkhīs al-athār al-‘ulwiya* par Abu el-Walid Ibn Rochd, ed. and annot. Jamal Eddine Alaoui (Beirut: Dar al-Gharb al-Islami, 1994), pp. 48–49. Levi quoted the Hebrew translation in *Wars of the Lord*, V 2.9: see Sara Klein-Braslavy, “Without any Doubt”: *Gersonides on Method and Knowledge* (Leiden: Brill, 2011), p. 182, n. 4. I am most grateful to Dr. Klein-Braslavy for bringing this passage to my attention. Levi's familiarity with this passage in Aristotle is also evident in his supercommentary on Averroes's *Epitome of Aristotle's Meteorology*: see Meiron, “Supercommentary,” pp. 21–22; Berlin, Staatsbibliothek, MS 110 (MS Or. Fol. 1055), fol. 203v.
- 23 For a detailed discussion of this issue, see Ruth Glasner, “Gersonides on Simple and Composite Motion,” *Studies in History and Philosophy of Science* 28 (1997): 545–584, on pp. 568–574.
- 24 A. I. Sabra, “The Andalusian Revolt Against Ptolemaic Astronomy,” pp. 133–153 in *Transformation and Tradition in the Sciences*, ed. Everett Mendelsohn (Cambridge: Cambridge University Press, 1984), on pp. 150–151, based on the Arabic text in Goldstein, *Arabic Version*, pp. 40–41. See also Paris, MS héb. 1028, fol. 75b. Cf. Murschel, “Structure and Function,” p. 39. For the analogy of planets with birds, see Cicero, *De natura deorum*, II.41–42, cited in Peter Barker and Bernard R. Goldstein, “Distance and Velocity in Kepler's Astronomy,” *Annals of Science* 51 (1994): 59–73, on p. 62, n. 11.
- 25 Nevertheless, Levi considered the stars and planets to be living, i.e., ensouled, beings: *Wars V 2.2* (*Milchamot*, p. 193; trans. Feldman, 3:37). Cf. Maimonides, *Guide of the Perplexed*, II 5.

Levi ben Gerson's *Astronomy*, Chapter 29

ספר התכונה לר' לוי בן גרשום, פרק כ"ט

<פ 47:א19; ק 33:ב13; נ 93:ב19> הפרק הכ"ט. [1] ואחר שהתישב שהגלגלים אשר לכוכב האחד הם מתנועעים קצתם מקצת והתבאר עוד מכח דברינו שאין הגלגלים העליונים והתחתונים מגלגלי הכוכב מניע כל אחד מהם חברו בתנועתו, [2] הנה לא ישאר אלא שיהיו הגלגלים העליונים מניעים התחתונים בדמיון תנועתם ולא יניעו התחתונים העליונים מהם, או יהיה הענין בהפך זה, והוא שיניעו התחתונים העליונים מהם <נ 94:א> בדמיון תנועתם ולא יניעו הגלגלים העליונים השפלים מהם. [3] והנה ראוי שנחקר בזה מחקר ראוי לפי מה שאפשר לנו. [4] ונאמר שכבר יראה לסבות רבות שהוא ראוי שיהיו התחתונים הם המניעים העליונים. [5] מהם, כי כבר התבאר בספר השמע שהוא מחויב בכל מתנועע בסבוב שיהיה לו דבר עליו יתנועע הוא באמצעו. [6] וזה שלא ימלט הענין בזה מחלוקה: אם שיתנועע על שטח הגלגל המקיף אותו, או על שטח הגלגל המוקף. [7] ומן השקר שיהיה מתנועע על שטח הגלגל המקיף אותו, שאם היה הדבר כן, היה מחויב בכל גרם שמימי שיהיה לו גרם שמימי למעלה ממנו יתנועע עליו, ויהיו הגרמים השמימיים בלתי בעלי תכלית במספר, וזה שקר. [8] או יונח שם גרם שמימי עליון בלתי מתנועע ויהיה לבטלה, עד שיתחייב מזה שיהיה מקום הגלגל שטח הגרם המקיף בו ויהיו הגרמים השמימיים בלתי בעלי תכלית במספר. [9] ולזה יחויב שיתנועע על שטח הגלגל המוקף, והוא הגלגל אשר תחתיו. <פ 47:ב> [10] ומה שמתנועע הדבר עליו מצד מה שהוא מתנועע עליו וחותר אותו יחויב שיהיה בלתי מתנועע בתנועה אשר יתנועע הוא בה, וזה מבואר בנפשו. [11] ולזה יתבאר שאין הגלגל העליון מניע התחתון, שאם היה מניע אותו בדמיון תנועתו לא היתה תנועת העליון על שטח הגלגל המוקף כמו שנתחייב ממה שקדם.

