XENOPHANES' CONTRIBUTION TO THE EXPLANATION OF THE MOON'S LIGHT

Studies in archaeoastronomy have established that many ancient cultures, from as far back as the fifth millennium B.C.E., kept records — though often not in writing — of the moon's cycles.[1] By contrast, the discovery that the moon derives its light from the sun came relatively late: it appears to have been made uniquely by the ancient Greeks, in the sixth or fifth century B.C.E. One is immediately inclined to ask: Precisely when, and by whom, or at least in what context or milieu, was the discovery made? I don't propose to revisit this larger historical question here; I shall only briefly review the *status quaestionis*.[2] My concern is rather to suggest that a philosopher who most definitely did not believe that the moon derives its light from the sun may nonetheless have drawn attention to data that ultimately clinched the case in favor of the correct explanation.

For convenience, let me refer to the true explanation of the lunar phases either as the «heliophotistic» model or simply as «heliophotism». There is general agreement that the model is well-attested for two mid-fifth century figures: Anaxagoras and Empedocles.[3] What makes the evidence especially compelling in these two cases is that heliophotism is put forward by both philosophers in close association with the true explanation of solar and lunar eclipses. Working backwards in time, it is reasonable for us to expect that the true explanation of lunar phases should have preceded that of eclipses. And indeed we have solid evidence in favor of placing that logically prior discovery a generation earlier.

1. In the case of some isolated findings, the evidence is of far greater antiquity. See Anthony F. Aveni, *Ancient Astronomers* (Montreal, St. Remy Press/ Washington, D.C., Smithsonian Books, 1993), pp. 18-19 and 22-24 (Neolithic Europe); 76-78 (China); 92-93 (Africa); 103-104 (Meso-America).

2. For the most recent canvassing of the evidence, see Georg Wöhrle, «Wer entdeckte die Quelle des Mondlichts?» *Hermes*, 123 (1995), pp. 244-245. The issue has been taken up again by two other scholars, in unpublished papers: Daniel W. Graham in «Parmenides' Scientific Discovery», a paper presented at an international colloquium on the pre-Socratics held in October 2000 at the Université Charles de Gaulle – Lille 3; Dmitri Panchenko in «Eudemus fr. 145: Wehrli and the Ancient Theories of Lunar Light». I am much indebted to both these scholars for my understanding of the ramifications of what I refer to (above) as the «larger historical question».

3. Hermann Diels, *Die Fragmente der Vorsokratiker*, rev. Walther Kranz, 3 vols., 6th edn., Dublin & Zürich, 1952 (and all subsequent photo-reprintings), hereafter referred to as «DK». For Anaxagoras, see DK59B18, A76, A77. For Empedocles, B42-43, B45, A57, A59.

The second part of Parmenides' philosophical poem lays out — albeit with some emphatic disclaimers on Parmenides' part — a cosmology «of human beliefs», the «Doxa», as it has come to be known. There we find these two remarkably apt and expressive descriptions of the moon's behavior:

> νυκτιφαὲς περὶ γαῖαν ἀλώμενον ἀλλότριον φῶς
> Night-shining, wandering around the earth, a light from somewhere else . . . . (DK28B14)[4]

> αἰεὶ παπταίνουσα πρὸς αὐγὰς ἠελίοιο
> Always gazing toward the shining beams of the sun . . . .(DK28B14)

What is said poetically and implicitly in these verses is made explicit in the Aëtius doxography: Parmenides held that the moon is illuminated by the sun (DK28A42). It is highly significant that Parmenides does not say ὑπὲρ γαῖαν, «above the earth», but περὶ γαῖαν, «around the earth». He has grasped that the moon's complete diurnal course, and — given heliophotism — the sun's diurnal course as well, take these two bodies on circular trajectories that lie partly above and partly below the earth.[5] But the testimonia also speak — which at first blush is confusing — of the moon's having a «fiery aspect» (πυρῶδες, πυρίνη) and of its being composed of a mixture of air and fire (DK28A37). The emerging consensus among interpreters is that Parmenides allowed for some residual fire in the moon (either exogenous, i.e., imparted by the sun along with light, or only endogenous, or both) so as to account for two quite familiar phenomena: the dim glow of the entire lunar disk on the early or late appearance of the lunar meniscus (just after or just before new moon the phenomenon we know today as «earthshine» or «earthlight»); and the residual reddish glow of the moon at the time of a total lunar eclipse.[6]

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4. For the abbreviations in citations, see preceding note.

5. With the adjective ἀλώμενον Parmenides highlights the vagaries implied in the moon's sidereal period: the moon keeps shifting its points of moonrise and moonset from one day to the next.

