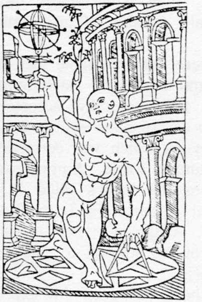
MAIMONIDES ON THE PTOLEMAIC SYSTEM: THE LIMITS OF OUR KNOWLEDGE



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I

Maimonides was among those twelfth-century philosophers who found Ptolemaic astronomy inconsistent with Aristotelian principles. These philosophers believed that our knowledge of physical principles is not easily translatable into terms of a mathematical model. In Chapter 23 of his *Guide of the Perplexed*, Maimonides promises a chapter on the status of our "knowledge as to the arrangement of the motions of the sphere";[1] the promised chapter (Chapter 24) is a critique of Ptolemaic hypotheses and Aristotelian principles. As we shall see, however, the critique is not merely concerned with astronomy, but carries important philosophical implications concerning what constitutes an adequate physical theory.

Historians of science distinguish opposing views of the logical status of physical theories. Those scientists who maintain that their system implies the *existence* of the entities postulated by the physical hypotheses are called "realists"; scientists who claim that their explanatory hypotheses do not contribute to our knowledge of the existence of the entities *per se* are called "formalists" or "instrumentalists."[2] Maimonides is in the formalist tradition: he believed that although the sublunary and the superlunary worlds are not as separable as Aristotle thought, they nevertheless differ radically in the ways that we are actually capable of interpreting them.

Other thinkers besides Maimonides were uncomfortable with the incompatibility of Aristotelian physics and Ptolemy's astronomical hypotheses. Some tried to construct philosophically acceptable planetary models; that is, they sought to describe the events in the heavens with Aristotelian physics—a physics which was commonly held to be applicable only to the sublunary world. Among such alternative models, Maimonides mentions Ibn Bajja's (died 1138) system of eccentric spheres, and Al-Bitruji (died ca. 1217) mentions the ideas of his master, Ibn al-Tufail. Al-Bitruji's own models, however, are the only extant examples of the attempt to construct philosophically acceptable planetary models.[3]

Maimonides' interest in astronomy, however, does not express itself in the construction of planetary models. Rather, he is interested in making a specific philosophical point. As we shall see, he attempts to delineate and to revise our conception of what the investigation and the knowledge of the superlunary world entail.

The *Guide of the Perplexed* was meant to be a reconciliatory book. Published in 1190, the book was intended to explain the "Account of the Beginning" (*ma'aseh bereshith*) and the "Account of the Chariot" (*ma'aseh merkabah*).[4] The Account of the Beginning is identified with the discipline of physics, and the Account of the Chariot deals with metaphysics. The *Guide* was written for those who, although familiar with philosophic argumentation, are perplexed by certain principles which seem irreconcilable with the Bible. Maimonides claims that physics and metaphysics are indeed compatible with the teachings of the Bible. The chapter on astronomy is written in the context of the discussion of creation and the eternality of the world. Maimonides concludes in Chapter 22 that the argument for the eternality of the world is even more doubtful than the argument for the creation of the world; the argument for creation, however, is itself not logically deducible, but merely more compelling. Maimonides' general purpose in these discussions is to destroy the Aristotelian system of necessity.[5] In the chapter on astronomy (Chapter 24), Maimonides delineates the areas in which Aristotelian principles may be correctly extended.

II

Maimonides mentions by name Ptolemy's astronomical work, the *Almagest*. We read in the *Almagest*, he says, that the principles which determine the motions of the celestial bodies are three: the epicycle (a circle in which a planet moves, which itself moves around the circumference of a larger circle called the deferent), the eccentric (a circle in which a planet moves, but which does not have the earth as its center), or both together. These principles, Maimonides claims, are "outside the bounds of reasoning and opposed to all that has been made clear in natural science."[6] By "natural science" he means the Aristotelian physics. Maimonides proceeds to advance certain arguments to substantiate his claim that Ptolemaic models are incompatible with Aristotelian principles. He finds that each hypothetical model results in repugnant physical consequences.

In his first argument, Maimonides concludes that the planet on the epicycles changes its place completely; that is, the epicycle would travel through the ether and dislodge the celestial spheres:

> If one affirms as true the existence of an epicycle revolving round a certain sphere, positing at the same time that that revolution is not around the center of the sphere carrying the epicycles...it follows necessarily that there is rolling.[7]

The implication of the epicyclic scheme is that the motion of a planet on such an epicycle will be uniform, not with respect to the center of the universe, but rather, with respect to its own center.[8] This violates the accepted Aristotelian principle that motion can only be around a fixed point which is the center of the universe. Planets, according to Aristotle, undergo no change other than change of place in a circular movement (*Metaphysics* 1073a30). In the epicyclic scheme, however, the planet neither has angular uniformity nor remains equidistant with respect to the center of the universe.