[12] ולזה הוא מבואר שהגלגל התחתון הוא המניע העליון בדמיון תנועתו וזה מבואר מאד. [13] וזה כי גבנונית הגלגל השפל הוא הדרך אשר יחתכו קבוב הגלגל העליון ממנו

[2] פ: מהם בדמיון] נ: מהם. [2] פנ: התחתונים העליונים מהם, או יהיה הענין ... ולא יניעו] חסר בכ"י ק. [4] פנ: הם המניעים] ק: המניעים. [7] פק: היה מחויב] נ: היה הדבר מחויב. [7] פנ: בלתי בעלי תכלית] ק: בב"ת. [8] עד שיתחייב] פ: עד שחויב; ק: עם שיתחייב; נ: עד שיתחייב. [8] פנ: בלתי בעלי תכלית] ק: בב"ת. [10] פנק: מצד ... עליון] המלים האלה הועתקו פעמים בכ"י פ. [10] פנ: בלתי] חסר בכ"י ק.

בתנועתו. [14] ולא יתכן שיתנועע הדרך בתנועת הדורך בו. [15] אבל ראוי שיהיה קים בלתי נ 94:ב> מתנועע בזאת התנועה, וזה מבואר בנפשו עד שהאריכות בבאורו הוא מותר. [16] ומהם, שכבר יראה כי הטבע אמנם יתן תמיד ליותר נכבד המקום היותר נכבד. [17] ובעבור שהיה הגלגל המקיף יותר נכבד מהמוקף מצד מה שהוא מקיף, הנה מן הראוי שיהיה הגלגל אשר בו הכוכב למעלה משאר הגלגלים אשר יעבדוהו בתנועתם. [18] וזה אמנם יהיה כשיניע הגלגל השפל הגלגל העליון עד שיהיו לגלגל אשר בו הכוכב כל תנועות הגלגלים אשר תחתיו.

[19] ומהם, שכבר יראה מצד תנועת האותות אשר יראו באויר שהגלגל השפל מגלגלי הירח הוא בלתי מתנועע בתנועת הירח. [20] וזה שכבר יראו אלו האותות בקצת העתים זמן ארוך תחת אחד מהכוכבים המאוחרים התנועה כמו שסופר. [21] וראינו אנחנו בעינינו מאות אחד שהתמיד להמצא אצל כוכב מהכוכבים הקימים כמו י' ימים. [22] וזה ממה שיראה ממנו שהגלגל השפל מגלגלי הירח, אשר הוא מניע <ק 34:א> יסוד האש בתנועתו, אינו מתנועע בתנועת הירח, שאם היה מתנועע בתנועת הירח, הנה מפני שהירח מהיר במהלכו יחויב שיעבר זה האות הכוכב בזמן קצר. [24] וכאשר התבאר שהגלגל השפל מגלגלי הירח אינו מתנועע בתנועת הירח הוא מבואר שאין הגלגל השפל מגלגלי הירח נושא לירח. [25] וכבר היה זה מחויב אם הונחו הגלגלים העליונים מניעים התחתונים. [26] ולזה הוא מבואר שהגלגלים התחתונים הם מניעים לעליונים.

[27] וכבר אפשר שנבאר מזה שהגלגל השפל מגלגלי הירח הוא הגלגל אשר הוא מתנועע בתנועה היומית, כי זאת התנועה היא אשר תאזן שתונח לאלו האותות לפי מה שיורגש מהם מבין <נ 95:א> שאר התנועות הנמצאות לירח. [28] ולזה הוא מבואר שהגלגל השפל מגלגלי הירח הוא מתנועע בתנועה היומית. [29] וממנו נקח ראיה על שאר הכוכבים. [30] ולזה ראוי שיונח בכלם שיהיה הגלגל השפל מהם הוא המתנועע בתנועה היומית. [31] וכבר יתבאר מצד אחר במה שיבא שהוא מחויב שיונח כן.

