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The First References in Hebrew to al-Biṭrūjī's *On the Principles of Astronomy*

This brief notice identifies and presents an English translation of the first references in Hebrew to al-Biṭrūjī's *On the Principles of Astronomy* (*Kitāb fi al-hayʿa*).¹ They appear in the three most important original works by Samuel Ibn Tibbon (ca.1165–1232): his *Glossary of Technical*

¹ I wish to thank Gad Freudenthal, Angela Jaffray, J. L. Mancha, Bernard Septimus and the three anonymous readers for many helpful comments, corrections, and bibliographical references. For the Arabic text of al-Biṭrūjī and the medieval Hebrew translation, together with an English translation and analysis of the astronomy and its historical significance, see Bernard R. Goldstein, ed. and trans., *Al-Biṭrūjī: On the Principles of Astronomy*, 2 vols. (New Haven: Yale University Press, 1971). For general descriptions of the work and further discussion of specific points, see also Francis J. Carmody, *Al-Biṭrūjī: De motibus celorum* (Berkeley: University of California Press, 1952), pp. 22–70; Julio Samsó, “Al-Biṭrūjī al-Iṣbīlī, Abū Ishāq,” in *Dictionary of Scientific Biography*, vol. 15 (New York: Charles Scribner and Sons, 1978), pp. 33–36; idem, *Las ciencias de los antiguos en al-Andalus* (Mapfre, 1992), pp. 330–356. For the philosophical movement that led to al-Biṭrūjī's astronomy, a project that was initiated by Ibn Bājja and continued by Ibn Ṭufayl, Averroes, and to some extent also Mai-

Terms used in the Guide of the Perplexed (*Peruš ha-millot ha-zarot*, completed 1213), his *Commentary on Ecclesiastes* (after 1213), and his last book, *Ma'amar yiqqawu ha-mayim* (1221 or 1231).² These references, consisting of brief summaries of al-Biṭrūjī's astronomy, were written not long after the original Arabic treatise was completed (between 1185 and 1192).³ The remarks found in the *Glossary*, (and perhaps those found in the *Commentary on Ecclesiastes* as well) predate the Latin translation made by Michael Scot in Toledo in 1217.⁴

With these early references to al-Biṭrūjī identified, and in light of other recent research, Bernard Goldstein's brief survey of his influence on Jewish literature⁵ can be expanded as follows. The original Arabic text was first referred to in Hebrew by Ibn Tibbon in his *Glossary*, *Commentary on Ecclesiastes*, and *Ma'amar yiqqawu ha-mayim*. It was cited in Arabic by Judah b. Solomon ha-Kohen in Toledo during the 1230s in his *Midraš ha-ḥoḳmah*, an encyclopedia of science that he subsequently translated into Hebrew in Italy in 1247.⁶ The complete Arabic text, perhaps from the same manuscript used by Samuel Ibn Tibbon, was translated into Hebrew by Samuel's son Moses in 1259 in southern France.⁷ Samuel Ibn Tibbon's summary statement in *Ma'amar yiqqawu ha-mayim* was reproduced verbatim by Gershon b. Solomon in his popular *Ša'ar ha-šamayim*, written during the last quarter of the thirteenth century in southern France.⁸ Al-Biṭrūjī's astronomical theory was briefly described and rejected by the southern French philosopher Levi b. Abraham b. Ḥayyim in his *Liwyat ḥen* (revised 1295 and 1299), a comprehensive encyclopedia of science and religion.⁹ Also in southern France, al-Biṭrūjī's work had a strong impact on Gersonides, who criticized it in detail in Book Five, Part One, Chapters 40–44, of his *Wars of the Lord*,¹⁰ the magnum opus that he continued to revise almost until his death in 1344.¹¹ Back in Spain, al-Biṭrūjī's astronomical principles were summarized in 1310 and dismissed by Isaac Israeli of Toledo in his scientific work, *Yesod 'olam*.¹² They served as the inspiration for Joseph Ibn Naḥmias' fourteenth-

monides, see: Goldstein, *Al-Biṭrūjī: On the Principles of Astronomy*, pp. 3–5; A. I. Sabra, “The Andalusian Revolt against Ptolemaic Astronomy: Averroes and al-Biṭrūjī,” pp. 133–153 in *Transformation and Tradition in the Sciences: Essays in Honor of I. Bernard Cohen*, ed. E. Mendelsohn (Cambridge: Harvard University Press, 1984); Y. T. Langermann, “The ‘True Perplexity’: *The Guide of the Perplexed* Part II, Chapter 24,” pp. 159–74 in *Perspectives on Maimonides*, ed. Joel Kraemer (London: Littman Library & Oxford University Press, 1991); Idem, “Maimonides and Astronomy: Some Further Reflections,” article IV in *The Jews and the Sciences in the Middle Ages* (Aldershot: Ashgate [Variorum], 1999). As for the Arabic *hay’a* tradition, in relation to which al-Biṭrūjī’s work ought to be considered, it has been the subject of considerable scholarship in recent years. See especially the following books and articles, each of which provides bibliography of earlier research: Y. T. Langermann, *Ibn al-Haytham’s On the Configuration of the World* (New York: Garland, 1990); Julio Samsó, “On al-Biṭrūjī and the *Hay’a* Tradition in al-Andalus,” article XII in *Islamic Astronomy and Medieval Spain* (Aldershot: Ashgate [Variorum], 1992); F. J. Ragep, *Naṣīr al-Dīn al-Ṭūsī’s Memoir on Astronomy (al-Ṭadhkira fī ‘ilm al-hay’a)* (New York: Springer-Verlag, 1993); Y. T. Langermann, “Arabic Cosmology,” *Early Science and Medicine* 2 (1997): 185–213; A. I. Sabra, “Configuring the Universe: Aporetic, Problem Solving, and Kinematic Modeling as Themes of Arabic Astronomy,” *Perspectives on Science* 6 (1998): 288–330; George Saliba, “Critiques of Ptolemaic Astronomy in Spain,” *Al-Qantara* 20 (1999): 3–25, and the lively interchange between Sabra and Saliba in *Perspectives on Science* 8 (2000): 328–45. For the influence of al-Biṭrūjī’s astronomy, see below, n. 5.

