The Universe as a System: Ibn Sīnā's Cosmology Revisited

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This article explores Ibn Sīnā's cosmological views and analyzes the underlying assumptions and arguments in support of the theories to which he subscribes. These include the notions of the central and stationary position of the earth in a finite, spherical cosmos, the impossibility of the existence of many universes, and the metaphysical forces that drive, guide, and maintain the perpetual movement of cosmic bodies.

Keywords: Ibn Sīnā, Islamic cosmology, geocentric universe, multiverses, cosmic motion, celestial spheres, celestial bodies, celestial intelligences.

Ibn Sīnā (d. 428/1037) is one of the most celebrated 'scientist-philosophers' the Muslim world has produced.[1] Besides the influential *Liber Canonis* on medicine, Ibn Sīnā wrote *Kitāb al-Shifā'*, a multi-volume encyclopedic masterpiece embodying a vast field of knowledge from logic and metaphysics to mathematics, astronomy and music, which was in part translated into Latin and exerted tremendous influence in subsequent centuries. This article aims to discuss some aspects of Ibn Sīnā's cosmology. An outline of his picture of the physical universe is given together with an exposition of its philosophical underpinnings, followed by an analysis of his views about the nature and motion of heavenly bodies.

1. For further details, see G.W. Wickens (ed.), *Avicenna: Scientist and Philosopher* (London: Luzac & Company, 1952); and S. M. Afnan, *Avicenna: His Life and Works* (London: George Allen & Unwin, 1958).

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1. General Picture of the Cosmos

Drawing on Aristotle's cosmology and Ptolemaic astronomy, Ibn Sīnā views the universe as consisting of nine concentric spheres contiguously nested, one within the other, from the lowest sphere of the moon to the outermost starless sphere. These spheres are thought to be concentric because they seem to share a common center, which is the center of the universe, taken as coincident with the earth's center. On this model, each of the seven known 'wandering stars' or planets (*al-kawākib al-mutaḥayyirah*)—namely, the moon, the two inner planets (Mercury and Venus), the sun, and the three outer planets (Mars, Jupiter, and Saturn)—and the 'fixed stars' (*al-thawābit*) are assumed to be attached to eight solid but transparent spheres that carry them as they revolve around the earth.[2] There is a ninth, outermost sphere (*kurah khārijah ʿanhā muḥīṭah*), which defines the edge or boundary of the universe and supposedly contains no star (*ghayr mukawkabah*), posited to explain the daily motion of the heaven, whereas the motion of the eighth sphere (that of the fixed stars) is said to be due to the precession of the equinoctial points (*nuqṭatā al-iʿtidāl*).[3] Each of these spheres, according to Ibn Sīnā, is governed by an intelligence and a soul, which are respectively the remote cause and proximate principle of their motion.

Ibn Sīnā's model rests on four fundamental assumptions, namely: (1) that the universe is one in number; (2) that it is finite in extent and spherical in shape; (3) that it has a center; and (4) that the earth lies at its center. Let us first consider the third and fourth assumptions. Ibn Sīnā argues for the central position of the earth by means of a logical argument which essentially de-

2. Ibn Sīnā, *Shifāʾ: Ilāhiyyāt,* ed. Y. Musa, S. Dunya and S. Zayed (Cairo: Organisme General des Imprimeries Gouvernementales, 1960), 401 lines 6-17; *Shifāʾ: Riyāḍiyyāt: ʿIlm al-Hayʾah,* ed. Muḥammad Mudawwar and Imām Ibrāhim Aḥmad (Cairo, 1980), 463; and *Shifāʾ: al-Tabiʿiyyāt: al-Samāʾ wa al-ʿĀlam,* ed. Maḥmud Qāsim (Cairo: Dār al-Kātib al-ʿArabī: 1969), 37 line 12; cf. Ibn Ḥammūdah, *Mukhtaṣar ʿIlm al-Hayʾah li al-Shaykh al-Raʾīs Abi ʿAli ibn Sīnā* in *Kitāb al-Mahrajān li Ibn Sīnā (Le Livre du Millénaire d'Avicenne)* (Tehran: Société pour la Conservation de Monuments Nationaux, 1956), III: 1-10. Cf. "The Arabic version of Ptolemy's Planetary Hypotheses," ed. B. Goldstein in *Transactions of the American Philosophical Society,* 57 (1967) 4: 27-9.

3. *Shifāʾ: Ilāhiyyāt*, 392 lines 10-14; cf. *Maqālāt al-Iskandar al-Afrūdīsī fī al-Qawl fī Mabādiʾ al-Kull,* in *Aristūʿind al-ʿArab,* 265 = Charles Genequand, *Alexander of Aphrodisias on the Cosmos* (Leiden: E. J. Brill, 2001), 12 and 82-5. Cf. C. A. Nallino, "Astrologia e astronomia pressi i Musulmanni," *Raccolta di scritti editi e inediti* (Rome: Istituto Per L'Oriente, 1944), 5: 64-6 and 75, cited in G. Endress, "Averroes' *De Caelo:* Ibn Rushd's Cosmology in his Commentaries on Aristotle's *On the Heavens*," *Arabic Science and Philosophy* 5 (1995), 43-4; and R. Walzer, *al-Fārābī on the Perfect State* (Oxford: Clarendon Press, 1985), 364.

rives from the Aristotelian physical theory of four elements (earth, water, air, fire) and their natural motion and place. For him as for Aristotle, any motion of natural bodies (that is, anything capable of motion and change, whether animate or inanimate) is either simple or composite, natural or unnatural. Simple motion, which belongs to simple bodies (as opposed to composite bodies), is either rectilinear (*mustaqīmah*) or circular (*mustadīrah*). Simple rectilinear motion is either motion away from the center, motion toward the center, or motion about the center.[4] Motion away from the center toward the cosmic circumference, termed upward motion, is natural to light bodies, whereas motion toward the center, called downward motion, is natural to heavy bodies.[5]

The motion of a body is said to be natural (*ṭabīʿiyyah*) if it drives the moving body toward the place where it will rest 'naturally', that is, by nature and not by an external force, whereas unnatural motion is that which is due to some external force contrary to the thing's nature[6]—"nature" being identified as an intrinsic principle of being moved and being at rest.[7] Since the sub-lunar elements (*ʿanāṣīr*) are natural simple bodies (*basāʾiṭ*), their motions must be both simple and natural,[8] but also rectilinear and not circular because, in the absence of any hindrance, each of the elements will by nature either move straight up or straight down, seeking its natural place.[9]