[32] ואם אמר אומר כי לא יחויב ממה שיראה בקצת האותות שיראו לפעמים זמן ארוך תחת אחד מהכוכבים המאוחרים התנועה שלא יהיה הגלגל השפל מגלגלי הירח מתנועע בתנועת הירח, [33] וזה כי אולי יש לזה הכוכב רושם בהולדת האות ההוא, ויחשב שהאות יתנועע בתנועת הכוכב ההוא מזולת שיהיה הענין כן, אבל הכוכב ההוא מוליד תחתיו זה האות. [34] אמרנו לו שזה בלתי אפשר שיונח כן, וזה שאם לא היה מתנועע החומר הנושא לזה האות היה א"כ נכבה זה הלהב מדי עבור אותו זה הכוכב, ויתחדש א"כ

[21] קנ: י' פ: עשרה.

Translation

Chapter 29.²⁶ [1] It has been established that the orbs of each planet are moved by one another and, furthermore, from the strength of our arguments it is clear that it cannot be the case for both the upper and lower orbs of a planet that each of them moves its neighbor with its motion. [2] It only remains [to be decided] if the upper orbs move the lower orbs with a motion similar to their own and that the lower orbs do not move the orbs above them or, if the contrary [is true], namely that the lower orbs move those above them with a motion similar to their own and that the upper orbs do not move those below them. [3] We intend to investigate this matter as far as it is possible for us.

[4] We say that for many reasons it is evident that the lower orbs move those above them. [5] For one thing, it was already explained in the Book of Physics²⁷ that a rotating body must move about something within it. [6] Indeed, there is no escaping the following disjunctive proposition [*ḥaluqah*]: either [*a*] [the orb] moves with respect to the surface of the orb surrounding it, or [*b*] with respect to the surface of the orb enclosing it. [7] But it is false [to claim] that it moves with respect to the orb surrounding it for, if it were so, it would imply that every celestial body has another celestial body above it with respect to which it moves and that the celestial orbs are infinite in number, which is absurd. [8] If it were assumed that there is a highest celestial orb which does not move, it would be useless, since [premise *a*] entails

26 For an earlier translation of this chapter, see Bernard R. Goldstein, "Preliminary Remarks on Levi ben Gerson's Cosmology," pp. 261–276 in *Creation and the End of Days*, ed. David Novak and Norbert Samuelson (Lanham: University Press of America, 1986), on pp. 269–273.

27 Aristotle *De caelo*, II 3, 286a14–286b21; Aristotle: *On the Heavens*, ed. and trans. W. K. C. Guthrie (Cambridge, MA: Harvard University Press, 1939), pp. 148–151. Cf. Aristotle *Physics*, VIII 9, 265b2–8. See also n. 13, above.

להב אחר בחומר הנמצא תחת הכוכב הנאות להתלהבות, וזה תמיד. [35] אבל כאשר הונח הענין כן יהיה יחויב מזה שלא יהיה זה האות נשמר בתמונה אחת אם לא במקרה וזמן מועט מאד, וזה הפך מה שיראה לחוש.

[36] ועוד, שאם לא היה מתנועע זה האות מי יתן ואדע האם מדרך זה הכוכב שיוליד זה הלהב מזולת שימצא החמר הנאות לזה, או לא יולידהו אלא כשימצא החמר בכל הדרך אשר יעבור בו. [37] ואם היה החמר הזה נמצא שם קודם עברו בו, מה זה שלא יתלהב קודם בא הכוכב כנגדו, ולמה זה יכבה זה החלק אשר עבר בו הכוכב מדי עברו? [38] והנה אין מתנאי ההתלהבות שיהיה תחת כוכב אחד מהכוכבים, וזה מבואר מן החוש, רצוני שאנחנו נראה פעמים רבות <נ 95ב> אלו הלהבות מזולת שיהיו תחת כוכב מאלו הכוכבים. [39] ובהיות הענין כן, הוא מבואר שלא יפול ספק מזה הצד במה שבארנו בכאן שהגלגל השפל מגלגלי הירח אינו מתנועע בתנועת הירח. [40] ובכאן התבאר שהגלגל השפל מגלגלי הכוכב הוא המניע הגלגל העליון, ושהגלגל אשר הכוכב בו הוא למעלה משאר הגלגלים אשר יעבדוהו בתנועתם.