- ² Bibliographical references for Ibn Tibbon’s writing will be given below.
- ³ For the dating of al-Biṭrūjī’s work, see Samsó, “On al-Biṭrūjī and the *Hay’a* Tradition,” pp. 7–8. Al-Biṭrūjī refers to his deceased teacher Ibn Ṭufayl (d. 1185), whereas his ideas seem to have influenced an anonymous Arabic manuscript dated 1192.
- ⁴ For the Latin translation, see Carmody, *Al-Biṭrūjī: De motibus celorum*.
- ⁵ See Goldstein, *Al-Biṭrūjī: On the Principles of Astronomy*, pp. 40–4. For al-Biṭrūjī’s influence on the Latin tradition, see also Reuven Avi-Yonah, “Ptolemy vs. al-Biṭruji: A Study of Scientific Decision-Making in the Middle Ages,” *Archives internationales d’histoire des sciences* 35 (1985): 124–47, with references to earlier literature; Michael

century *Light of the World*, originally written in Judeo-Arabic but subsequently translated into Hebrew.¹³

Before we turn to the texts themselves, a few remarks about the provenance of Ibn Tibbon's references and his method of citation are in order. Although Ibn Tibbon lived most of his life in southern France, it is more likely that he learned about al-Biṭrūjī's work not in Lunel, Arles, or Marseilles but in Toledo, which he visited at least once, sometime between 1204 and 1210.¹⁴ This venue for his first exposure to al-Biṭrūjī suggests that he and Michael Scot may have known each other during their stays in this center of the Arabic-to-Latin translation movement.¹⁵ If corroborated, this thesis would reinforce the importance of Toledo as the principal point for the dissemination of al-Biṭrūjī's work.

Also noteworthy is the way in which Ibn Tibbon refers to al-Biṭrūjī. Like Levi b. Abraham, Gersonides, and Isaac Israeli after him, Ibn Tibbon refers to al-Biṭrūjī by a cognomen rather than naming him explicitly:¹⁶ Levi b. Abraham and Gersonides both write of the "master of a new astronomy" (*ba^cal tekunah ḥadašah*); Israeli uses the phrase, "an individual who shook [the world]" (*ʿiš ha-mar^ciš*, cf. Haggai 2:10); Ibn Tibbon uses the biblical locution (Gen. 41:38), "an individual possessed by the spirit of God" (*ʿiš ʿašer ruah ʿelohim bo*).¹⁷ But while all three of these later scholars rejected al-Biṭrūjī's novel theories, Ibn Tibbon's expression seems to indicate approval of al-Biṭrūjī and respect for the discipline in which he worked.¹⁸ This conclusion is borne out by a passage in the preface to the *Commentary on Ecclesiastes* in which Ibn Tibbon explains that he believes that the "work of the chariot" in Ezekiel, which Maimonides had identified with Aristotelian metaphysics,¹⁹ consists chiefly of astronomy; only the "man," he explains, is part of metaphysics.²⁰ In light of this, any new development in astronomy has great significance for understanding this most important prophecy of the Bible; furthermore, any astronomer or philosopher who contributes to a truer understanding of the celestial "chariot"

Shank, "The 'Notes on al-Biṭrūjī' attributed to Regiomontanus: Second Thoughts," *Journal for the History of Astronomy* 23 (1992): 15–30, correcting the earlier article by F. Carmody, "Regiomontanus' Notes on al-Biṭrūjī's Astronomy," *Isis* 42 (1951): 121–30; Edward Grant, *Planets, Stars, Orbs: The Medieval Cosmos, 1200–1687* (Cambridge: Cambridge University Press, 1994), pp. 563–66. A full study of the reception of al-Biṭrūjī in Hebrew awaits the editing and careful study of the most important texts in this tradition, namely, those listed below by Judah b. Solomon ha-Kohen, Levi b. Abraham b. Ḥayyim, Gersonides, and Joseph Ibn Naḥmias.

- 6 See again Goldstein, *Al-Biṭrūjī: On the Principles of Astronomy*, pp. 40–44, and especially Y. T. Langermann, "Some Remarks on Judah b. Solomon ha-Cohen and his Encyclopedia, *Midrash ha-Hokhmah*," pp. 371–389 in *The Medieval Hebrew Encyclopedias of Science and Philosophy*, ed. S. Harvey (Dordrecht: Kluwer Academic Publishers, 2000).
- 7 The translation was edited by Goldstein, *Al-Biṭrūjī: On the Principles of Astronomy*, with the Hebrew text facing a facsimile of the Arabic manuscript.
- 8 See James T. Robinson, "Gershon b. Solomon's *Sha'ar ha-Shamayim*: Its Sources and Use of Sources," p. 263 in *The Medieval Hebrew Encyclopedias of Science and Philosophy*.
- 9 See Vatican MS 383 (Institute for Microfilmed Hebrew Manuscripts, Jerusalem; hereafter: IMHM, 484), 6a–7b. For a discussion of the astronomy section, with complete table of contents, see Gad Freudenthal, "Sur la partie astronomique du *Liwyat Hen* de Lévi ben Abraham ben Ḥayyim," *Revue des études juives* 148 (1989): 103–12. For Levi b. Abraham's work in general, with full bibliography, see most recently Warren Zev Harvey, "Levi ben Abraham of Villefranche's Controversial Encyclopedia," pp. 171–190 in *The Medieval Hebrew Encyclopedias of Science and Philosophy*.
- 10 See Goldstein, *Al-Biṭrūjī: On the Principles of Astronomy*, pp. 40–43, and especially Gad Freudenthal, "Sauver son âme ou sauver les phénomènes: Sotériologie, épistémologie et astronomie chez Gersonide," pp. 317–52 in *Studies on Gersonides—A Fourteenth-Century Jewish Philosopher-Scientist*, ed. G. Freudenthal (Leiden: E. J. Brill, 1992) (the article expands and elaborates upon two earlier articles). For Gersonides' astronomy in general, see Bernard Goldstein's many articles, translations, and editions; for those written before 1992, see Menahem Kellner, "Bibliographia