By 'natural place' (*ḥayyiz ṭabīʿī*) is meant the place to which a natural body is moved or inclined to move and where it will rest naturally,[10] namely, the cosmic center for heavy bodies, and the circumference for light ones. Given all these principles, it is reasonable for Ibn Sīnā to conclude that the earth must lie at the center of the universe. This is so because the earth, being the heaviest of all the elements, must naturally move toward the center and cannot be placed anywhere but where it belongs by nature. Indeed, even if at any time it should not have been at the centre of the cosmos, it would have been bound to reach it long ago by natural rectilinear motion which, because of the finiteness of directions (*tanāhī al-jihāt*) within the universe, cannot be perpetual. And now that it is situated in its natural place, the earth must be at rest and motionless. That is to say, given its present natural position, the earth cannot have rectilinear motion; nor can it revolve about an axis at the center of the

4. *Shifāʾ: Ṭabīʿiyyāt: Samāʾ wa ʿĀlam,* 6 lines 5-7.

5. Ibid., 7 line 18 and 8 lines 1-6.

6. See Ibn Sīnā, *Kitab al-Najāt* (Cairo, 1938), 109-10. Unless indicated otherwise, subsequent references are to this edition.

7. Ibn Sīnā, *Shifāʾ: Ṭabīʿiyyāt: Samāʾ Ṭabīʿī,* ed. Said Zayed (Cairo: Organisme General des Imprimeries Gouvernementales, 1983), 34 lines 8-9.

8. *Shifāʾ: Ṭabīʿiyyāt: Samāʾ wa ʿĀlam,* 9 lines 17-8.

9. *Shifāʾ: Ṭabīʿiyyāt: Samāʾ Ṭabīʿī,* 318 lines 5-17 and 319 lines 1-9.

10. *Najāt,* 134-5.

universe, because circular motion belongs only to celestial bodies.[11]

Interestingly, Ibn Sīnā discards other arguments for the geocentric thesis on the grounds that they all share one wrong assumption, namely, that "the earth is forced to stay at the center (*al-arḍ maqsūrah ʿalā al-qiyām fī al-wasaṭ*)." For how, he asks, can a thing be forced [to remain somewhere] except when it is not in its natural place?[12] Thus Ibn Sīnā rejects, for example, the theory which claims that the earth stays as it is and does not fall downward because it floats on water, or that it remains stable by virtue of its dryness. For still can one ask, Ibn Sīnā contends, the further question of what then supports the water. He also rejects the idea that the earth is at rest because it is like a cylinder in shape (*ṭabliyyat al-shakl*), having an extended plane surface top and bottom (*musaṭṭaḥat al-qaʿr munbasiṭah*). Equally unacceptable to him is the idea that the earth has a ball-like shape (*kuriyyah*) and that it stays aloft and motionless, not supported by anything but staying where it is because it is pulled to every direction with the same force by the celestial sphere and therefore remains at the same distance from everything.[13] That this cannot be the case is explained by Ibn Sīnā in the following passage:

> As for those who say that [the earth is at rest and motionless] because of the attraction (*jadhb*) of the celestial sphere from all directions equally, their claim and opinion are flawed in several respects. First, if we suppose that this attraction has vanished, then the earth would either stay still in the center or it would rather move. Now if it were to move, then it certainly would move toward the sphere—for those people think that the sphere contains [the earth] and that the earth is in the middle---so that if it moved toward the sphere, then it would have turned its natural motion upward, which is impossible. But if it stays where it was, then the reason they give for the earth's quiescence is superfluous; even without that reason [the state of] being at rest would still be there. [For if there is] something whose very existence does not require the existence of something else, [then] this something else cannot be the cause for that thing which does not need it at all. Therefore, such an attraction cannot be the cause for the earth's quiescence. Secondly, small things would be attracted faster than big things; but why is it that a piece of earth is not attracted toward the sphere, and instead is moving away from it toward the center? Also, things near [to the sphere] would be attracted more than things far away, according to their nature; now, a piece of earth thrown up [to the air] is [on such an assumption] approaching the sphere, so that it should have been attracted to its [the sphere's] nearest point, rather than to the whole earth. Furthermore, as you know, rectilinear nat-

11. *Shifāʾ: Ṭabīʿiyyāt: Samāʾ wa ʿĀlam,* 55 lines 5-7.

12. Ibid., 57 lines 6-7.

13. Ibid., 56 lines 7-18 and 58 lines 6-16.

> ural motion must lead to the place of rest (*jihat al-qarār*) naturally, and a piece of earth simply moves in order to be at rest, be it at the sphere [i.e. the periphery] or at the supposed center; but it does not move toward the sphere—for otherwise the opposite direction of its motion would be more appropriate, since it is nearer. Therefore, it [the piece of earth] must have moved toward the center to be at rest by nature.[14]

As we can see, here and in the subsequent passages Ibn Sīnā emphasizes clearly that it is neither 'by force' (*qasran*), nor 'by choice' (*ikhtiyāran*), nor 'by chance' (*bi al-bakht*), but rather 'by nature' that the earth stays where it is, at rest at the center of the universe. It cannot be due to some coercive factor, he says, because it is impossible for the sphere surrounding the earth to change the earth's inclination (*mayl*) by repulsion (*daf'an*). For if it were possible, then a piece of earth falling toward the center would move less quickly the closer it is to the earth, because the speed of a body moved by force diminishes the farther away it is from the moving agent. Nor can we say that it chooses to be so, because being inanimate the earth cannot have choice or will of its own, but simply behaves in accordance with its nature. Ibn Sīnā also rejects the view that the earth owes its stability to chance on the grounds that what happens by chance cannot be perpetual and is itself due to some cause.[15] As we can see, all these arguments for the stationary and central position of the earth ultimately rest on his theory of *mayl* which says, *inter alia*, that "every body will lose its inclination once it reaches its natural place."[16]

Turning to the idea that the universe is finite in extent and spherical in shape, having the outermost, starless sphere as its circumference and the earth at its centre, Ibn Sīnā seems content with making only a brief argument. For him, as for Ptolemy whose *Almagest* he paraphrases, the sphere is the only figure most fitting for circular motion such as that of celestial bodies, and is the noblest (*ashraf al-ashkāl*),[17] most encompassing (*azyaduhā iḥāṭatan*),[18] and most perfect because of its unique form limited by a single surface. Most importantly, it is the only one which, by rotating on its axis, can move within its own limits without change of place. Indeed, sphere is among bodies as the circle is among plane figures; it is the most uniform of all solid figures, since it is equidistant every way from centre to extremity. Now, according to Ibn Sīnā, one can infer the universe's sphericity from the circular motion of the heavenly bodies. The cosmic sphere cannot be infinite, because an infinite body is

14. Ibid., 59 lines 7-19 and 60 lines 1-7.

15. Ibid., 61 lines 1-13.

16. Ibid., 69 lines 1-2.

17. *Shifā': Ṭabīʿiyyāt: Samā' Ṭabīʿī,* 41 line 14.