6. Cf. WÖHRLE, p. 245. The better interpretation, I believe, is that the mixture of air and fire in the moon is nothing other than the play of sunlight on the inherently dark stuff that constitutes the moon. «Night» is one of the constitutive forms in Parmenides' «Doxa». He characterizes it as νύκτ' ἀδαῆ, πυκινὸν δέμας ἐμβριθές τε, «obscure night, thick-textured and heavy body» (DK28B59). The doxographers' term «air» (ἀήρ) does not occur in the «Doxa»; but ἀήρ from Homer through much of early Greek literature is the stuff and factor of «mist» or «fog», something that makes for opacity and darkness. In Parmenides almost certainly it would be an aspect of Night. On this detail, the explanation offered by Karl Popper is exactly right. See the posthumous collection of his essays, *The World of Parmenides: Essays on the Presocratic Enlightenment*, London and New York, Routledge, 1998, pp. 72-73.

Might we say, then, that it was Parmenides who made the discovery?[7] Not necessarily. The simple fact that the explanation is offered in a context that is laden with irony[8], in the part of the poem devoted to «Opinions», should give us pause. And what is especially unsettling is that the explanation posits a play of light and darkness: precisely the constitutive duality that makes the cosmology «deceptive» and «untrustworthy» (cf. B8.52 κόσμον ... ἐπέων ἀπατηλόν, 8.54 ἐν ᾧ πεπλανημένοι εἰσίν, 8.60 διάκοσμον ἐοικότα, B1.30 βροτῶν δόξας, ταῖς οὐκ ἔνι πίστις ἀληθής).[9] Indeed, A42, the testimonium from Aëtius cited above, specifically does not name Parmenides as the πρῶτος εὑρέτης, «first to discover».[10]

That recognition is bestowed rather on two sixth-century figures: in one tradition of testimony, to Anaximenes (DK13A16); in another, to Thales (DK11A17b).[11] The first of these options has found no support among modern scholars. For we also have reports that Anaximenes posited two classes of celestial bodies: luminous ones, which are made of fire in its most volatile and sublimated form; and «invisible earthy bodies, moving about, along with the stars» (DK13A14, cf. A7). The moon is expressly included among the «fiery» bodies (A7). The conceptually accommodating explanation that has gained favor à propos of Parmenides (exogenous *and* endogenous fire) is not available for Anaximenes, whose moon is not an earth-fire compound: pure fire does not provide a reflective surface. The «invisible earthy bodies» are very plausibly a device intended to account for eclipses and occultations; and it is not unreasonable to suppose that Anaximenes had recourse to this second class of celestial bodies in order to account for lunar phases as well.[12] Accordingly, the

7. The question is answered affirmatively by Popper, pp. 87-88, 94-96, 136. Graham also has supported the affirmative (presentation referred to above, n. 2). Wöhrle, more cautiously, eliminates all other candidates except Parmenides and Anaxagoras (pp. 246-247).

8. For irony in the second part of Parmenides' poem, and in B14 in particular, see my *The Route of Parmenides*, New Haven & London, Yale University Press, ch. 9, esp. pp. 224-25 (repr. in my collection, *The Pre-Socratics*, 2nd edn., Princeton, Princeton University Press, ch. 14, see esp. pp. 314-315).

9. Here I make an observation directly opposed to the thesis advocated by Popper (p. 100 and passim): he holds that it was the play of light and shadow on the moon that prompted Parmenides' insight into the unseen («dark») reality of Being.

10. Our sources typically use the phrases πρῶτος ἔφη, «first to argue», or πρῶτος εὗρε, «first to discover».

11. One other sixth-century figure is mentioned in DK11A17b, but with no associated claim to the status of πρῶτος εὑρέτης, Pythagoras. In this case, there is near-universal agreement in recent scholarship that the reports reflect a doctrine that was held not by Pythagoras himself but by Philolaus and later Pythagoreans.

12. P. J. Bicknell has argued that the «invisible bodies» are the earthy cores of sun, moon, and planets, and that eclipses, according to Anaximenes, are caused by interstellar clouds: «Anaximenes' Astronomy», *Acta Classica*, 12 (1969), 53-85, esp. 56-71. The first part of this

prevailing view is that the ranking of Anaximenes as πρῶτος εὑρέτης of the heliophotistic model arose from the simple confusion of his name with that of Anaxagoras.[13]

The other option, that of Thales as πρῶτος εὑρέτης, has for a long time been viewed with strong skepticism by modern scholars — largely because of the unreliability of ancient reports, which, in the case of this quasi-legendary figure, are even more derivative and speculative than they are for the pre-Socratics in general.[14] But Dmitri Panchenko has recently provided a more favorable context for that option. In a series of articles[15], he stresses that we ought to respect the authority of Eudemus, who is the likely remote source for DK11A17b, the testimonium at issue. Connecting A17b with reports that Thales predicted a solar eclipse (DK11A5), Panchenko offers a fresh analysis of the relevant astronomical data, together with a new reconciliation of these data with the doxographical reports. He judges credible the report that Thales had grasped the moon-interposition explanation of solar eclipses (DKA17a), which makes viable the consideration that Thales may have also grasped the heliophotistic model.[16]