Maimonides cites Ibn Bajja's argument as further proof against the existence of epicycles. There are three types of motion: motion *from* the center, motion *towards* the center, and motion *around* the center. Following Ibn Bajja, Maimonides claims that "if an epicycle existed, its motion would be neither from that point [the center] nor toward it nor around it."[9] The assertion here is that the term *motion* is interpreted *relative to only one point,* namely, the center of the universe. The motion of an epicycle, however, is not viewed in relation to that center, but in relation to an imaginary point invented in order to create a descriptively accurate astronomic system. Maimonides uses the above argument to criticize the eccentric sphere as well: "in the case of eccentricity, we likewise find that the circular motion of the spheres does not take place around the midmost point of the world, but around an imaginary point that is other than the center of the world."[10] The eccentric scheme violates the assumption that motion is always motion relative to the center of the universe.

Maimonides adduces a third argument against the epicycle. A planet on an epicycle travels around a point which is not immobile; the center of the epicycle revolves around the circumference of the deferent. Such motion violates the Aristotelian principle that circular motion necessarily takes place around an immobile point:

It is one of the preliminary assumptions of Aristotle in natural science that there must necessarily be some immobile thing around which circular motion takes place. Hence it is necessary that the earth should be immobile. Now if epicycles exist, theirs would be a circular motion that would not revolve round an immobile thing.[11]

Maimonides uses the term *immobile thing* (Hebrew *davar kayam*), which can have the senses of 'enduring,' 'fixed,' or 'existing.' It is not clear which sense of the term he intends, and hence its occurrence is ambiguous. It may be that Maimonides means that circular motion must be around an object (rather than a point) which is both fixed (rather than *ad hoc*) and actual (rather than imaginary)—requirements that only the earth fulfills.

The preceding arguments, we have seen, are based on the following assumptions: (1) there are three kinds of motion (from the center, towards the center, and around the center); (2) motion can only be around a fixed point; and (3) the center of the universe can be the only fixed point. Each argument depends upon these assumptions for its validity. Each argument affirms that the center of the universe is the only point from which it is possible to establish a frame of reference for circular uniform motion; each denies that a planet on an epicycle or eccentric sphere displays uniform circular motion with respect to that point. Only an astronomical scheme of concentric spheres (e. g. Aristotle's scheme) admits and does not violate the laws of motion and the criteria of fixed points.

At this point, Maimonides opens his attack on the eccentric. Let us suppose, he writes, that someone with no knowledge of astronomy suggests that we may define the "center" as the *entire area* inside the sphere of the moon. Thus, the required center point would still be within the center so long as the movement occurred with reference to some place within the moon's sphere. But Maimonides rejects the above counter-factual solution: even if we concede that such a hypothesis would not violate the three kinds of motion, it would still contradict the assumption that motion can only be around a *fixed* point. For inside the area of the moon's sphere, we may postulate a plurality of points, in other words, a plurality of centers, each of them equally *ad hoc*. Thus, the motion of the spheres would not take place around a fixed point, but around a variable point that is not the center of the universe.

Furthermore, Maimonides claims, the hypothesis that the lunar sphere is the center must be incorrect because measurements which assume the eccentric scheme (i.e., Ptolemy's) have shown that the center point lies outside the lunar sphere:

> It has consequently become clear that the eccentric point around which the sun revolves must of necessity be outside the concavity of the sphere of the moon and beneath the convexity of the sphere of Mercury. Similarly the point around which Mars revolves...is outside the concavity of the sphere of Mercury and beneath the convexity of the sphere of Venus....See now how all these things are remote from natural speculation![12]

Maimonides is unhappy with the fact that the eccentric model places the centers around which each planet revolves further and further away from the center of the universe. Implicit again are the assumptions that motion can only be around a fixed point and that the center of the universe is the only fixed point.