18. *Shifā': Riyāḍiyyāt: ʿIlm al-Hay'ah,* 16 line 11 and 19 lines 5-10.

logically impossible. Being spherical, the universe is said to exhaust all space, so that there exists neither body nor place nor void outside this all-embracing cosmic sphere.[19] This view has led Ibn Sīnā to maintain, paradoxically, that the universe is not in a place, since 'place' is defined as that *in which* a body is found and that which contains or surrounds the body[20]—a definition which doubtless presupposes the existence of at least two contiguous bodies, 'place' being the innermost surface of the containing body in direct contact with the contained body, and implies that no two bodies can occupy one and the same place at the same time.[21]

Now it is easy to see why the universe or heavens as a whole cannot be said to be in place: the whole body (that is, the universe) is surrounded neither by another body nor by a void, since it is assumed that there is no such thing and there exists no material body beyond the universe to serve as its container. To be sure, denial of a place to the last, outermost sphere constituting the whole universe is a consequence forced upon Ibn Sīnā in order to avoid an infinite regress of material places; for if the outermost sphere is contained by another sphere, the latter, in turn, would require a further containing sphere, and so on *ad infinitum,* a process that would inevitably lead to the assumption of an infinite universe.

Not only the whole cosmos is believed to be spherical but also the earth is thought of as having a ball-like shape.[22] That the earth cannot be flat almost necessarily follows from the theory of elemental motion according to which the heavy element earth is naturally inclined toward the center of the universe, while light elements by nature tend to move up toward the circumference. Thus, supposing that the earth was originally in a state of dispersal, when the dispersed particles of earth traveled to the center (i.e. to the earth), they would naturally impinge upon one another and form a spherical body, because any anomalies (*taḍārīs*) would be self-correcting: a lump on the sphere would be heavier than the counter-balancing portions of it, and so it would continue to press toward the center until all was in balance, just like the case of water seeking its own level, although such a process would no doubt take a very long time, being gradual, and hence—given the earth's dryness and hardness—hardly noticeable.[23] Indeed, for Ibn Sīnā the sphere is just the natural shape (*shakl ṭabīʿī*) of simple bodies,[24] which is why each of the elements is supposed to seek and stay at their proper natural place, forming its own

19. *Shifāʾ: Ṭabīʿiyyāt: Samāʾ Ṭabīʿī,* 104-5.

20. *Najāt,* 118.

21. *Shifāʾ: Ṭabīʿiyyāt: Samāʾ Ṭabīʿī,* 263 line 14.

22. Ibid., 41 line 8.

23. *Shifāʾ: Ṭabīʿiyyāt: Samāʾ wa ʿĀlam,* 19-21; cf. *Najāt,* 135.

24. *Najāt,* 135; cf. *Shifāʾ: Riyāḍiyyāt: ʿIlm al-Hayʾah,* 19 lines 7-10.

sphere and surrounding one another.[25] Furthermore, given its central position and being mostly composed of the heaviest element, the earth cannot but be spherical, for only a spherical body could be equidistant (*fī sawāʾ al-wasaṭ*) from all the points on the cosmic circumference.[26] The sphericity of the earth can also be inferred from the curved, crescent-like (*hilālī*) or even sometimes circular shadow which the earth casts on the moon's surface no matter at what position it passes the moon.[27] Added to that is the observation that the portion of the sky that is visible changes as one moves even quite a short distance north or south on the earth's surface.[28]

2. Impossibility of Many Universes

Along with Plato and Aristotle, Ibn Sīnā denies the existence of other universes apart from our own. For him there cannot be more than one universe, and he adduces two arguments in support of this view. First, he says, if there were many universes (*ʿawālim kathīrah*) then a given body (say, water) would have several natural places differing only numerically yet placed and scattered in diverse directions. The body would consequently be subject to contrary natural motions (simultaneously towards and away from the centre, as some would move downward while others upward). Since natural motions and natural places are interdependent, indetermination of motion would imply indetermination of place. This would, moreover, result in a contradiction, because places would be determinate (since they would form a universe) and yet, at the same time and in the same respect, also indeterminate (since they would be the goals of contrary motions).

> If [assuming that there were many universes] every universe is the same in form as another, such that in each universe there exist similar earth, fire, water and air, then bodies of the same species would tend [to move] to many natural places that vary in position or in nature, and this we have shown to be absurd. Rather, as we have explained in [the treatise on] the universal principles, there must be one place where all earths would gather forming a single sphere

25. *Najāt,* 136-7 and 144-5.

26. *Shifāʾ: Riyāḍiyyāt: ʿIlm al-Hayʾah,* 21-3.

27. *Shifāʾ: Ṭabīʿiyyāt: Samāʾ Ṭabīʿī,* 42 line 13.

28. *Shifāʾ: Riyāḍiyyāt: ʿIlm al-Hayʾah,* 20-1; cf. *Shifāʾ: Ṭabīʿiyyāt: Samāʾ Ṭabīʿī,* 41 line 17. Ibn Sīnā does not, however, invoke the a priori argument found in Aristotle that all heavy bodies fall at equal angles to the earth's surface, that is, that the angles between the line of fall and all lines on the earth's surface radiating from the point of impact are equal. Consequently, lines of fall (that is, the lines directed toward the center of the universe) are not parallel to each other, for only if the earth were like a flat disk would lines of fall, vertical to the earth's surface, be parallel. See Aristotle, *De Caelo,* 296b 16-25.