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thesis requires a quite forced interpretation of the wording in Hippolytus' testimony: *σελήνην καὶ τὰ ἄλλα ἄστρα πάντα πύρινα ὄντα ... ἐκ δὲ τοῦ πυρὸς μετεωριζομένου τοὺς ἀστέρας συνίστασθαι, εἶναι δὲ καὶ γεώδεις φύσεις ἐν τῷ τόπῳ τῶν ἀστέρων συμπεριφερομένας ἐκείνοις* (DK13A7). The second part of his thesis, speculative though it is, may well be used to reinforce the standard interpretation Bicknell rejects. In certain cases (e.g., in lunar eclipses, at totality, at which stage the moon generally is still visible, albeit reduced to a reddish glow), the invisible earthy bodies may indeed be clouds: earthy exhalations (cf. *ἐκ γῆς ... ἰκμάδα ἀνίστασθαι*, A7) that have not progressed to the extreme of rarefaction.

13. Mistakes involving the three «Anax-» figures among the pre-Socratics (Anaximander, Anaximenes, Anaxagoras) are common in student papers today. Panchenko, in the unpublished paper referred to above (n. 2) points out that such mistakes appear no less in our ancient sources.

14. At least on those grounds, I myself judge the skepticism reasonable. I do not, however, accept Wöhrle's argument (p. 244) that the vast plain of water on which Thales' earth rides precludes Thales' entertaining the hypothesis that the sun, when not in the sky, could still provide the moon's illumination. The auxiliary hypothesis of northern mountains (or of a terrestrial uplift toward the north), behind which region the sun hides in the course of the night, might have been exploited by Thales as it was exploited by Anaximenes and «many of the ancient cosmologists» (DK13A14).

15. See «Thales and the Origins of Theoretical Reasoning», *Configurations*, 3 (1993), pp. 387-414, esp. 399-404; *Journal of the History of Astronomy*, 25 (1994), 275-288. I also draw on the unpublished paper referred to above (n. 2).

16. It is worth noting, however, that the most comprehensive and detailed study of the evidence concerning Thales' contributions to early Greek science, that by Χρίστος Α. Τέζας (*Θαλής ο Μιλήσιος και οι αρχές των επιστημών*, Δωδώνη, παράρτημα αρ. 44, Ιωάννινα, 1990) rules out the possibility that Thales understood that the moon gets its light from the sun (p.166), or that he knew the true cause of eclipses (pp. 131-132). Τέζας reaches these negative conclusions even though he offers a generally sympathetic assessment of Thales' contributions to science, and defends at length (pp. 107-149) the credibility of the reports that Thales succeeded (with some measure of luck) in predicting a solar eclipse.

This conflict in our sources and in scholarship need not be resolved here. For what this review of the *status quaestionis* shows is that, even if heliophotism (or, in a bigger stretch, the moon-interposition model for solar eclipses) had been introduced right at the start of Greek cosmological thinking, by Thales, it took at least two generations for the model to gain other adherents. For, with the highly dubious exception of Anaximenes, there's no inkling of heliophotism among Thales' Ionian successors. Anaximander's explanation of lunar phases and of solar or lunar eclipses posited periodic or sporadic openings and closings (partial or total) of certain celestial vents (DK12A11, A21, A22); Anaximenes had a fiery moon and probably (as suggested above) explained lunar phases and eclipses by positing screening by earthy bodies; Xenophanes, whom I shall be discussing presently, posited regular and spasmodic «quenchings» of the moon's inherent glow (21A43); Heraclitus posited bowls of fire that would alternately turn, facing either down toward the earth or away from it (DK22A1[9-10]).

In broader scope, the resistance exerted against heliophotism by common-sense intuitions must have been formidable. Converts to the Greek Enlightenment may well have embraced the notion that the sun and the moon are purely physical objects — not divinities which, after making their respective disappearances in the west, wend their way back east through the interior of the earth or via the encircling river Okeanos. But before the «centrifocal» model of the universe[17] had engaged the attention of intellectuals — let alone captivated their imagination — any suggestion that the moon gets its light from the sun would have been countered (however unfairly) with seemingly stumping «common-sense» challenges such as these:

1. How can the moon continue to shine after the sun has set? That it should *seem* to shine more brightly in the hour or so after the end of twilight, or in the hour or so before the onset of dawn, is acceptable, given familiar intuitions of light contrast. But in the middle of the night, when the sun is long gone from the sky and sunrise is not yet approaching, why should it keep on glowing with undiminished brightness?
2. Why should the moon shine brightest when it seems to be farthest away from the sun, at full moon, and least bright when it appears closest to the sun, at first or last crescent? Why should its luminousness increase while it seems to be moving farther and farther away from the sun, in its waxing phase? Conversely, in the waning phase, why should luminousness decrease when the moon appears to be getting progressively closer to the sun?