[41] וראוי שלא יעלם ממנו שמה שהביא אליו העיון הסכימו בו ארסטו והקודמים. [42] וזה יתבאר לך ממה שזכר בטלמיס בספרו בספור תנועת הכוכבים הנבוכים, כי שם אמר דבר, זה לשונו: [43] "והיותר נפלא ממה שבכאן שוּמָם הכדורים האחרונים מניעים לכדורים הראשונים, והכדורים יוקף בם מניעים למקיפים בם, והכדורים הרבי החלוף לכדורים הפשוטים בחלוף הסברא הטבעית". [44] עכ"ל. [45] והנה יתבאר לך ממה שקדם לו מהמאמר הזה שם שכבר רמז בזה אל ארסטו ולקצת הקודמים זולתו. [46] והוא מבואר שדבורו זה הוא מופשט מהראיה, [47] ולזה לא יהיה ממנו טענה על מה שהתבאר בזה המקום. [48] והנה ג"כ אין זאת ההנעה על דרך הראשיות, אבל היא על דרך העבודה והשירות כמו הענין במלאכות הראשיות שתהיינה להם מלאכות משרתות אותם, כמו הענין במלאכת המלחות עם מלאכת עשיית הספינות ומלאכת חתוך הקורות אשר מהם יעשו.

[סוף פרק כ"ט]

[37] פ: זה החלק] קנ: החלק. [38] פ: כוכב אחד] קנ: כוכב. [38] פק: אלו הלהבות] נ: מאלו ההתלהבויות. [38] נ: שיהיו] פק: שיהיה. [39] פק: במה] נ: כמו. [40] ק: המניע] פנ: מניע. [40] קנ: הכוכב בו] פ: בו הכוכב. [42] קנ: דבר] חסר בכ"י פ. [43] פק: יוקף] נ: אשר יוקף ("אשר" בשולים). [43] פק: הרבי] נ: הרבים. [45] נ: מהמאמר הזה] פק: מהמאמר בזה. [48] פנ: על דרך העבודה] ק: ע"ד העבודה.

that the place of the orb is the surface of the orb surrounding it and [thus] that celestial orbs are infinite in number. [9] Therefore, it is necessary that an orb move with respect to the surface of the orb which it encloses, that is, the orb below it. [10] Now when something [A] moves with respect to something else [B] and traverses it [B], it follows that it [A] does not move with the [same] motion [as B], and this is self-evident. [11] Therefore, it is clear that the upper orb does not move the lower orb for, if it moved [the lower orb] with a motion similar to its own, the motion of the upper orb would not take place with respect to the surface of the enclosed orb, as must be the case according to the previous argument.

[12] Therefore, it is evident that the lower orb moves the upper orb with a motion similar to its own, and this is very clear. [13] This is because the convexity of the lower orb is the path that the concavity of the upper orb traverses with its motion. [14] But it is impossible that the traversed [i.e. the lower orb] move with the [same] motion as that which traverses it [i.e., the upper orb]. [15] Rather, there must be something in this motion which is fixed and immobile; this is self-evident and prolonging its explanation would be superfluous.

[16] For another, it may be seen that Nature always gives to the more noble [thing] the more noble place. [17] Since the surrounding orb is more noble than the enclosed orb in so far as it surrounds [the lower orb], it is fitting that the orb on which the planet lies be above the rest of the orbs [associated with that planet] which serve it with their motion. [18] Thus it is that the lowest orb moves the orb above it until the orb on which the planet lies has all the motions of the orbs below it.

[19] For yet another, the motion of meteors [*ba-ʾotot*],²⁸ which are observed in the air, makes it evident that the lowest orb of the lunar orbs does not move with the motion of the Moon. [20] This is because these meteors are sometimes visible for a long time beneath one of the slow-moving planets,²⁹ as has been reported. [21] We ourselves have

observed with our own eyes a meteor that continued to be found near one of the fixed stars for about ten days. [22] From this it is evident that the lowest orb of the orbs of the Moon, which moves the element fire with its motion, does not move with the motion of the Moon. [23] For if it moved with the motion of the Moon and, given that the motion of the Moon is swift, it would follow that this meteor would pass by the star in a short time interval. [24] Since it has been made evident that the lowest orb of the Moon does not move with the motion of the Moon, it is clear that the lowest orb of the Moon does not carry the Moon. [25] But that [namely, that the lowest orb of the Moon carries the Moon] would follow if it were assumed that the upper orbs move the lower orbs. [26] Therefore, it is clear that the lower orbs move the upper orbs.