> and fill it. Likewise is the place of each of the remaining elements. Now if that is the case, then [the element] earth, for instance, either would be forced to stay in all [those universes], so that it would have no [single] natural place, which is impossible; or its [current] place would be natural in all [universes], which is equally impossible, as we have explained; or its natural place should be one only, but it has been forced to remain in other places. But if so, how can it be distinguished from bodies that determine directions and are impenetrable? What then is the difference between them? And from this it follows that one nature [i.e. a natural body] moves naturally towards contrary directions (*ṭakūn ṭabīʿah wāḥidah tataḥarrak bi al-ṭabʿi ilā jihāt mutaḍāddah*).[29]

Secondly, if there were many universes, then there would be more than one center. But such a situation is impossible because, Ibn Sīnā argues, the earth of each universe, each being the center, must by virtue of their similar nature eventually gather in one place, forming a new center; there is no reason why they should not do so (*hādhā al-ijtimāʿ mimmā lā māniʿa lahu ʿanhu fī ṭabʿihi*), for one and the same nature cannot be separated and differentiated (*fa inna al-ṭabīʿah al-wāḥidah al-mutashābihah la taqtaḍī al-iftirāq wa al-tabāyun*).[30] That is to say, if there were another universe, its elements would be one and the same as those in our universe; and since all elements are essentially the same everywhere and so are moved toward their respective natural places, each element would be moved to its proper place in our universe—for example, that earth would be moved to the center of our world—which is impossible because, from the point of view of its own universe, that earth would be moved upward (that is, away from its center), just as the earth from our universe would be moved upward if moved toward the center of another cosmos.

> All earths are one in [that they have the same] natural form. And as mentioned earlier, things that are one [that is, similar] in form must have the same natural place in which all of them should gather—as scientific verification and explanation has shown. It follows that all other earths cannot remain in various places naturally and have no choice but [to move and rest in] their natural place. Also, the earth that has reached its natural place will not move rectilinearly, as we already know; but neither will it move circularly, because by nature earth can only have rectilinear motion. And as we have explained, no single body can have a natural tendency for both rectilinear and circular motions.[31]

In short, the assumption of more than one universe entails not only denial of the identical natures of the elements and the oneness of their respective

29. *Shifāʾ: Ṭabīʿiyyāt: Samāʾ wa ʿĀlam,* 74 lines 5-14.

30. Ibid., 75 lines 1-3.

31. Ibid., 54 line 17 and 55 lines 1-7.

motions throughout the different universes, but also denial of place as the principle rendering the cosmos determinate in respect to direction—that is, in respect to "up," "down," and "middle." For the natural motion of each element is defined in relation to its place in the universe; and it is either away from the center and toward the circumference (*min al-markaz ilā al-muḥīṭ*), or toward the center and away from the circumference, or about the center.[32] In other words, if there were many universes existing in an infinite space where there is neither center nor circumference, there would be no motion, since bodies would have no place to serve as the goal of their motion and one could not point to one direction as up and another as down.

> Furthermore, how can there be [many cosmic] heavens (*samāwāt*) for different places? What is it that makes their places different, such that there should be numerous centers? Indeed from the foregoing theses it is clear that heaven constitutes the cause for determining all other places, and therefore all other places cannot be the cause for defining its place. So the cause for [defining] the different places [of those heavens], in such a way that they do not pass across one another and do not share one common place, must be something other than their own nature; nor can it be some other bodies whose very places are defined by them [i.e. the heavens]. And no doubt, it must be by force since it is not something natural—both in respect to the [celestial] body and in respect to the other [non-celestial] bodies. But we have said that compulsory change of place (unnatural locomotion) is impossible in the case of this [celestial] body. Therefore, since it is impossible for the defining bodies that are similar in nature (*al-muḥaddidāt al-mutashābihat al-ṭibāʿ*—i.e. the heavens of the presumed universes) to have different places by nature, and impossible too by compulsion, there cannot be many centers. Such being the case, we have made it clear that there cannot be many universes with similar elements having similar natures.[33]

3. Celestial Nature and Motion

Before dealing with Ibn Sīnā's theory of celestial motions, it is worth discussing his views on the nature of heavens. According to Ibn Sīnā, heavenly substances differ fundamentally from earthly things in many respects. First of all, celestial things are simple in that they are not composite, and, second, they are made of a unique simple substance called aether (*athīr*), which, unlike the four sublunary elements, is eternal and changeless in the sense that it is neither

32. Ibid., 6 lines 5-7; cf. Ibn Sīnā, *ʿUyūn al-Ḥikmah,* ed. ʿAbd al-Raḥmān Badawī (Cairo: Institut Français d'Archéologie Orientale, 1954); repr. in *Rasāʾil Ibn Sīnā* (Qomm: Intishārāt Bīdār, 1980), 35 (page reference to the reprint).

33. *Shifāʾ: Ṭabīʿiyyāt: Samāʾ wa ʿĀlam,* 75 lines 3-13.

generated nor destructible (*lā yaqbal al-kawn wa al fasād*).[34] This is because generation and destruction apply only to composites—i.e., things which contain contrary qualities, and represent change into and out of opposites, as will be explained below. Indeed, this so-called 'fifth element' (*al-jism al-khāmis* or *al-ṭabīʿah al-khāmisah*,[35] the *quinta essentia* of the medieval scholastics) is immune not only to the process of generation and destruction (substantial change) but also to other kinds of change, such as locomotion (which entails movement to natural place in search of rest), alteration (qualitative change), and growth and diminution (quantitative change), since all these changes imply contrary qualities, whereas heavenly bodies are simply devoid of contraries (*lays lahā ʿunṣur ayy shayʾ qābil liʾl-ḍiddayn*).[36]

The simple celestial substance (the aether), Ibn Sīnā tells us further, moves only in a circle, circular motion being the only simple motion natural to it on the grounds that the other simple motion (rectilinear) is natural and belongs to the four simple terrestrial elements (fire, air, water, earth) or anything composed of them in which one element predominates (*bi ḥasab al-ghālib*).[37] For given that each of the simple (terrestrial) bodies has only one natural motion (e.g. either upward or downward) and since a motion can, if at all, have only one contrary, the conclusion is drawn that circular motion (which, however, has no contrary) cannot be the unnatural motion, let alone be the natural motion of one of the four elements; rather, it should belong to another simple element, namely the 'fifth body'.[38]