ought to be considered an individual with prophetic insight. This significance is evident in the third text translated below, from *Ma'amar yiqqawu ha-mayim*.²¹

The three passages from Ibn Tibbon's writings translated here are the following:

- (1) The complete text of one entry of the *Glossary*, namely, the definition of "daily motion" (*tenu'ah yomit*).
- (2) The full explication of Eccl. 1:5, a verse that, according to Ibn Tibbon, is part of Solomon's preface to his philosophical treatise. To prove that everything "under the sun" is subject to destruction ("vanity") he must first establish continuity in the processes of the sublunar world, including the material cause—first matter—and the agent cause—the perpetual movement of the celestial bodies along the ecliptic. (The appendix presents a critical edition of this unpublished text.)
- (3) A digression in *Ma'amar yiqqawu ha-mayim*, Chapter 10, which comes in the midst of an extended explication of Ezekiel, Chapter 1.

Texts

(1) Samuel Ibn Tibbon, *Glossary of Technical Terms used in the Guide (Peruš ha-millot ha-zarot)*, ed. Yehudah Even-Shemuel, published as an appendix to his edition of the *Guide of the Perplexed* (Jerusalem: Mosad ha-Rav Kook, 1987), s.v. *tenu'ah yomit*, p. 91.

"Daily Motion" is a term that signifies the motion of the outermost orb, which revolves around the entire world in a single day, which consists of twenty-four hours.²² It is a volitional motion governed by desire.²³ All of the orbs that are contained within [this outermost orb] move because of this motion; they are drawn after its motion in such a way that it is as if [this motion] for them is enforced, for this motion forces them to move in this way in opposition to their own volitional

- Gersonideana,” in *Studies on Gersonides*, pp. 398–402; for those from 1992 to present, see the update of Kellner’s bibliography in the present volume.
- ¹¹ For the dating of *Wars of the Lord*, see especially J. L. Mancha, “Levi ben Gerson’s Astronomical Work: Chronology and Christian Context,” *Science in Context* 10 (1997): 471–93, where it is shown that, although Gersonides himself asserts that the astronomy section was completed November 24, 1328, he continued to revise it at least until 1340 and probably until 1344.
- ¹² See *Yesod ‘olam*, Book Two, Chapter 9 (Berlin, 1776/7), pp. 29a–b; ed. B. Goldberg and L. Rosenkranz (Berlin, 1846), pp. 25–26; Goldstein, *Al-Biṭrūjī: On the Principles of Astronomy*, pp. 40–43. For Israeli in general, see also Y. T. Langermann, “‘The Making of the Firmament’: Rabbi Ḥayyim Israeli, Rabbi Isaac Israeli, and Maimonides” (Hebrew), *Shlomo Pines Jubilee Volume*, part 1, *Jerusalem Studies in Jewish Thought* 7 (1988), pp. 461–76; idem, “Science in the Jewish Communities of the Iberian Peninsula,” pp. 8–9 in *The Jews and the Sciences in the Middle Ages* (Aldershot: Ashgate [Variorum], 1999).
- ¹³ This work remains in manuscript and has not been studied in any detail. On the manuscripts, plus a brief discussion of the contents and the identity of the author, see Bernard Goldstein “Scientific Traditions in Late Medieval Jewish Communities,” in *Les Juifs au regard de l’histoire: Mélanges en l’honneur de M. Bernhard Blumenkranz*, ed. G. Dahan (Paris: Picard, 1985), p. 237; Gad Freudenthal, “The Distinction Between Two Rabbis Named Joseph b. Joseph Naḥmias—The Commentator and the Astrologer” (Hebrew), *Qiryat Sefer* 62 (1988/89): 917–19; Langermann, “True Perplexity,” p. 173; Langermann, “Arabic Cosmology,” p. 206.
- ¹⁴ In the preface to his translation of Aristotle’s *Meteorology*, completed in 1210, Ibn Tibbon mentions having consulted manuscripts in Toledo and Barcelona. See *Otot ha-Shamayim: Samuel Ibn Tibbon’s Hebrew Version of Aristotle’s Meteorology*, ed. and trans. Resianne Fontaine (Leiden: E. J. Brill, 1995), pp. 4–5. For biographical information in general, see James T. Robinson, “Samuel Ibn Tibbon’s *Commentary on Ecclesiastes* and the Philosopher’s Prooemium,” in *Studies in Medieval Jewish History and Literature*, vol. 3, eds. I. Twersky and J. M. Harris (Cambridge: Harvard University Press, 2000), pp. 83–146; idem, “Samuel Ibn Tibbon’s *Commentary on Ecclesiastes*” (Ph.D. Dissertation, Harvard University, 2002).

motion which, according to that which has been postulated in all previous astronomical models [*tekunot*],²⁴ proceeds from west to east.²⁵ But even if their motion proceeds from east to west, as has been stated by one of the modern scholars, an individual possessed by the spirit of God [see Gen. 41:38], this same motion of the first orb will cause [inferior orbs] to move more swiftly than [they would have moved] with their own [volitional] motion. This enforced or quasi-enforced motion that all the other orbs experience with the outermost orb is also called “daily,” for although it is enforced or quasi-enforced, this does not keep it from being referred to with the very same term.