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17. Borrowing the apt terminology used in David Furley, *The Greek Cosmologists: Vol. I, The formation of the atomic theory and its earliest critics*, Cambridge, Cambridge University Press, 1987, pp. 24-28, 53-57.

3. When both the sun and the moon are visible in the sky, at quadrature, either in waxing or waning phase, why do we just see the blue of the sky behind the white-glowing semicircle of the lunar disk? True, in our terrestrial environs, in total darkness, when a torch or lamp sheds its light on the right or left half of a convex and opaque object, only that illuminated half of the object is visible; the opposite side is lost in the surrounding darkness. When, however, the same object, in the same relation to the observer, has one side of it illuminated by the strong light of the sun in plain daylight, the effect is markedly different: there's only shading on the side that lies away from the sun; the object's surface features on that opposite side are distinctly visible; there is no blurring into the surroundings.

But now, in reverse role-play, let us consider what observations would have stimulated and nurtured belief in heliophotism. The crucial observations are none other than the ones recorded in Parmenides fr. B15: «Always gazing toward the shining beams of the sun». Though Parmenides must have envisaged the moon as spherical, the observations he summarizes with this semantically charged line of poetry would also have been compelling to an observer who saw the moon in the traditional way — as waxing and waning within the geometric confines of an actual or potential disk. Let me list all the relevant observations here, putting in parentheses those that are not directly implied by the language of B15:

a. When, at first crescent, the moon reappears after its two-three days of monthly disappearance, it does so in the western sky. Close behind the sun, visible just barely in the afterglow of sunset, it soon follows the sun into setting. In its brief time of visibility, the horns of the crescent point eastward, i.e., the convex edge of the thin crescent faces the setting sun. The darkened portion of the lunar disk is away from the sun.
b. As the moon waxes into first quarter, it is seen progressively higher in the sky at dusk, and it shines progressively longer before moonset. But the horns continue to point eastward, and the convex side of the waxing crescent continues to be oriented in the direction of the sun's disappearance below the horizon. (On the two-three nights after first crescent, observers with good eyesight can also see a thin luminous line which, starting from the two horns, completes the circle of the moon. Moreover, they can detect a faint glow on the darkened portion of the lunar disk — the phenomenon of earthshine that was mentioned above).
c. Later yet in the waxing phase, in the days before and after quadrature, the moon is now far enough from the sun and bright enough to be visible even before the sun has set. The effect of facing the sun is maintained: while the sun is also present in the sky, the luminous part is oriented toward the sun; after the sun has set, the luminous part is oriented in the direction of the

sun's disappearance below the horizon. (The thinly visible line at the opposite edge, and the faint glow of the unlit part of the disk are no longer visible. The unlit part is indistinguishable from the background — blue by day, black by night.)

d. Full Moon rises as the sun sets; Full Moon sets as the sun rises. The disks of the two luminaries are in direct opposition, «face-to-face», an impression that is heightened at moonrise by the familiar intuition of a human face on the moon.

e. As the moon wanes, rising later and later in the night during third quarter, it is its westward portion that becomes progressively darkened. The luminous part now appears oriented toward the east. After sunrise, both moon and sun are visible in the sky, and the luminous part is again on that side of the lunar disk which faces the sun.

f. In the last days of last quarter, the waning meniscus rises toward the end of the night or at dawn, just ahead of the sun. In its progressively brief time of visibility, before the risen sun's glare has blotted the moon out, the horns of the crescent point westward, i.e., the convex edge of the thin crescent faces the risen sun; before sunrise, the moon is oriented toward the region of the horizon where the sun will be appearing. The darkened portion of the lunar disk is, as always, away from the sun. (Once again one may be able to notice the thin luminous line that completes the circle of the moon, as well as the faint glow on the darkened portion of the lunar disk.)[18]

In Parmenides' hexameter line, the two spondees before the main caesura in B15 (– – | – – | – ∪) augment the emphasis on the word ἀεί, «always». It is relevant to remind ourselves here that in pictures not drawn from nature (cartoons, free drawings, illuminated manuscripts, and the like) one sometimes sees the horns of the moon pointing toward the sun; or the illuminated half of the lunar disk at quadrature facing away from the sun; or, in either of the gibbous phases, the darkened portion positioned between the illuminated portion and the sun. None of these things ever happen. Parmenides was right to have said ἀεί, «always», with such expressive emphasis. A modern manual for navigators and outdoorsmen records the same facts — with none of Parmenides' flare of poetry — through prosaic repetition of the word «always»:

> New crescent moon (waxing) always close behind the sun. . . . When full moon is rising the sun is always setting. . . . When the full moon is setting the sun is always rising.[19]

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18. Cf. Harold Gatty, *Nature is Your Guide: How to find your way on land and sea*, Harmondsworth, Middlesex, Penguin Books, 1979.