Moreover, since it has no inclination (*mayl*) for rectilinear motions, the heavenly substance is neither heavy nor light, whether actually or potentially, for heaviness implies downward motion towards the centre, and lightness implies motion away from the centre.[39] Above all, the reason why the celestial element deserves all these properties lies in the fact that it is ever actual, its matter being always attached to its form (*mawqūfah ʿalā ṣūratihā*),[40] its form having no contrary and its properties unchanged.[41]

> The sphere (*falak*) has a physical reality (*jawhar jismānī*), is round in shape, and circular in motion by nature [*sic!*]; it never leaves its natural place and yet does not rest at one fixed position within its natural place; to its power and nature are due all that happens

34. Ibid., 34 line 6.

35. Ibid., 25 line 9 and 15 line 6.

36. Ibid., 28-34; the quoted sentence is on page 31 line 1.

37. Ibid., 17-18; cf. *Najāt,* 134-5.

38. Ibid., 11-12.

39. Ibid., 7-9 and 64-5.

40. Ibid., 30 line 17, 31 lines 1-3, and 34 lines 7-11.

41. Ibid., 33 lines 4-5.

> in the [terrestrial] world of elements. Its circular motion, which is meant for glorification (*tasbīḥ*), is due to God's command (*li amr Allāh*). It is absolutely impossible for it to have a rectilinear motion; nor can it be affected by elemental bodies (*al-ajsām al-ʿunṣuriyyah*, i.e., terrestrial elements)[42]...which [in contrast to celestial spheres] will not move at all [once they are] in their natural places and will not move at all according to [their] nature except when they are in foreign [i.e. unnatural] places; indeed they do not move by nature except in a straight line, and are constantly affected by aetherial bodies (*al-ajsām al-athīriyyah*).[43]

He elsewhere remarks that:

> Every body which is generated has in it a principle or innate impulse for linear motion (*mabdaʾ ḥarakah mustaqīmah*), and every body lacking this principle for linear motion is not generated. Now, a body which has such a principle for circular motion by nature is not generated out of another body, nor is it found in the place of another body. Rather, it is originated [not out of pre-existent matter] (*mubdaʿ*) and, therefore, [is the one that] preserves time and never fails to do so (*lā yukhill*). Consequently it needs no other body to determine its direction, for [all] directions are determined by it. Nor does it ever leave its [natural] place, because if it did, then it could not be the essential determinant of directions. We also maintain that its "nature" has no contrary.[44]

It should be noted that the term "nature" as used in the passage just cited refers to the principle of any motion, rest and other perfections (*kamālāt*) which every natural body may have within and by itself. As Ibn Sīnā explains it, 'nature' is the first of the three kinds of powers (*quwā*) which pervades the body and preserves its perfections (e.g., its shape, its natural place, and its action).[45] It is an internal source or cause of being moved and being at rest, that within things by virtue of which they move (taking 'motion' in its broadest sense which includes all kinds of change) and come to rest. Whereas for living beings the intrinsic mover is their soul (*nafs*), for the elements and other non-living things it is the inclination (*mayl*) of each to reach and rest in its proper, natural place. Thus nature is identified with soul as well as inclination in the case of animals (ensouled bodies) and inanimate objects respectively. But in both cases nature expresses itself in the thing's motion, motivating the thing to actualize its potentialities and achieve its existential purpose.

Let us now turn to Ibn Sīnā's theory of celestial motions. To begin with,

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42. *Risālah fī al-Ajrām al-ʿUlwiyyah* in *Tisʿ Rasāʾil,* 57 lines 1-7.

43. Ibid., 57 lines 11-14.

44. *Shifāʾ: Ṭabīʿiyyāt: Samāʾ wa ʿĀlam,* 28 lines 6-12.

45. *Kitāb al-Najāt*, ed. Majid Fakhry (Beirut: Dār al-Āfāq al-Jadīdah, 1985), 137; cf. Aristotle, *Physics*, II.1.

Ibn Sīnā rejects Aristotle's quite complicated theory according to which the motion of celestial spheres is due to forty-seven or fifty-five unmoved movers, the first of which, identified as *theos*, is said to be directly responsible for moving the outermost sphere of the fixed stars.[46] That is to say, the stars and the planets are rotating because they are attached in some way to a series of rotating spheres, each of which is moved by an unmoved mover. Instead, like Alexander of Aphrodisias before him, Ibn Sīnā adopts the simplified version of the theory, positing only nine spheres, while at the same time appropriating the remaining Aristotelian views: that the so-called Prime Mover, being both the efficient and final cause in the sense of an object of both love and thought (*to orekton kai to noêton*),[47] produces motion while all other things move by being moved, and that the first moving sphere, which embraces all the orbs involved in the daily motion, seeks to become as much like the Prime Mover as possible and thus wishes to come to rest in imitation of the First Unmoved Mover. Nevertheless, since it is impossible for any celestial sphere to acquire such a state of perfection, the first moving sphere remains in a continuous, eternal state of rotational motion as it strives for its unattainable goal. The celestial motion is eternal, partly because of its circularity—since it is assumed that a body which moves in a circle is perpetual and is never at rest—but mainly by virtue of the eternal, unchanging First Principle of Being (*hê arkhê kai to prôton tôn ontôn akinêton*).[48] Ibn Sīnā's position is explained in the following passage:

> You know that the essence of the First Beloved Good is one; and it is impossible for the whole universe (*jumlat al-samā'*) to have more than one first mover. It is true that each one of the celestial spheres has its own proximate mover as well as its own beloved and object of desire, according to the First Teacher and subsequent peripatetic scholars. But they deny multiplicity to the mover of the [universe as a] whole (*muḥarrik al-kull*), although they affirm plurality to the separate movers as well as the non-separate movers for each one of the spheres, thereby making the first of these specific movers responsible for moving the first sphere—namely, that of the fixed stars, according to those before Ptolemy, or the outermost, all-embracing one that contains no star, followed by those which move the succeeding spheres, according to either opinion, and so on. Thus, they [i.e. the commentators] think that the cosmic mover is one and that each of the succeeding spheres has its own mover, whereas the First Teacher assumed the number of the moved spheres, ac-

46. Aristotle, *Metaphysics,* XII.8. 1074a 1-14 and 1072b 26-30; cf. P. Merlan, "Aristotle's Unmoved Movers," *Traditio* 4 (1946), 1-30; J. Owens, "The Reality of Aristotle's Separate Movers," *Review of Metaphysics* 3 (1950), 319-37 and J. G. deFilippo, "Aristotle's Identification of the Prime Mover as God," *Classical Quarterly* 44 (1994) 2, 393-409.