[27] We may deduce from this that the lowest orb of the lunar orbs moves with the daily motion, for this motion—from among the other motions found for the Moon—agrees with the motion that has been assumed for these meteors, based on [our] observation [*lit.* perception] of them. [28] Therefore, it is clear that the lowest lunar orb moves with the daily motion. [29] From this [case] we extend this proof to the other planets. [30] Therefore, it is appropriate to assume for all them that

28 For a discussion of the term “meteor” in this context, see the Introduction.

29 Heb. אחד מהכוכבים המאוזרי התנועה. For another example of this expression, see Levi ben Gerson, *Wars*, VI 1.9 (*Milchamot*, p. 326; trans. Feldman, 3:266). The slow planets are Mars, Jupiter, and Saturn, in contrast to the swift planets, Mercury and Venus. Cf. Bernard R. Goldstein, *Al-Biṭrājī: On the Principles of Astronomy* (New Haven: Yale University Press, 1971), 1:65 (Eng.); 2:72 (Heb.): The three planets above the Sun are “heavy and slow” (הכבדים המתאחרים) and those below the Sun are “light and swift” (הקלים והמהירים).

30 In his *Astronomy*, ch. 43, §§269–277, Levi repeats the claim that Aristotle supports his own view on the transfer of motion: see Mancha and Freudenthal, “Criticism,” pp. 94–97, 156–157.

the lowest of their orbs moves with the daily motion. [31] This will be clarified in another way in what follows, namely that it is necessary that it be so assumed.

[32] Someone might say that it does not follow from what is observed in some meteors—which are sometimes visible for a long time under one of the slow-moving planets—that the lowest orb of the Moon does not move with the motion of the Moon. [33] For [he might] reason, perhaps this star has an influence on the generation [*rošem be-holedet*] of that meteor and he might imagine that the meteor [seems to] move with the motion of this star without this actually being the case; rather, [the meteor moves with the motion of the star because] this star generates the meteor below it. [34] We say to him that it is impossible to support this assertion for, if the material [*ba-ḥomer*], which is the substrate [*ba-noše*] of this meteor, did not move, this flame [i.e. the meteor] would be extinguished each time this star passed beyond it, and another flame would have to be generated in the material found under this star appropriate for bursting into flame, and this would have to take place continually. [35] But, if it were so assumed, it would follow that the meteor would not maintain a single shape, except accidentally and for a very brief time, and this is contrary to observation [*lit.* sensory perception].

[36] For yet another, if this meteor did not move, let someone explain to me whether it is the nature of this star to generate this flame [i.e. the meteor] without there being material appropriate [for this purpose], or whether it only generates it [i.e. the meteor] when the material is found in the entire path through which it passes. [37] But, if this material was found there prior to its passing, why does it not burst into flame prior to the star coming towards it, and why, each time the star passes beyond this part [of the sky], is it extinguished? [38] In fact, it is not a necessary condition for bursting into flame that [the material] be under one of the stars: this is clear from perception, that is, we ourselves often observe these flames [i.e. meteors] when they are not below one of these stars. [39] Since this is so, it is evident that, from

this argument, no doubt befalls what we have explained here, namely that the lowest orb of the Moon does not move with the motion of the Moon. [40] Hence, it has been made evident that the lowest orb of a planet's orbs moves the upper orb, and that the orb on which the planet lies is above the rest of the orbs that serve it with their motion.

[41] It should not be concealed that Aristotle and the ancients agree with what [our] investigation yielded.³⁰ [42] This is will be evident to you from what Ptolemy mentioned in his *Planetary Hypotheses*, and this is what he said:³¹ [43] “Most wonderful here is their³² placement [of the partial orbs with respect to one another], namely the latter spheres [*kaddurim*]³³ move the former spheres, the enclosed spheres move those that surround them, and the spheres with much diversity [move] the simple spheres, contrary to the doctrines of natural philosophy.³⁴” [44] His words [end] here. [45] It should be

31 Ptolemy, *Planetary Hypotheses*, Paris, MS héb. 1028, f. 75a:11–13 (quoted exactly); cf. Goldstein, *Arabic Version*, p. 40:9–10:

والاعجب ما هاهنا تصبيرهم الاكر الاواخر محركة للاكر الاول والاكر التي يحاط بها محركة للمحيط بها والاكر الكثرية الاختلاف للكورة البسيطة علي خلاف المذهب الطبيعي

The Hebrew is a word-for-word translation of the Arabic.