19. Gatty, p. 218.

Anyone who has realized that observations (a)-(f) admit of no exceptions has either grasped, or is on the way to grasping, heliophotism.

And now to Xenophanes. This Protean figure of the Greek Enlightenment (poet, social critic, cosmologist, theologian, epistemologist) held that all luminous objects and apparitions in the skies (rainbow, lightning, St. Elmo's fire, comets, meteors, stars, moon, sun) are variant types or variant states of clouds (DK21B32, A38-A45).[20] And just as violent motion within ordinary clouds causes lightning, sustained internal motion or agitation within those other and extraordinary clouds causes luminescence.[21] Concerning the moon in particular, Xenophanes reportedly believed (DK21A43) that it is a νέφος πεπιλημένον, «compressed [or 'compacted', 'condensed', 'solidified'] cloud»;[22] that it shines with «its own light» (ἴδιον...φῶς); and that its monthly disappearance is caused by «quenching» (κατὰ σβέσιν). Generally speaking, among those clouds which we too would view as ordinary, the ones that are most compellingly seen as «compressed» are the familiar detached, fair-weather, «cumulus» clouds. More precisely, in modern meteorological terminology, these are known as «cumulus humilis» and «cumulus mediocris». Had the ancients developed a similar terminology, νέφος πεπιλημένον might very aptly have been the term for either type. The suggestiveness of this association of the moon with cumulus clouds has been noted by P. J. Bicknell:

> Quite often the moon is visible during the day, and sometimes it is seen against a clear blue sky amongst small high cumulus clouds. On these occasions the greyish white colour of the lunar disc is exactly the same as that of the surrounding clouds.[23]

Bicknell goes on to remark that bulging or hollow features, like those seen on cumulus clouds, are also conspicuous on the full moon, which is what prompts

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20. See my essay «'X Is Really Y': Ionian Origins of a Thought Pattern», in K. J. Boudouris, ed., *Ionian Philosophy*, Athens, International Association for Greek Philosophy, 1989, pp. 280-290. I shall be offering a detailed new reconstruction of Xenophanes' natural philosophy in a monograph, which is now in progress. One chapter of that work was presented, under the title, «Earth and Stars in the Cosmology of Xenophanes», at a meeting of the Society for Ancient Greek Philosophy, Chicago, Illinois, April 21, 2000, and also at the international colloquium on the pre-Socratics held in October 2000 at the Université Charles de Gaulle-Lille 3.

21. See A38 νεφέλια κατὰ τὴν ποιὰν κίνησιν παραλάμποντα, A44 νεφῶν ... κινήματα, A45 λαμπρυνομένων τῶν νεφῶν κατὰ τὴν κίνησιν.

22. The noun-participle combination, νέφος πεπιλημένον, probably reflects Xenophanes' exact wording, since the combination fits nicely into dactylic meter (∪—' ∪ ∪—∪ ∪).

23. «A Note on Xenophanes' Astrophysics», *Acta Classica*, 10 (1967), pp. 135-136.

the familiar intuition[24] of a human face on the moon.

We may supplement Bicknell's felicitous observations by pointing out that the resemblance of the moon to a cloud is also striking vis-à-vis three other cloud types. Lenticular clouds (altocumulus lenticularis) appear to have a smooth white surface and an elegantly regular shape, that of a bulging disc or flattened sphere, and thus invite comparison with the moon at any phase between full-moon and quadrature. The pendulous white globules of mammatus clouds bear comparison with full and near-full moon. Finally, the lunar crescent in first or fourth quarter, when seen by day in the vicinity of cirrus uncinus clouds, can easily be mistaken for yet another of the hook-shaped tufts or filaments characteristic of this type of high-altitude cloud. At least the first[25] and third of these comparisons are very likely to have served as additional supports for Xenophanes' thesis.[26]

Be that as it may, it is the association of moon with ordinary cumulus clouds which is of greater significance in the present context. Cumulus humilis or cumulus mediocris are very common and very familiar. They tend to be uniformly opaque, and more or less convex in their geometry. Often bulbous as a whole or with bulbous parts and hollow features, they can have a shape that is sufficiently well-defined to suggest to observers comparisons not only with the moon but also with terrestrial objects, such as animals or artifacts. Let me distinguish here four situations and effects that involve play of sunlight on clouds.