47. Aristotle, *Metaphysics,* XII.7. 1072a 26-7.

48. Aristotle, *Metaphysics,* XII.8. 1073a 24-34.

> cording to the data available to him at the time, to correspond to the number of the separate principles [of motion]. But some of his companions [*sic,* namely, Alexander of Aphrodisias] gives the most correct opinion as he asserts in his treatise "On the Cosmic Principles" (*Fī Mabādiʾ al-Kull*) that the mover of the whole heaven is one and cannot be many in number, even though each one of the spheres has a mover and a beloved of its own.[49]

Crucial to understanding the whole theory is the general principle, first enunciated by Aristotle and adopted by Ibn Sīnā, that 'everything that moves is moved by some agent.' Specifically, this means that all natural bodies owe their motion to a certain cause or principle, which can be either intrinsic (*ʿan dhātihā*) or extrinsic (*bi-sabab khārij*). The external factor capable of producing and/or obstructing motion in a body is called 'force' (*qāsir*), and its effect 'violent' or unnatural motion. The intrinsic principle, on the other hand, is further classified into that which brings about 'voluntary' motion (*bi irādah*), and that which causes involuntary but non-violent (and hence natural) motion (*lā ʿan irādah wa lā ʿan taskhīr qāsir*), the former being identified as soul (*nafs*), the latter as nature (*ṭabīʿah*).[50] In short, if anything is in motion, it must be moved by something else: either by nature, by soul, or by force.

These assumptions entail that nothing is, strictly speaking, self-moved. Indeed, self-motion is impossible because motion broadly defined is the first perfection (*kamāl awwal*) or actualization of a potency (*quwwah*),[51] a process that requires an agent (namely, the cause or principle of motion) which itself must be actual and perfect. Thus, the moving principle must already be in the state at which the motion of the patient is aimed because otherwise we would have an infinite series of such agents, which is absurd. It is clear that each moving object presupposes some cause (*ʿillah*) which sets and sustains it in motion. However, since the series of such causes cannot regress indefinitely, therefore, the motion of each moving object must be ultimately sustained by a first cause, which moves the rest but itself is unmoved.[52] On Aristotle's account, there exist no less than fifty such unmoved movers, whereas Ibn Sīnā recognizes only ten, which he identified as separate intelligences (*ʿuqūl mufāriqah*), apart from the First one (*al-ʿAql al-Awwal*).[53]

According to Ibn Sīnā, the circular motion of celestial bodies cannot be natural, because natural motion can occur only when a body is located elsewhere from its proper place. But celestial bodies are and have always been

49. *Shifāʾ: Ilāhiyyāt,* 392 lines 7-17 and 393 lines 1-2.

50. *Shifāʾ: Ṭabīʿiyyāt: Samāʾ Ṭabīʿī,* 29-30.

51. Ibid., 83 lines 2 and 5.

52. *Najāt,* 235.

53. *Shifāʾ: Ilāhiyyāt,* 401 lines 6-14.

in their natural place.[54] A second reason is that natural motion is aimed at rest (*li ajli ṭalab sukūn*), which is characteristic of rectilinear motions, whereas the circular motion observed in celestial bodies is perpetual. However, such a motion cannot be said to be unnatural or enforced either, since it is assumed that there cannot be any force greater than that of celestial bodies themselves which could move them contrary to their nature. Now, since the circular motion of celestial spheres is neither by nature nor by constraint, it must originate from the voluntary power (*quwwah irādiyyah*) of ensouled bodies or living beings.[55] This view seems to contradict his statement elsewhere that the celestial bodies move circularly by nature (*bi al-ṭibāʿ*).[56]

Nevertheless, one need only to recall the distinction Ibn Sīnā maintains between the nature of terrestrial elements (or bodies composed thereof) and that of the fifth element that constitutes celestial bodies. Nothing could be more natural to such simple but animated bodies as the heavenly spheres than circular motion. Whereas in the case of bodies of the sublunary region 'nature' and 'soul' are differentiated, in the case of celestial bodies they are identical. Since the heavenly bodies are simple and changeless, only circular and everlasting motion is proper to them. However, since they are believed to be ensouled and alive (*ḥayy dhū nafs*),[57] their motion is, strictly speaking, voluntary. At best, one could say with Ibn Sīnā that the celestial motion, apart from being intellectual in a sense, is 'quasi-natural' (*kaʾannahu ṭabīʿiyyah*).[58]

> The celestial sphere is moved by [its] soul (*nafs*), the soul being its proximate principle of motion. This [celestial] soul is blessed not only with renewed conception and volition (*mutajaddidat al-taṣawwur wa al-irādah*) but also with imagination (*mutawahhimah*); that is to say, it can perceive changeable things such as particulars, and it has got desire for particular, concrete things. It [i.e. the soul] represents the perfection (*kamāl*) of the celestial body and is the latter's form. Indeed, if it were not so—that is, if it were self-subsistent in every respect—then it would have been pure intelligence, unchanged, unmoved, and unmixed with anything potential. The proximate mover of the celestial spheres, being itself not an intelligence, is nevertheless preceded by an intelligence which is the prior cause of the [celestial] motion.[59]

Thus, while their simple circular motion is due to their soul, the perpetuity of the motion is due to their intelligence; the former serves as the interme-

54. *Najāt,* 109.

55. *Shifāʾ: Tabīʿiyyāt: Samāʾ Tabīʿī,* 302 lines 16-17 and 303 lines 1-3.

56. For example in *Risālah fī al-Ajrām al-ʿUlwiyyah* in *Tisʿ Rasāʾil,* 57 line 2.

57. *Najāt,* 145 line 1.

58. *Mabdaʾ wa Maʿād,* 53 (last line).