(2) Samuel Ibn Tibbon, *Commentary on Ecclesiastes 1:5* [see Appendix].

The sun rises and the sun goes and glides back to its place, there it rises [Eccl. 1:5].²⁶

Before beginning to interpret the present verse, I need to make known the following preliminary information, which is needed to interpret both this and the following verse. Namely, I need to make known that the sun has two motions. One is natural to it, that is, it is not consequent upon anything other than itself; whereas the other is enforced, that is, it is consequent upon the motion of something other than itself. The natural motion [of the sun] is from west to east, while its enforced motion is from east to west; [it is compelled in this way] by the motion of the outermost orb, the motion of which is from east to west. [The outermost orb] circles around the world with this motion in one day, on account of which it is called “daily motion.” With its [daily] motion, it is as if [the outermost orb] draws after it all the orbs contained within it, leading [these inferior orbs] to proceed also from east to west with the same rapid motion.²⁷ The planets fixed in these orbs also move according to this motion, in the way that the part moves with the whole.²⁸ But while the sun continues to move perpetually with this

- ¹⁵ That Ibn Tibbon and Michael Scot had some personal relationship was already postulated in the nineteenth century on the basis of the connection at Frederick's court in Sicily between Scot and Ibn Tibbon's son-in-law, Jacob Anatoli. On this relationship, see: M. L. Gordon, "The Rationalism of Jacob Anatoli" (Ph.D. Dissertation, Yeshiva University, 1974), pp. 234–242, with reference to earlier literature; Colette Sirat, "Les traducteurs juifs à la cour des rois de Sicile et de Naples," in *Traduction et traducteurs au moyen âge*, ed. G. Contamine (Paris, 1989), pp. 168–75, 181–90. But there is evidence, despite some chronological difficulties, that they had already been in contact earlier. I intend to examine the information relevant to this subject in a separate study.
- ¹⁶ For the cognomens used by Gersonides and Israeli, see Goldstein, *Al-Biṭrūjī: On the Principles of Astronomy*, pp. 40–43. For Levi b. Abraham, see, e.g., Vatican MS 383 (IMHM 484), 6a–7b. I thank Gad Freudenthal for focusing my attention on this phenomenon.
- ¹⁷ In the biblical context alluded to, Pharaoh praises Joseph with this expression after Joseph had explained his dreams. Note that the biblical phrase seems to reflect al-Biṭrūjī's opinion of himself. See, e.g., Goldstein, *Al-Biṭrūjī: On the Principles of Astronomy*, par. 16: "I remained perplexed and confused for some time and stopped studying (the rest of) the book to meditate and (overcome my) confusion. Finally, I was inspired by (God) and awakened from my stupor and confusion. Thereupon an idea arose in my mind which had not occurred to anyone—but it did not come from human speculation, for God wished to show His wondrous things and to reveal the secret of the heavens." See also par. 96: "We have discussed the model for the motion of the starry sphere, one which we discovered with the help of God." It seems that these remarks, moreover, and Ibn Tibbon's representation of them, are what Judah ha-Kohen has in mind in his own assessment of al-Biṭrūjī. See the text translated by Langermann, "Some Remarks," p. 386: "Know that a great secret was revealed to [al-Biṭrūjī]. Had he been a Jew, he would have been worthy of the divine wisdom."
- ¹⁸ There is no reason to suspect that Ibn Tibbon had an interest in suppressing the name of an Islamic philosopher; elsewhere in his work he cites by name and makes clear reference to al-Fārābī, Avicenna, and Averroes. Moreover, the only other scholar to

enforced motion, it also moves in its own orb from west to east according to its natural motion. With this [natural] motion it completes [a cycle of] its orb in 365¼ days.

This is all according to what previous astronomers have proposed; all of this can be found in their books.²⁹ But now there is an individual possessed by the spirit of God [see Gen. 41:38] who has discovered an astronomical model [*teḵunah*] that does not suppose two motions contrary to each other;³⁰ nor does it [postulate] an orb that does not revolve around the center of the world³¹ or an epicycle.³² As for the apparent motion of the planets from west to east, he says that they do not really experience this motion. Instead, what happens is that they fall short of completing in one day the full circle that is completed by the orb specific to [the circle of daily motion].³³ [This recent astronomer] also placed in their nature a westward motion specific to [each of] them through which they make up some of the lag [*hissaron*], for they are not able to complete it [all].³⁴ Rather, each one [of the orbs] has a daily lag, some more and some less, depending upon its relative position:³⁵ the closer any individual orb is to the outermost orb, which is specific to the daily motion, the smaller its lag; the farther it is, the greater its lag.³⁶ This is all according to what can be found in the book that this sage has composed according to this astronomical model. Aristotle had already alluded to an astronomy like this, for he saw that all of the other models were impossible according to the [physical principles] that he had postulated in natural science.³⁷

Returning now to our subject of enquiry, we say that the circle that the sun makes according to its specific natural motion, which accounts for its lag,³⁸ is called the “orb of the zodiac.”³⁹ It is given the name of the corresponding circle in the orb of the fixed stars. The twelve constellations, which are called the twelve “signs” of the zodiac, were contained in [this circle] at the time when they were given this name.⁴⁰ The circle called “orb of the zodiac” is a “great circle,”⁴¹ which divides and cuts the circle called the “celestial equator”⁴² into two equal parts.

whom Ibn Tibbon refers by an honorific is Maimonides, whom Ibn Tibbon esteems above all others; he calls him the "True Sage."