Maimonides' final argument against the eccentric is based on the Aristotelian requirement that there must be as many unmoved movers as there are simple motions involved in the movements of the planets (*Metaphysics* 1073a25-39). Imagine, Maimonides writes, two spheres, one inside the other, so that whenever the larger sphere moves, it sets the smaller one in motion. If we accept the hypothesis concerning eccentricity, enigmatic consequences follow. Unless the spheres are concentric, the larger sphere will not impart motion to the other; each sphere will have its *own* individual motion. But since each sphere must receive its motion from another, a new sphere which imparts motion must be hypothesized. In turn, the hypothesized sphere requires its own eccentric point around which it rotates:

> Hence necessity obliges the belief that between every two spheres there are bodies other than those of the spheres. Now if this be so, how many obscure points remain? Where will you suppose the centers of those bodies existing between every two spheres to be? And those bodies should likewise have their own particular motion.[13]

The crux of Maimonides' objection appears to be his repugnance to further hypothesizing of unattested spheres. Since a vacuum does not exist (an accepted Aristotelian assumption), there would be no location in which these new spheres could lie.

Here Maimonides completes his arguments against the Ptolemaic hypotheses. Ptolemy's scientific theory is incompatible with accepted Aristotelian physical principles. This incompatibility, however, troubles Maimonides:

> Is it in any way possible that motion should be on the one hand circular, uniform, and perfect, and that on the other hand the things that are observable should be observed in consequence of it, unless this be accounted for by making use of one of the two principles [epicycle and eccentric] or of both of them?[14]

The problem is not simply that Aristotle's principles are incompatible with the Ptolemaic theory but, more important, that they are incompatible with a scientific theory that *correctly* predicts the positions and activity of the planets! Maimonides admits that this incompatibility is problematic ("this is the true perplexity"[15]) and that it demands an explanation.

III

The problem that Maimonides has undertaken to investigate may be regarded as that of knowledge of the superlunary world, or more generally, that of constructing an adequate physical theory. Aristotelian principles preclude the possibility of the existence of either epicycles or eccentrics. Yet, the Ptolemaic hypotheses have predictive power: observable facts are deducible from these hypotheses. The perplexity vanishes, Maimonides writes, when we realize that the astronomer merely seeks to formulate a system which describes the pattern of celestial events, and which describes the systematic relationship between celestial bodies, "*regardless of* *whether or not things are thus in fact.*"[16] The intended function of the astronomer's hypotheses and models is to "save the phenomena"—that is, to provide accurate mathematical models which correctly describe the celestial events—whether or not the models correspond to physical reality. The predictive power of the hypotheses does not contribute to our understanding of the phenomena *per se*. Thus, the astronomer's calculations may be correct and may conform to observation even though his physical model is incorrect.

Maimonides intimates that the Ptolemaic hypotheses are not false if we understand their intended function, namely, to predict celestial occurrences and their relationships. In this context, Aristotle and Ptolemy are not the proponents of rival astronomical theories. With regard to the superlunary world, Aristotelian science does not have explanatory power: it does not offer the physical model of the planets. Further, because "in his [Aristotle's] time mathematics had not been brought to perfection,"[17] Aristotelian physics does not have the predictive power of the Ptolemaic system. Aristotelian science can explain only the motion of those bodies in the *sublunary* world because those act in accord with *known* mechanical and teleological principles (viz., Aristotle's four causes):

> All that Aristotle states about that which is beneath the sphere of the moon is in accordance with reasoning; these are things that have a known cause, that follow one upon the other, and concerning which it is clear and manifest at what points wisdom and natural providence are effective.[18]

The tacit assumption is that *if* we could know the true laws of the superlunary world, they would be fundamentally different from sublunary physical principles.

Thus, Maimonides concludes that neither Aristotle nor Ptolemy presents a physical model of the superlunary world. Aristotelian physics addresses itself to the sublunary world, while Ptolemaic hypotheses function to formulate the mathematics from which observed phenomena of the superlunary world are deducible. For Maimonides, the mathematical knowledge that we have of the superlunary world at least assures us that the celestial processes operate according to fixed laws. He maintains that the laws are fixed although he rejects the notion of a universe thoroughly necessary. Maimonides' view is that the universe is contingent upon God's will. In modern parlance, the laws in such a universe display hypothetical necessity: although not logically necessary, they are still statements of order in the universe.

The view that the universe contains specific phenomena which have no necessary cause for being as they are in nature is found repeatedly in the Middle Ages and the early modern period; it is the basis of the physicotheological proof for God's existence. Aquinas will argue that there is no necessity in the structure of the heavens; while he accepts the assumption that the *number* of spheres is determined by the nature of the heavens, the nature of the heavens itself is not necessary, but dependent upon God's will.[19] Descartes assumes that the universe is a radically contingent, or purposed system. In such a system, arbitrary decisions are permissible: God could choose any number of means which could equally serve the purpose of the world. Descartes extends God's omnipotence further than did previous thinkers.[20] Spinoza's criticism of the concept of a creating God is, in part, a response to the tradition that maintains that the universe is contingent. Spinoza rejects the element of arbitrariness in the relationship between God and his creation which runs through the accounts of these previous thinkers. In his *Ethics*, Spinoza does away with a creating God altogether when he identifies the attribute of matter as one of the attributes of God.[21] The concept of a creating God proves completely abhorrent to Spinoza's determinism. In his essay *On the Ultimate Origin of Things* (1697), Leibniz retorts that one cannot understand the entire universe even with a mechanistic interpretation. Such an interpretation can articulate the systematic relationships between the various phenomena *within* the universe; it cannot, however, explain why the universe exists as a whole.[22] Leibniz is certainly within a Maimonidean tradition.