i. In an otherwise clear sky, when seen in maximum opposition to the sun, as when the sun is low in the western part of the sky and the clouds low in the eastern part, or vice versa, cumulus clouds show distinctly their full expanse. Their overall tint contrasts with the background of the sky, and their bulges, folds, or hollows appear in high relief through various hues and grades of shading.

ii. When the sun and cumulus clouds are respectively located in opposite regions of the sky but mid-way between horizon and zenith, then the upper or frontal part of the cloud, the part that is geometrically closer to the sun

24. Xenophanes, the critic of anthropomorphism in religion, would, no doubt, have scoffed at this «intuition» as another instance of anthropocentrist prejudice.

25. Lenticular clouds are not rare in the Mediterranean region. In October 1998, off the southern coast of Crete, approaching the harbor of the town of Sfakyiá on a ferry, I personally observed a magnificently elegant, isolated lenticular cloud above the Cretan mountain range. I overheard several of the passengers on the ferry using the image of «flying saucer» (now commonly made by observers of lenticular clouds).

26. The second of these comparisons may be of marginal significance only, since mammatus clouds are more rare in the eastern Mediterranean region than they are, say, in the plains of the north American continent.

(«facing» the sun, as it were), is brightly lit. The upper or frontal edges, whether neatly curved or scalloped or frayed, show sharply against the blue sky. By contrast, the cloud's lower or rear portion is shaded and appears relatively flat and featureless. Moreover, the borders of that shaded part are often fuzzy, blurring into the clear sky with nothing like the sharp outline evident on the illuminated side.

iii. If a thick cloud is directly in front of the sun while both are close to the horizon, what we see at the cloud's border is a bright simmering line, and within the cloud's border we see a flat, featureless, brownish or grayish-black spread.

iv. Soon after the sun has set, clouds in the western horizon that are close to the point of sunset are likewise brilliantly colored at their border. Depending on their degree of thickness, the interior part, i.e., the part within the border, may appear either dark or translucently darker-colored. Clouds that are close to the horizon but farther toward the south or north appear as uniformly dark splotches — which is the appearance progressively assumed by all clouds as the afterglow of sunset diminishes.

The last two effects can also be striking with other types of clouds (such as swelling cumulus, stratocumulus, or altocumulus). However, shapeless clouds (such as stratus or cirrostratus) or thin translucent clouds (such as cirrus) are not suited to produce these effects — they have, of course, their own different and marvelous patterns of interacting with sunlight.

Comparison with the data cited in connection with Parmenides B15, those marked above as (a) through (f), makes one appreciate that the cloud-observations detailed in (i)-(iv) are intriguingly germane. In (i), we have extreme sun-cloud opposition, which corresponds to the circumstances of full moon. Worth additional notice is the fact that the full moon rises with a reddish tint, not unlike that of eastern-horizon clouds that glow with the last rays of the sun or in the sunset's afterglow. A like effect obtains as the full moon comes close to setting among western-horizon clouds in their pre-sunrise glow. In (ii), we have a large portion of the cloud (half, or somewhat more, or somewhat less) fully in the sun, the rest of it in the shade — which corresponds to quadrature and to either of the two gibbous phases, waxing or waning, i.e., either to (c) or to (e). In (iii) and (iv), we have effects that correspond to what is observed either in early first quarter, or late fourth quarter, i.e., to (a)-(b) and to (f). Of special note is the analogue of earthshine in the effects of luminous borders and darker translucent interiors of clouds in (iii) and (iv). Finally, the reduction of luminous clouds to dark splotches provides a perspicuous model for what occurs during the two-three days of the moon's total disappearance.

There must have been many among sky-gazers in the early fifth and even in the sixth century B.C.E. who had taken note of (a)-(f). As for awareness of the play of sunlight on clouds, this reaches, no doubt, far into humanity's remote past. Among Xenophanes' Greek contemporaries and successors, awareness of that play of sunlight in the skies would have been made much keener for those who knew his theories, precisely because of his drawing attention to phenomena and effects involving clouds. What logically or heuristically may be the next step in suggesting the heliophotistic model is to connect (a)-(f) with (i)-(iv). Toward the making of this connection one can hardly imagine a better stimulus than Xenophanes' speculative identity thesis, his claim that the moon *is* a special sort of cloud.

The last two of the «stumping» challenges to heliophotism have easy rejoinders for those who have made that crucial connection. With respect to objection (2), one need only remark that at first or last crescent the moon is not necessarily closer to the sun. A cloud which cuts off the sun's rays need not be any closer to the sun than a cloud which glows in the east while the sun is low in the western horizon. With respect to (3), observation (ii) may well have been seen as cogently pertinent. When a cumulus cloud and the sun hold positions in the sky comparable to those sun and moon hold at or near quadrature, then too the darkened portion of the cloud blurs into the sky.