- ¹⁹ For Maimonides' definition of the "work of the chariot," see Steven Harvey, "Maimonides in the Sultan's Palace," in *Perspectives on Maimonides*, pp. 47–76, where relevant passages in Maimonides are identified and previous studies referred to.
- ²⁰ See Robinson, "Samuel Ibn Tibbon's Commentary on Ecclesiastes," pp. 228–29, par. 19: "As for the prophet Ezekiel, he wrote at length about the 'chariot' using the method of 'chapter headings.' Since then, divine science—or say: astronomy with divine science—has been called the 'work of the chariot.' This is because most of what is alluded to therein is done so by means of certain wondrous secrets represented figuratively as four *Hayyot* [see Ezek. 1:5]. The chariot itself is the four beasts, as has been explained by the True Sage in his Noble Treatise, namely, in Chapter Seventy of Part I. It seems, as we have said, that the 'work of the chariot' includes both astronomy and divine science. The latter is the science through which one knows that which is beyond nature, that is, everything that has no natural capacity for motion, rest, or anything else circumscribed by the term 'nature.' The statement made by the Master, in several places, that the 'work of the chariot' is identical to divine science is quite surprising. For he did not make any mention of astronomy, and yet I see that [the 'work of the chariot'] is comprised more than anything of astronomy. Only the 'man' [see Ezek. 1:26] is a part of divine science." See the similar remark in *Ma'amar yiqqawu hamayim*, ed. M. Bisliches (Pressburg, 1837), p. 55. It should be noted, however, that whereas Ibn Tibbon seems to recognize the importance of astronomy in Aristotle's *Metaphysics*, he differentiates the discipline—metaphysics or divine science—from the contents of the book. Moreover, what he understands as astronomy (Hebrew *hokmat ha-tekunah*; Arabic *'ilm al-hay'a*) is not mathematical astronomy but astronomy and celestial physics; his "work of the chariot" is really a Jewish cosmology that corresponds very closely to the Arabic *hay'a* tradition, about which see the sources referred to in note 1.
- ²¹ It should be emphasized that the philosophical commentaries on Isaiah 6 and Ezekiel 1, 10, many of which remain in manuscript, as well as the commentaries on Maimonides' interpretation of these visions in *Guide* 1:69–70 and 3:1–7, constitute a still unexplored source for the history of astronomy and celestial physics. Many follow

The celestial equator is an imaginary circle in the orb of the fixed stars.⁴³ These circles [namely, the equator and zodiac] are two of the great circles drawn from east to west. Because this is so, and [because] each one divides the other in the middle, and the equator is in the middle of the world, from east to west, the circle corresponding with the orb of the zodiac divides [the equator] as follows:⁴⁴ half of [the circle of the zodiac] is in the north and half of it is in the south, in accordance with the distance between it and the equator.⁴⁵ For [the equator and circle of the zodiac] have only two points of intersection or conjunction.⁴⁶ When the sun is in some part of the orb that inclines toward the north, one says that it is in the northern direction and “goes” [see Eccl. 1:6] in the north. This continues of necessity for half a year. When it is in the half that inclines toward the south, one says that it is in the southern direction and “goes” in the south. This continues for the other half year.

After having given this preliminary statement, in summary fashion, I say that in the previous verse [namely, Eccl. 1:4] he introduced [the notion] that a “generation” goes and a “generation” comes and that this process continues perpetually. The same meaning is implied when he says: “and the earth abides forever.” That is, he explained the unity of the material cause. He comes now to indicate the unity of the agent causes, one of which—indeed, one of the greatest—is the rising and setting of the sun, which occurs as the result of [the sun’s] enforced daily motion. This motion is the cause of day and night, for the period of time in which the sun can be seen is called “day,” in whatever place it can be seen, whereas the [period of] time in which the sun is concealed is called “night”; and both [day and night] are causes of generation and corruption. What he says here is that they, that is, rising and setting, continue perpetually without change. This he indicates with the phrase “it glides back to its place, there it rises.” That is, [the sun] continues perpetually to rise every day at the same place, or close to the same place, where it had risen the previous day. This perpetual continuity is

Maimonides and Ibn Tibbon closely, elaborating upon or disputing specific points in light of new developments in philosophy and science. See, e.g., Ḥanokh b. Solomon al-Qonṣṭanṭīni, *Marʾot ʾelohim*, ed. and trans. Colette Sirat (Jerusalem, 1976); Joseph Ibn Kaspi, *Menorat kesef*, in *ʿAṣarab kelei kesef*, ed. Isaac Last (Pressburg, 1912), vol. 2, pp. 75–142. The preface and section on Ezekiel in the latter work were reedited by Menachem Cohen in *Miqraʾot gedolot ha-keter: Ezekiel* (Ramat Gan: Bar-Ilan University Press, 2000), pp. 334–39.