59. *Shifāʾ: Ilāhiyyāt,* 386 lines 14-17 and 387 lines 1-3; cf. *Najāt,* 240-1.

diate cause of motion. It is their intelligence, whose sole concern it is to attain to the Pure and True Good (*al-khayr al-maḥḍ al-ḥaqīqī*) and to contemplate the First Principle and to strive to become like Him, that actually causes their soul to continuously revolve the celestial body around it, and always in the same way.[60] For intellectual contemplation alone is not accompanied by motion; nor are mere desire and volition sufficient to produce motion. The celestial soul, we are told, must not only will and comprehend the objective of its motion, but also has to 'imagine each one of the successive motions' (*tatakhayyal al-aynāt al-juzʾiyyah*) that are required to satisfy its eternal longing for Pure Intelligence, its desired object, just as a man who has resolved to travel from one place to another must know his destination and imagine each one of the successive steps that are required for him to cross the distance.[61]

Indeed, according to Ibn Sīnā, there is a great affinity between the celestial and human souls in terms of capacities and inclination.[62] The human souls have three kinds of desire (*shawq; ishtiyāq*) or love (*ʿishq*), namely: appetite (*shahwah*), passion (*ghaḍab*), and free will (*irādah*) or rational choice (*ikhtiyār*), corresponding to the soul's three faculties—the vegetative, the animal, and the rational.[63] In the case of the heavenly bodies, however, since they are said to be changeless and eternal, one can only ascribe to them intellectual desire and rational will, because the two lower kinds of desire are appropriate only for the changing and perishable beings of the sublunary region. Thus, despite their seemingly mechanical movements, celestial substances do exercise free choice precisely because their souls, being their direct moving principle, are endowed with eternal will that is ever renewed.[64] The point is summarized neatly in the *Risālah fī al-ʿishq* as follows:

> It has been explained that one who knows something good will naturally love it (*yaʿshiquhu*). We have also indicated that the First Cause is loved by the divine souls (*al-nufūs al-mutaʾallihah*). Furthermore [as we have made it clear] since the perfection of both the human and angelic souls lies in (1) comprehending the intelligibles as they really are as much as they can in order to become similar to the essence of the Absolute Good (*al-khayr al-muṭlaq*) and (2) producing fair deeds proper to them, such as [acting in accordance with] human virtues as well as the imparting of motion by the angelic souls to the celestial substances (*al-jawāhir al-ʿulwiyyah*) with a

60. See *Najāt,* 262-73.

61. Ibid., 241.

62. *Shifāʾ: Ilāhiyyāt,* 387 lines 4-8.

63. Ibn Sīnā uses the terms *shawq, ishtiyāq, tashawwuq* and *ʿishq* interchangeably, a fact which seems to suggest the influence of Alexander's *Mabādiʾ*. See Genequand, *Alexander on the Cosmos,* 37; and Walzer, *al-Fārābī,* 391.

64. *Najāt,* 241.

> view to preserving [the continuous process of] generation and corruption—again in an attempt to imitate the Absolute Good.... Now, this love exists in them eternally, without ever ceasing (*wa hādhā al-ʿishq ghayr zāʾil al-battah*).[65]

It should be added that unlike that of terrestrial animals, the celestial intelligences, being the remote and final cause of their motion, are possessed of infinite power (*quwwah ghayr mutanāhiyah*), pure and wholly free from all the determinations which belong to matter, such that they have nothing to lose, nor to gain, from what is below them.[66] Otherwise they would be subject to change and hence could not be eternal. The motion of the celestial spheres cannot be due to its own innate power because the heavens as a whole, being a finite body, cannot contain the infinite power capable of causing and sustaining its eternal motion over an infinite time.[67] Since an infinite power cannot be in a body, Ibn Sīnā concludes that the power which causes the eternal, circular motion of the heaven (and which is infinite in the sense of exerting its action during an infinite time) must be incorporeal, separated from matter; that is, Intelligence.[68]

One might wonder why circular motion is deemed most appropriate for the celestial bodies. To this Ibn Sīnā has the following reasons. First of all, circular motion is prior (*awlā bi al-taqaddum*) and superior (*awlā bi al-sharaf*) to rectilinear motion, because it alone is numerically one (*wāḥid bi al-ʿadad*), well-balanced (*mustawiyah*), and most prior and most complete of the two simple motions (*aqdam wa atamm al-basīṭayn*). In contrast to circular motion, a rectilinear motion is—if the distance is finite and should the motion turn back—in fact a composite of two contrary motions, while if it does not turn back and stops at a terminal point, then the motion is incomplete. On the other hand, if we suppose the distance is infinite (which is impossible, given the finitude of the cosmos) and the motion does not turn back but goes on to infinity, then it is incomplete. Indeed, for Ibn Sīnā, there is no such thing as an actually infinite straight line, and even if there were, it could not be traversed by anything in motion, for the impossible does not happen and it is impossible to traverse an infinite distance.[69] Furthermore, circular motion is considered complete because one cannot add to it without repeating its course (*idhā tammat al-dawrah falā yuzād ʿalayhā bal takarrara*), whereas rectilinear motion can

65. *Risālah fī al-ʿIshq,* in *Rasāʾil Ibn Sīnā*, 391 lines 15-18 and 392 lines 1-2 and 10-11; and Emil L. Fackenheim, "A Treatise on Love by Ibn Sīnā," *Mediaeval Studies* 7 (1945), 224.

66. *Shifāʾ: Ilāhiyyāt,* 387 lines 2 and 8.

67. *Shifāʾ: Ṭabīʿiyyāt: Samāʾ Ṭabīʿī,* 228-32.

68. *Najāt,* 127; cf. P. Lettinck, *Aristotle's Physics and Its Reception,* 662-3.

69. See *Shifāʾ: Ṭabīʿiyyāt: Samāʾ Ṭabīʿī,* 215 lines 6-15 and 217 line 9.

always be added to and extended infinitely—potentially, of course, without such a consequence. Finally, given the eternity of celestial substance, only circular motion is proper to it, precisely because it is ceaseless and perpetual, since in circular motion every destination is a fresh starting-point (*idhā tammat dawrah ibtada'at min ra'sin*).[70]

On Ibn Sīnā's account, no motion is eternal except the celestial, since in all rectilinear motions rest must occur once the moving body arrives at its proper, natural place; and with the occurrence of rest the motion has perished. A further reason is that circular motion has no contrary, which is not the case with simple rectilinear motions. Unlike circular motions, rectilinear motions are the contraries of each other, since they set out from opposite starting-points and proceed in opposite directions (upward and downward).[71] Motions around the circumference of a circle, on the other hand, even if in opposite directions, are nevertheless motions from and to the same point. Two motions are said to be contrary to each other only if they start from and end in two opposite points (*fa al-ḥarakāt al-mutaḍāddah hiya allatī tataqābal aṭrāfuhā*).[72]