Early proponents of heliophotism would probably have experimented with the lighting of more or less spherical objects, seeking to understand how a single light source in a dark room would produce on such objects effects similar to those of the lunar phases. This would have been very much in the spirit of exploiting homey analogies, which is characteristic of early Greek cosmology. Nonetheless, nothing would have seemed more compelling toward explaining non-evident celestial effects than analogies drawn from other effects in the sky that are intuitively evident. And there would have been no better field for the study of light and shadow on convex objects than the grand spectacle of the play of light and shadow on clouds. Not that it would have taken extensive research to gain the requisite insight. Even isolated single observations under favorable conditions of just two of alignments (i)-(iv) of sun with cumulus clouds could have led to the conceptual breakthrough of heliophotism.

But if Xenophanes came so close to discovering heliophotism, why didn't he? Was it perhaps because he wanted no exceptions to the unified model he sought to apply to celestial bodies (all are clouds; all luminescence is the result of motion)? I think not. After all, ordinary clouds already provide exceptions to the kinetic theory of luminescence: brilliant white and other colors on the surface of clouds are quite obviously the effects of reflected sunlight. The conceptual block to heliophotism lay in another part of Xenophanes' cosmology.

He did not believe that the sun was on a circular orbit that took it under the earth; he held that the sun proceeds indefinitely westward on a straight line, its curved path above the earth being an illusion of perspective (DK21A41a). The startling consequence of this, viz., that there is a steady procession of suns from east to west, he was willing to embrace. And he probably thought that in all the corresponding respects this was true of the moon as well — but we have no such testimony. Yet even with only the sun (or, more properly, the suns) on this rectilinear course, «stumping» objection (1) would have seemed insuperable. And there would have been other problems. By day, at waxing moon before and after quadrature, while sun and moon are together in the sky, the white glow of the moon is suggestively comparable (as Bicknell saw) to that of clouds. But once the sun has set, shouldn't the moon-cloud assume the appearance of other clouds at sunset? And as it approaches the western horizon, should it not regress, so to speak, to the state of back-sided illumination, assuming again the appearance it had in early first quarter? Heliophotism, accordingly, was not an option for Xenophanes. In the context of his own theory, it was required that the moon should have its own light.

Xenophanes' linear-planar cosmology found no adherents. But in the next generation, thinkers must have debated the case in favor of the new centrifocal model of the cosmos — and I leave undecided the issue whether this model was introduced by Anaximander, or by the Pythagoreans, or by Parmenides. In that dialectical environment, Xenophanes' cloud-phenomenology must have provided not only the opportunity and the stimulus but also no small part of the evidence from analogy that clinched the case for heliophotism.

If the argument I have pursued here is not misguided, then Xenophanes' cosmology is an arresting example of two poignantly contrasting circumstances in the history of science. A wrong theory may nonetheless spur observations that are eventually turned to good account by the right theory. And yet, as Heraclitus said, «Eyes and ears are poor witnesses for men if their souls are not conversant in the right language»[27]; or, as today's philosophers of science admonish us, observations may prove valueless to those who have made them if the observations are made without the benefit of the right theory — in the present context, the assumption that the sun and the moon circle under as well as over the earth.

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27. DK22B107: κακοὶ μάρτυρες ἀνθρώποισιν ὀφθαλμοὶ καὶ ὦτα βαρβάρους ψυχὰς ἐχόντων. As many commentators have pointed out, βαρβάρους ψυχάς must not be translated «barbarian souls». But «if their souls speak/understand a foreign tongue» is rather too weak. I have tried to capture the tinge of chauvinistic disdain by referring to the non-Greek language as «not . . . right».