- ²² I translate *galgal* as “orb” rather than “sphere” throughout the following texts, following the distinction discussed by Grant, *Planets, Stars, Orbs*, p. 115, n. 137.
- ²³ See Samsó, “On al-Biṭrūjī and the *Hayʾa* Tradition in al-Andalus,” pp. 9–13, for a discussion of the use of “desire” in al-Biṭrūjī’s astronomy as a cosmic principle.
- ²⁴ On the meaning of *teḵunah*, which translates the Arabic *hayʾa*, see the literature cited above (n. 1).
- ²⁵ See, e.g., Ptolemy, *Almagest* 1:8.
- ²⁶ New JPS translation; cf. RSV: “The sun rises and the sun goes down, and hastens to the place where it rises.”
- ²⁷ Reading *ha-tenuʿah ha-hiʾ ha-memaheret* as an accusative. Or: with an increasingly rapid motion.
- ²⁸ See Aristotle, *De caelo* 1:3, 270a2ff.
- ²⁹ Literally: “This is all according to what astronomers have proposed according to what can be found in their books from then.” See, e.g., Ptolemy, *Almagest*, 1:8, 3:1.
- ³⁰ See, e.g., Goldstein, *Al-Biṭrūjī: On the Principles of Astronomy*, par. 33.
- ³¹ He seems to mean that there are no eccentrics, i.e., orbs that revolve around a center slightly removed from the center of the world. The expression used here, *galgal mitnoʿeʿa loʾ saviv merkaz ha-ʿolam*, however, differs from the term used for eccentric in the *Glossary*, namely, *galgal ha-yoṣeʾ ḥuṣ la-merkaz*, which translates literally the Arabic term *khārīj ʿan al-markaz*.
- ³² See, e.g., Goldstein, *Al-Biṭrūjī: On the Principles of Astronomy*, par. 54.
- ³³ See, e.g., *ibid.*, par. 56, 104ff. The source of motion is the outermost orb, which distributes a power to the lower orbs, each having less power the farther it is from the outermost orb. On desire and impetus see Samsó, “On al-Biṭrūjī and the *Hayʾa* Tradition in al-Andalus,” pp. 9–13.

the cause of generation and corruption. This is agreed upon by all sages.⁴⁷

(3) Samuel Ibn Tibbon, *Ma'amar yiqqawu ha-mayim*, ed. M. Bisliches (Pressburg, 1837), pp. 46–47.

As for the sphericity of the *Hayyot* [see Ezek. 1:5], this was alluded to with the phrase “[and the soles of their feet] are like the [spherical] soles of a calf [*‘egel*]” [Ezek. 1:7].⁴⁸ As for the soul and intellect [of the *Hayyot*], this was alluded to when he hinted that all of them possess the face of a man, all of the faces “are faces of man” [see Ezek. 1:10], even though some of them tend toward the other forms that he had mentioned.⁴⁹ As for the desire [of the *Hayyot*],⁵⁰ we say that he alluded to this with [the phrase] “in whatever direction the spirit would go [they went, they turned not when they went]” [Ezek. 1:12]. As for the existence of the two actions [alluded to here], finally, this is something known through sense perception, insofar as all of the *Hayyot* revolve with one motion from east to west, on several axes, but they also have an additional motion; namely, each *Hayyah* has a motion specific to it, which appears to proceed from west to east and which turns on several axes other than that of the “firmament” which is “over the heads of the *Hayyot*” [see Ezek. 1:22] and around a center different from that around which the “firmament” moves.⁵¹

However, just recently one of the sages of this science in this generation, an individual possessed by the spirit of God [Gen. 41:38], discovered an astronomical model according to which the motion specific to each *Hayyah* also proceeds from east to west, like the motion of [the outermost orb] which contains [them]. All of the [inferior orbs] that are drawn after [this encompassing orb] follow the motion of the outermost “firmament,” revolving around its center but on different axes.⁵² [According to this model, furthermore,] the backwards motion that exists with respect to the planets is not the result of their possessing

- ³⁴ See, e.g., Goldstein, *Al-Biṭrūjī: On the Principles of Astronomy*, par. 65, 67, 86, 104ff. Each body has its own motion, a “motion of completion,” through which it attempts to compensate for the lag. In this way it tries to imitate the motion of the outermost orb.
- ³⁵ Literally: “everything according to the order of some from some.” He refers to the relative speed of the orbs, as is explained in the following sentence.
- ³⁶ That is, contrary to Ptolemy’s model, in which motion accelerates from top to bottom, al-Biṭrūjī’s system decelerates from top to bottom. The farther away an orb is from the first cause and the closer it is to the moon, the slower is its motion; the outermost orb is the only source of power, and power determines speed. See, e.g., Goldstein, *Al-Biṭrūjī: On the Principles of Astronomy*, par. 22, 57.
- ³⁷ Al-Biṭrūjī himself makes this claim; see, e.g., *ibid.*, par. 9–10, 17, 32; see the studies of the Andalusian “revolt against Ptolemy” referred to in n. 1. For Aristotle, the source of power and principle of motion come from the outside, from the prime mover. There is uniform motion, in one direction; contrary motions from a single mover are unacceptable. One substance (the fifth substance) should have no opposition. Moreover, there can be no vacuum, which eccentrics and epicycles would create.
- ³⁸ Literally: “completes its lags.”
- ³⁹ That is, the ecliptic.
- ⁴⁰ He is referring to the precession of the equinoxes; the signs are no longer aligned with their so-called fixed positions, in which 0 Aries is the vernal equinox.
- ⁴¹ I.e., it revolves around the center of the world; it is not a small circle or epicycle.
- ⁴² Literally: “the straight line that goes through the middle of the world.” See *Glossary*, s.v. *qaw ha-šawweh*.
- ⁴³ Namely, it does not represent a physical reality but is rather a mathematical device used for calculation and celestial orientation, mapping the apparent motions of the celestial bodies.
- ⁴⁴ Literally: “the circle that divides it will have half...”
- ⁴⁵ That is, they are divided such that each part rises further away from the intersection, either to the north or to the south; i.e., the northern section is defined from the equinox to the summer solstice or Tropic of Cancer and the southern section from the equinox to the winter solstice or Tropic of Capricorn.

a [specific volitional] motion from west to east in opposition to the westward motion [of the “firmament”]; on the contrary, it [the motion of the planets] is also from east to west. But this motion, according to which they are drawn after the westward daily motion of the outermost orb, does not include the whole completed circle of the outermost orb, for the velocity of that which is drawn is not as swift as the velocity of that which draws it. Rather, there remains a considerable portion of this [circular motion of the outermost orb] which [the inferior orbs] do not complete and they remain because of this significantly behind. With the motion specific to each of them they make up some but not all of the lag. But regarding the lag that exists with respect to each of the planets, the moon completes a full circle in one month, the sun in one year, and similarly all other [planets] according to a fixed period.⁵³ All of this can be found, with strong proofs and demonstrations—with respect to whatever can possibly be demonstrated—in the book that this sage set forth concerning this new astronomy.