Maimonides believes that a deterministic universe puts the existence of God into doubt; it is from the *contingency* of the universe that Maimonides discerns an ordering hand rather than an immanent necessity. Maimonides accepts the physicotheological proof for the existence of God on the basis that a world of heterogeneous elements, which seems to follow a pattern but falls short of perfect symmetry, allows for the possibility of a willful creator. Maimonides believes that in principle we could never understand all the physical laws of the universe. As we have seen, his careful delineation of the functions of Aristotelian principles and Ptolemaic hypotheses indicates the limits of scientific investigation. Maimonides is thus a formalist rather than a realist in his view of the sort of knowledge of the superlunary world which is available to man. The only knowledge we have of the superlunary world is mathematical; although mathematical knowledge allows us to make predictive statements about celestial bodies, it does not give us knowledge of how these bodies operate in reality. Maimonides concludes that only God knows the true physical principles which determine the operations of the celestial bodies.

Notes

1. Moses Maimonides, *The Guide of the Perplexed*, trans. Shlomo Pines (Chicago: The University of Chicago Press, 1963), p. 322. The translations in this article are from the Pines edition; for some problematic passages I consulted the Hebrew version of the *Guide*: *Moreh Nebukim*, ed. Dr. Yehudah Evenshmuel [Kaufman] (Jerusalem: Mossad Harav Kook, 1958).
2. A discussion of the "realist" versus the "instrumentalist" science is found in Pierre Duhem, *To Save the Phenomena. An Essay on the Idea of Physical Theory from Plato to Galileo*, trans. Edmund Doland and Chaninah Maschler (Chicago: The University of Chicago Press, 1969).
3. B. Goldstein, *Al-Bitruji: On the Principles of Astronomy*, 2 vols. (New Haven: Yale University Press, 1971), Vol. 1, pp. 3-5.
4. Twelfth and thirteenth-century Kabbala had its roots in the traditions of the first- to fourth-century discussions of Ezekiel's vision of the *merkabah*, the Divine Chariot-Throne. The history of the terminological system that grew out of these discussions can be found in Gershom Scholem's *Jewish Gnosticism, Merkabah Mysticism, and Talmudic Tradition* (New York: The Jewish Theological Seminary of America, 1960).
5. Julius Guttmann, *Philosophies of Judaism*, trans. David Silverman (London: Routledge and Kegan Paul, 1964), pp. 167-170. See also Emil Fackenheim, "The Possibility of the Universe in Al-Farabi, Ibn Sina, and Maimonides," *Proceedings of the American Academy for Jewish Research* 16 (1946-47): 39-70.
6. Maimonides, *Guide*, p. 322.
7. *Ibid.*, pp. 322-323.
8. I depict here an epicycle revolving around a deferent which has a point in the middle. The ambiguity of the text is resolved, perhaps, by placing a planet on the epicycle, and accepting that Maimonides is speaking about the relative motion of such a planet.
9. *Ibid.*, p. 323.
10. *Ibid.*
11. *Ibid.*
12. *Ibid.*, p. 324.
13. *Ibid.*, pp. 324-25.
14. *Ibid.*, pp. 325-26.
15. *Ibid.*, p. 326.

16. *Ibid.* The emphasis is mine.
17. *Ibid.*
18. *Ibid.*
19. Thomas Aquinas, *Quaestiones Disputatae de Potentia Dei*, ed. Raymondi M. Spiazzi (Turin: Marietti, 1949), pp. 30-31. Respondo, III, 17.
20. Amos Funkenstein, "Descartes, Eternal Truths, and the Divine Omnipotence," *Studies in the History and Philosophy of Science* 6 (1975): 185-199.
21. Benedictus de Spinoza, *Ethics*, in John Wild, ed., *Spinoza: Selections* (New York: Charles Scribner's Sons, 1930), p. 108. Prop. 15.
22. Gottfried Wilhelm Leibniz, "On the Ultimate Origin of Things," in Philip Wiener, *Leibniz: Selections* (New York: Charles Scribner's Sons, 1951), pp. 345-355.

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