32 The antecedent of “their” is not clear; but presumably Ptolemy is reporting the view of some predecessors (probably those who constructed planetary models). In §44, Levi takes these predecessors to be Aristotle and some other ancients (cf. §41). For a discussion of Ptolemy's own views on the transmission of motion in the heavens, see Murschel, “Structure and Function,” pp. 39–50.

33 In this context, “sphere” has the sense of “orb”; see n. 3, above.

34 A literal translation of the Hebrew, *be-hilluf ha-sevarah ha-tiv'it*, is “contrary to the natural opinion,” which corresponds to the Arabic *‘alā khilāf al-madhab al-ṭabī‘ī* (contrary to the natural doctrine/school). The Arabic *madhab* has many meanings, including opinion, doctrine, and school. I take the sense of the Arabic expression to be “contrary to the doctrines of the school of natural philosophers.”

clear to you from [Ptolemy's] previous remarks in that work [i.e. the *Planetary Hypotheses*] that he was alluding to Aristotle and some other ancients. [46] It is evident [however] that this assertion of his [namely, that this arrangement is contrary to natural philosophy] is devoid of [sound] reasoning. [47] Therefore, no argument can be derived from it against what has been explained in this place. [48] Moreover, this cause of motion [*ba-hana'ab*]³⁵ is not in the category of primary [causes]; rather, it is in the category of support and service [*ba-'avodah weha-šerut*], just as the master [*lit.* primary] crafts have subordinate crafts which serve them, as in the case of the craft of seafaring with respect to the crafts of shipbuilding and of wood-cutting from which [ships] are constructed.³⁶

[End chapter 29]

Acknowledgments

I am most grateful to Gad Freudenthal, Resianne Fontaine, Sara Klein-Braslavy, Tzvi Langermann, and Shlomo Sela for their comments and advice.

35 Cf. Levi ben Gerson, *Wars*, V 3.11.

36 A parallel passage is found in Levi ben Gerson, *Wars*, I 6 (*Milchamot*, p. 37; trans. Feldman, 1:147 [modified]: "... the master-craft ... has under it several [different] subordinate crafts. In the latter case, each product derives from one agent, i.e. the master-craft; for it is the latter which directs all the subsidiary crafts. For example, the carpenter cuts all the boards from which a ship will be made, and the boat-builder uses them in making the boat"). Another place where Levi uses this analogy is in *Wars* V 3.13 (*Milchamot*, p. 287; trans. Feldman, 3:187). See also Levi ben Gerson, *Wars*, I 6 (*Milchamot*, p. 44; trans. Feldman, 1:158: "In truth, an activity completely derives from the master-craft that directs all the subordinate crafts in what they are supposed

to do. ... God performs many activities by means of the movers of the heavenly spheres, since the movers possess instruments, i.e. the heavenly bodies, by virtue of which the activity is accomplished"). Cf. Maimonides, *Guide of the Perplexed* II 4; trans. Shlomo Pines (Chicago: University of Chicago Press, 1963), pp. 255–259.

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Editor's foreword

I have the pleasure to announce that, at my suggestion, *Aleph's* Executive Board has decided to appoint Dr. Resianne Fontaine of the University of Amsterdam, certainly not a new face in this journal, as Associate Editor. In the title above, the apostrophe is on the left of the *s*. Henceforth, and already below, it appears to its right. I am confident that this small change in orthography will prove to be significant for *Aleph's* quality and permanence.

Gad Freudenthal

Editors' foreword

This volume of *Aleph* is dedicated in warm friendship and high esteem to Ruth Glasner of the Hebrew University of Jerusalem, to mark her retirement this year. Ruth's scholarly endeavors fall squarely within the domain to which *Aleph* is dedicated and, indeed, Ruth was pivotal in its founding. Of no less importance has been her continuing behind-the-scenes role in the running of *Aleph* since its inception and the judicious and informed advice she provided when delicate decisions were required. The dedication of this volume to Ruth is a small token by which her friends and colleagues seek to express their recognition and respect for her inspiring scholarly work without trespassing her explicit and reiterated demand that no festschrift be published in her honor. We hope that this gift will be accepted in the spirit in which it is offered and wish her many more years of creative and innovative research.

Resianne Fontaine
Gad Freudenthal