Appendix: A Critical Edition of Samuel Ibn
Tibbon, *Commentary on Ecclesiastes* 1:5

The text presented here is based on my edition of the complete *Commentary on Ecclesiastes*, included in my unpublished doctoral dissertation. That edition draws on three manuscripts, which are described there in detail:⁵⁴ I=Biblioteca Medicea Laurenziana (Florence), Plut. II.51 (Institute for Microfilmed Hebrew Manuscripts 17811); F=Biblioteca Medicea Laurenziana (Florence), Plut. I.5 (IMHM 17633); R=Biblioteca Nazionale Centrale Vittorio Emanuele (Rome) II, 7 (IMHM 402). The apparatus at the end of the text lists all variants except changes in spelling. I have standardized the spelling in the text itself and added paragraph divisions, punctuation, and biblical references. Sentences are numbered in order to facilitate use of the apparatus.

- ⁴⁶ Namely, the vernal and autumnal equinoxes.
- ⁴⁷ Heat and light cause generation, whereas the absence of heat and light causes corruption. This is also why there is more generation in the summer and more corruption in the winter. Note also that too much heat and light can cause corruption, as in the southern hemisphere where, according to medieval geography, habitation is impossible. It should be added that establishing the celestial causes of heat and light, mixture and blending, generation and corruption, is one of the main purposes of Ibn Tibbon's Solomon in Ecclesiastes, as is explained at length in his commentary on Eccl. 3:1–22. For background in Aristotle and Averroes, see especially the series of articles by G. Freudenthal: "Providence, Astrology, and Celestial Influences on the Sublunar World in Shem-Tov Ibn Falaquera's *De'ot ha-Filosofim*," pp. 335–370 in *The Medieval Hebrew Encyclopedias of Science and Philosophy*; "The Medieval Astrologization of Aristotle's Biology: Averroes on the Role of the Celestial Bodies in the Generation of Animate Beings," *Arabic Sciences and Philosophy* 12 (2002): 111–38; "Averroes' Changing Mind on the Role of the Active Intellect in the Generation of Animate Beings," in *Proceedings of the Congreso internacional VIII centenario de Averroes (Cordoba, 9–11 December 1998)*, ed. Ahmed Hasnaoui (forthcoming). I thank Gad Freudenthal for giving me a preprint of his article.
- ⁴⁸ For the identification of Ezekiel's *Ḥayyot* with the celestial orbs, see *Guide* 3:1–7. Note that Ibn Tibbon's explanation of the verse is based upon the etymological relation between *ʿegel*, calf, and *ʿiggul* or *ʿagullah*, circle or sphere, a connection which is made by Maimonides in *Guide* 3:2.
- ⁴⁹ The complete verse is: "As for the likeness of their faces, they had the face of a man; and they four had the face of a lion on the right side; and they four had the face of an ox on the left side; they four also had the face of an eagle" (1917 JPS translation).
- ⁵⁰ See again n. 23 regarding the notion of desire with respect to celestial movement.
- ⁵¹ For the meaning of "firmament," see *Guide* 3:1–7.
- ⁵² Here the source text is awkward, so the translation is paraphrastic.
- ⁵³ Here too the translation is paraphrastic, because of the awkwardness of the text.
- ⁵⁴ See Robinson, "Samuel Ibn Tibbon's Commentary on Ecclesiastes," pp. 470–500 (a description of the manuscripts and the method of editing) and pp. 596–8, par. 172–75 (the Hebrew text).

זורח השמש ובא השמש ואל מקומו שואף זורח הוא שם [קהלת א:ה]

[1] קודם שאתחיל בפירוש זה הפסוק, אקדים להודיע מה שצריך בפירושו ובפירוש הפסוק הבא אחריו. [2] והוא להודיע שיש לשמש שתי תנועות: אחת טבעית לו, כלומר שאינו נמשך בה אחר זולתו; ואחת הכרחית, כלומר שהוא נמשך בה אחר תנועת זולתו. [3] והתנועה הטבעית לו הוא ממערב למזרח, ותנועתו ההכרחית היא ממזרח למערב בתנועת הגלגל העליון, שתנועתו ממזרח למערב ומקיף בתנועה ההיא העולם ביום אחד, ועל כן נקראת התנועה היומית. [4] ובתנועתו הוא כמושך אחריו כל הגלגלים אשר בתוכו ללכת גם כן ממזרח למערב התנועה ההיא הממהרת. [5] והכוכבים הקבועים בגלגלים ההם מתנועעים התנועה ההיא גם כן בתנועת החלק בכל. [6] ובעוד השמש בתנועה ההיא המוכרחת תמיד, היא מתנועעת תנועה הטבעית בגלגלה ממערב למזרח. [7] ובתנועה ההיא משלמת גלגלה בשש"ה יום ורביעי.