Η ΣΥΜΒΟΛΗ ΤΟΥ ΞΕΝΟΦΑΝΗ ΣΤΗΝ ΕΞΗΓΗΣΗ ΤΟΥ ΦΩΤΙΣΜΟΥ ΤΗΣ ΣΕΛΗΝΗΣ

Περίληψη

Ὁ Ξενοφάνης οὔτε ἤξερε οὔτε πίστευε ὅτι ἡ σελήνη φωτίζεται ἀπὸ τὸν ἥλιο, κάτι ποὺ πρωτοεξηγήθηκε τουλάχιστον μιὰ γεννεὰ ἀργότερα (ἀσφαλῆ σχετικὰ στοιχεῖα ὑπάρχουν γιὰ τὸν Ἀναξαγόρα καὶ τὸν Ἐμπεδοκλῆ, καὶ μᾶλλον πιθανὰ στοιχεῖα γιὰ τὸν Παρμενίδη). Στὴν κοσμολογία του Ξενοφάνη ὅλα τὰ οὐράνια σώματα ἢ φαινόμενα εἶναι τύποι νεφῶν, καὶ ἡ λάμψη τους ὀφείλεται σὲ ἐσωτερικὴ δόνηση – ὅπως ἡ ἀστραπὴ ὀφείλεται σε δόνηση μέσα στὰ σύννεφα. Ἡ ὀρθὴ ἐξήγηση τῶν φάσεων τῆς σελήνης ἐμποδίζεται ἀπὸ τὸ δόγμα τοῦ Ξενοφάνη ὅτι ἡ γῆ εἶναι ἄπειρος σὲ βάθος, ὥστε ν' ἀποκλείεται ἡ δυνατότητα φορᾶς, εἴτε τῆς σελήνης εἴτε τοῦ ἥλιου, κάτω ἀπὸ τὴν ὁριζόντιο ἐπιφάνεια τῆς γῆς.

Δὲν εἶναι ὅμως διόλου ἀπίθανο ὅτι αὐτὴ ἡ ἐσφαλμένη καὶ ἁπλοϊκὴ θεωρία συνέβαλε στὴ σύλληψη τῆς ὀρθῆς αἰτιολόγησης τοῦ φωτισμοῦ τῆς σελήνης. Ἔχοντας προτείνει ὅτι ἡ σελήνη δὲν εἶναι παρὰ *νέφος πεπιλημένον*, ὁ Ξενοφάνης προκάλεσε τοὺς συγχρόνους του καὶ τοὺς ἀμέσως ἑπόμενους στοχαστὲς νὰ παρατηρήσουν σημεῖα ὁμοιότητας τῆς σελήνης μὲ τὰ γνώριμα σύννεφα. Στὸ πλαίσιο τῶν σχετικῶν παρατηρήσεων, κάτι ποὺ σίγουρα θὰ ἐντυπωσίασε εἶναι τὰ φωτιστικὰ καὶ σκιαστικὰ ἐφὲ ποὺ ὁ ἥλιος ἀσκεῖ πάνω στὰ σύννεφα. Κατὰ πρόσωπο φωτισμένο, ἕνα σύννεφο τύπου «σωρείτης» δείχνει ἐμφανῶς τοῦφες καὶ κοιλώματα (πβ. τὸ «πρόσωπο» στὴν πανσέληνο). Πλησιάζοντας νὰ σκιάσει τὸν ἥλιο, ὁ σωρείτης φαίνεται σκοῦρος καὶ ὁμαλός, χωρὶς πλαστικὰ χαρακτηριστικά, μὲ μιὰ στίλβουσα λεπτὴ γραμμὴ εἴτε σ' ὅλη τὴν περιφέρεια τοῦ σωρείτη ἢ στὴν πλευρὰ ποὺ εἶναι γεωμετρικὰ πλησιέστερη στὸν ἥλιο (πβ. ἀρχὲς τοῦ πρώτου τετάρτου σελήνης καὶ τέλη του σεληνιακοῦ μηνός). Μερικῶς φωτισμένος, ὁ σωρείτης δείχνει καθαρὰ τὴν ἄκρη τῆς περιφέρειάς του ἀπὸ τὴν πλευρὰ ποὺ φωτίζεται ἀπὸ τὸν ἥλιο, ἐνῶ ἀπὸ τὴ σκιερὴ πλευρὰ ἡ περιφέρεια σβύνει συγκεχυμένα στὸ φόντο τοῦ οὐρανοῦ (πβ. σελήνη στὸν τετραγωνισμὸ ἢ στίς μέρες πρὶν ἢ μετὰ τὸν τετραγωνισμό).

Ἡ κοσμολογία τοῦ Ξενοφάνη ἀποτελεῖ συναρπαστικὸ δεῖγμα ἐσφαλμένης θεωρίας ἡ ὁποία, παρὰ τὸ σφάλμα της, προωθεῖ παρατηρήσεις φαινομένων ποὺ τελικὰ ἀξιοποιοῦνται ἀπὸ τὴν ὀρθὴ θεωρία. Μᾶς δείχνει ἐπίσης πῶς καίριες παρατηρήσεις μπορεῖ νὰ μένουν ἄχρηστες ἐφόσον δὲν ἐλέγχονται ἀπὸ τὶς ἁρμόζουσες ὑποθέσεις – στὴ συγκεκριμένη περίπτωση, τὴν ὑπόθεση ὅτι ὁ ἥλιος καὶ ἡ σελήνη κινοῦνται κυκλικὰ πάνω καὶ κάτω ἀπὸ τὴ γῆ.

Ἀλέξανδρος - Φοῖβος Δ. ΜΟΥΡΕΛΑΤΟΣ