While he appears to accept Ptolemy's theory of epicycles in order to account for the retrograde motions of the 'wandering stars' in the course of their revolutions around the earth, Ibn Sīnā adopts Alexander's view in pointing out the reason behind those irregular and complex motions of the planets. To recall, ancient astronomers in the time of Plato had discovered that the planets' apparent motions are actually not uniform; they noticed that the circular course of each planet is at certain times interrupted by a movement in a loop: the planet retards its movement and turns back, moving for a certain while in the opposite direction; then it stops and once again advances beyond the turning-point, and so on.[73] As is well-known, Ptolemy proposes that a planet's motion may be represented geometrically either by an eccentric circle (*falak khārij*) possessing a center other than the earth's center; or, if the earth's center is to be retained, an epicycle (*falak tadwīr*) must be added to the circumference of the deferent circle (*falak ḥāmil*); or finally, some combination of eccentric and epicyclic circles could be employed.[74] Having accepted this solution, Ibn Sīnā gives a further explanation: whereas the regular, daily motion of the planets from east to west is due to the desire felt by their souls for a common beloved (*ma'shūq mushtarak*), namely the First Principle, and is but the mechanical effect of the motion of the outermost, first moving sphere, their other

70. Ibid., 266 lines 1-9.

71. Ibid., 282 lines 5-15.

72. Ibid., lines 15-16; see also 289 lines 2-3.

73. See S. Sambursky, *The Physical World of the Greeks* (London: Routledge and Kegan Paul, 1987), 58-64.

74. *Shifā': Riyāḍiyyāt: 'Ilm al-Hay'ah,* 466 ff = Ptolemy, *Almagest,* Bk. IX, Chap. 3 ff.

irregular motions reflect their having different principles of motion as well as different objects of longing after the First—that is, because each of them is guided by its own intelligence.[75]

> For us it is correct [to hold], as it has been established in *Almagest,* that the celestial motions and spheres are many [in number], just as they vary in direction and velocity. It follows that for each motion there is a mover [i.e. soul] as well as a beloved (*mutashawwaq*) different from one another, for otherwise there would be no variety in direction and speed. And we have explained that these lovers are themselves pure good (*khayrāt maḥḍah*) separated from matter. And it is the love for the First Principle, which is common to all the spheres and motions, that makes it possible for them to participate in the perpetuity and circularity of [cosmic] motion.[76]

As one might notice, there seems to be a contradiction in the foregoing account. On the one hand, it is said that celestial bodies are changeless, while on the other we are told that they do nevertheless move, albeit with a circular motion. The difficulty arises because motion is defined and understood as equivalent to if not synonymous with change. How does Ibn Sīnā explain this? It is true that since they lack the primary contrary qualities (hot, cold, dry, moist) that are indispensable for manifold and continuous changes, celestial bodies cannot be said to be generated or destructible any more than they undergo change in terms of quality or quantity, for they have always been in the same state, as astronomers have recorded from the earliest times. So, it is argued, we have good reason to believe that celestial bodies do not move or pass from one quality to another and that they seem to continuously remain as they are. But what about their motions? According to Ibn Sīnā, the motion of celestial bodies, far from being locomotion or change of place, merely entails positional changes or motion in position (*ḥarakah fī al-waḍʿ*), which allows the heaven as a whole to remain where it is while its parts move and change their different positions. As he explains in the following passage:

> As to whether something can change its position (*yatabaddal waḍʿuhu*) only, without changing its location, we may know its possibility from the motion of the [celestial] sphere (*ḥarakat al-falak*), which can be in either of these ways: like that of the highest sphere which is 'not in place' (*laysa fī makān*) in the sense of being the defining end of the all-embracing entity (*nihāyat al-ḥāwī al-shāmil*) that we call 'place' or, alternatively, it is said to be in place except that it does not leave its place as a whole, the change being confined to the relation of its parts to the parts of [i.e., various points on] its very location (*innamā tataghayyar ʿalayh nisbat ajzāʾihi ilā ajzāʾi makānih*) which it [always] retains. Indeed, nothing occurs [in ce-

75. *Shifāʾ: Ilāhiyyāt,* 399 lines 4-8.

76. *Shifāʾ: Ilāhiyyāt,* 393 lines 6-10.

> lestial spheres] except this change [in position], but the location remains unchanged (*thābit*). Now, since this kind of change is change of relation, and since this relation represents position (*wa hādhihi al-nisbah hiya al-waḍʿ*), therefore, such a kind of change is change in position.[77]

It is interesting to note that this idea of positional change is found nowhere in Aristotle's works. Whether Ibn Sīnā got it from some no longer extant Arabic commentaries on Aristotle's *Physics* is difficult to ascertain given our present-day knowledge.

Conclusion

Ibn Sīnā envisages a universe that is one in number, finite in extent, and spherical in shape. The cosmos is divided into two realms: first, the supra-lunar region of eternal, immutable, ungenerated, and incorruptible celestial spheres, and, second, the sublunar region of the four elements subject to generation and corruption. On this model, the universe is structured as a set of nested spheres, all centered upon the center of the universe, which coincides with the earth's center. Nearest the center are the sublunary spheres of earth, water, air, and fire. It is within these spheres that all fundamental changes involving the elements occur, such as locomotion, alteration, growth and diminution, and generation and corruption. Beyond those four central spheres are the nesting crystalline solid but transparent spheres made of a fifth element, aether, that carry around and move the celestial bodies, namely the moon, the sun, all the planets, and the fixed stars.

Ibn Sīnā corroborates his theses with a set of arguments, mostly *a priori* in kind and largely derived from the Aristotelian physical system. The geocentric thesis, the arrangement of the spheres, the immobility and spherical shape of the earth, and the impossibility of other universes similar to ours are all explained in terms of Aristotelian theories of natural and forced motions, simple and composite motions, and circular and rectilinear motions. Ibn Sīnā differs from Aristotle, however, when it comes to the metaphysical question as to what causes the celestial motions. Whereas Aristotle posited forty-seven or fifty-five unmoved movers, Ibn Sīnā not only reduced the number into one single unmoved mover for all, but also gives a non-Aristotelian explanation for celestial phenomena from a religious point of view, saying that the circular movement of celestial spheres is meant for glorification (*tasbīḥ*) and is due to Divine Command (*li amr Allāh*).

77. *Shifāʾ: Ṭabīʿiyyāt: Samāʾ Ṭabīʿī,* 104 lines 10-14.