[8] זה כולו לפי מה שהציעו חכמי התכונה לפי הנמצא בספריהם מאז. [9] אך עתה נמצא איש אשר רוח אלהים בו [ראה בראשית מא:לח] ומצא תכונה שלא יניח בה שתי תנועות זו הפך זו ולא גלגל מתנועע לא סביב מרכז העולם ולא גלגל היקף. [10] אך אמר בתנועה שנראית לכוכבים ממערב למזרח אינו שיש להם תנועה כן. [11] אך הם מקצרים להשלים ביום אחד העגולה כולה שמשלים אותה הגלגל המיוחד בה. [12] ושם בטבעם תנועה מיוחדת בהם מזרחית גם כן ישלימו בה קצת בחסרון, כי לא יוכלו להשלימו. [13] אך ישאר לכל אחד חסרון ביומו קצתם מועט וקצתם רב והכל על סדר קצתם מקצתם, כלומר שכל אשר יקרב הגלגל לגלגל העליון המיוחד בתנועה היומית יהיה חסרונו יותר מועט, וכל אשר ירחק יהיה חסרונו מרובה, ככל אשר ימצא בספר ההוא אשר חבר החכם ההוא בזאת התכונה. [14] וכבר רמז ארסטו אל תכונה כזו לראותו כי התכונות האחרות היו נמנעות לפי מה שהונח בחכמה הטבעית.

[15] ונשוב אל מקומינו ונאמר שהעגולה שעושה אותה השמש בתנועה המיוחדת בה הטבעית לה להשלים חסרונותיה נקראת גלגל המזלות בשם עגולה שהיא כנגדה בגלגל הכוכבים העומדים. [16] והיו בה בזמן שקורא לה השם ההוא הצורות ההם השתים עשרה הנקראות שנים עשרה מזלות. [17] והעגולה ההיא שנקראת גלגל המזלות היא עגולה גדולה וחולקת והותכת העגולה הנקראת הקו השווה המהלך באמצע העולם לשני חלקים שווים. [18] הקו השווה המהלך באמצע העולם היא עגולה מדמה בגלגל הכוכבים העומדים. [19] ושתי העגולות הנזכרות הם מן העגולות הגדולות נרשמות ממזרח למערב. [20] ואחר שהוא כן וכל אחת חולקת חברתה באמצע והקו השווה הוא באמצע העולם ממזרח למערב, אם כן עגולת

גלגל המזלות החולקת אותה יהיה חציה לצד צפון וחציה לצד דרום כפי הרוחק אשר בינה ובין הקו השווה, כי אין חבור ולא דבוק להם כי אם בשתי נקודות. [21] וכשיהיה השמש בקצת הגלגל ההוא הנוטה לצד צפון יאמר בו שהוא בפאה הצפונית ושהוא הולך בצפון, וזה יתמיד לו בהכרח חצי שנה. [22] וכשיהיה בחצי הנוטה לצד דרום יאמר בו שהוא בפאה הדרומית ושהוא הולך בדרום ויתמיד לו חצי שנה אחרת.

[23] ואחר שהקדמתי זה בקצרה אומר כי כאשר הקדים בפסוק אשר לפני זה שדור הולך דור בא ושהוא חוזר חלילה תמיד, כן באמרו והארץ לעולם עומדת [ראה קהלת א:ד], כלומר שבאר בו אחדות הסבה החומרית, בא להזכיר עתה אחדות הסבות הפועלות שאחת מהם, אך מן הגדולות שבהם, היא זריחת השמש ובואה בתנועתה היומית ההכרחית לשמש שהוא סבת היום והלילה, שמדת הזמן שיראה בו השמש נקרא יום במקום שיראה זמן העלמו יקרא לילה, ושניהם סבות להויה ולהפסד. [24] ואמר שהם חוזרים חלילה תמיד בלא שני, כלומר הזריחה והביאה, וזהו אמרו: ואל מקומו שואף זורח הוא שם, כלומר שהוא חוזר חלילה תמיד לזרוח בכל יום מן המקום שזרח אתמול או קרוב לו. [25] ותמידות חזרתו חלילה הוא סבת ההויה וההפסד. [26] זה מוטכם מכל החכמים.

[1] זהו I חסר ו I אקדים I אתחיל ו בפירושו ובפירוש I בפירוש [2] נמשך...שהוא F חסר ט' הדומות ו הכרחית R בהכרחית ו תנועת F חסר [3] הוא R והוא ו ותנועת I והתנועה ו היא I הוא ו למערב...ממזרח I חסר ט' הדומות ו נקראת RF נקראה [4] כמושך I המושך ו ללכת גם כן R גם כן ללכת [5] ההם F מהם [7] משלמת I משלימה [8] מאז F מאד [9] אך I ער ו איש F חסר ו סביב מרכז I ברב מרב [10] ממערב למזרח F ממזרח למערב ו להם I בהם ו כן I כך [12] ושם I השם ו קצת בחסרון I החסרון ו כי I ועם כל זה [13] ישאר I נשאר ו ככל I וכל ו התכונה F התנועה [14] כזו I בזו, R כזאת [15] בתנועה I בתנועתה ו בגלגל R בגלגל ו ההם I חסר ו הנקראות I הנקראים [17] והעגולה I ועגולה ו שוים I שגם [18] מדרמה I חסר [19] הם F הן ו נרשמות R ברשמות [20] וכל I כל [21] בקצת R בצד ו ההוא I חסר ו ושהוא R שהוא [22] ושהוא F וכשהוא ו לן F בהכרח [23] אשר לפני I שלפני ו חלילה RF חללה ו באמרו I כאמרו, F אמרו ו אך I אף ו מן הגדולות I מהגדולות ו ההכרחית F בהכרחית ו שהוא F שהיא [24] כלומר F כמו ו וזהו R וזה הוא ו מן R ומן I אתמול I אתמול, R או מול [25] חלילה RF חללה ו סבת I טובב תמידות.