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ANAXAGORAS ON THE MILKY WAY AND LUNAR ECLIPSES*

In this paper, I will investigate the interrelations between three astronomical theories that are attributed to Anaxagoras. The first theory is the explanation of the Milky Way as resulting from the earth's shadow. The second is the explanation of eclipses of the moon as caused by the earth's shadow. The third is the explanation of eclipses of the moon as due to invisible heavenly bodies below the moon. I will investigate how well these theories are attested, to what extent they are mutually compatible, and whether or not they harmonize with Anaxagoras' other astronomical conceptions, especially that of a flat earth.

The Milky Way

The Milky Way is visible as a band of varying angular width (roughly 30°) in the night sky.[1] An ancient legend says that the Milky Way derives its name from the stream of milk that poured from the breast of Juno, heaven's queen. Another story tells that it is the path through which the souls of heroes pass to heaven. Some people supposed that the Milky Way was the seam where the two hemispheres of the heavens were sewed together. Others feared that the firmament was about to split in two (cf. Manilius, *Astronomica* 1. 718–761). The Milky Way also troubled several Presocratics. Metrodorus is said to have identified the Milky Way as the sun's path among the stars. A similar theory, which says it is the former path of the sun, is ascribed to the Pythagoreans and to Oenopides. The Pythagoreans seem to have linked the Milky Way with the fall of Phaëthon,

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[1] For a general review, see Jaki 1973, 1–32.

while Oenopides adds that the direction of the sun's course reversed on that occasion. Some others are said to hold that the Milky Way is a reflection of our vision to the sun. Parmenides maintains that a mixture of dense and thin produces the milky color. Anaxagoras explains the Milky Way as a band of stars that light up in the earth's shadow.[2] These ideas unmistakably illustrate how little was understood at that time of the heavenly phenomena. This should be a warning sign to those scholars who are inclined to attribute to the ancient Greek thinkers − in this case, to Anaxagoras − all kinds of astronomical knowledge they did not possess.

Anaxagoras on the Milky Way

As we shall see, Anaxagoras' idea, as strange and wrong as it was, can be regarded as one of the first attempts of a rational explanation of the Milky Way in natural terms, supported by an optical theory. It is well documented: Gershenson and Greenberg, who classify it in their first category "Reliable Traditions", count seven testimonies,[3] the first of which

[2] For Metrodorus, see Aët. in Ps.-Plut. *Plac.* 3. 1. 3 = DK 70 A 13. For the Pythagoreans, see Arist. *Meteor.* 345 a 17 = DK 41 A 10, cf. Aët. in Ps.-Plut. *Plac.* 3. 1. 2 = DK 58 B 37c, and Manil. *Astronom.* 1. 735–744. For Oenopides, see Ach. Tat. *Introd.* 1. 24 = DK 41 A 10. For "some others" (perhaps Hippocrates and Aeschylus), see Arist. *Meteor.* 345 b 9 = DK 42 A 6. For Parmenides, see Aët. in Ps.-Plut. *Plac.* 3. 1. 4 = DK 28 A 43 a. For Anaxagoras, see texts below.

[3] Gershenson and Greenberg 1964, 333. Modern handbooks, textbooks, and monographs are rather reticent in giving information about this topic. DK misses Olympiodorus (text C) and does not give Ps.-Plutarch's version of Aëtius (text H), while Alexander of Aphrodisias (text B) is tucked away in the doxography on Democritus (DK 68 A 91). Gilardoni and Giugnoli 2002 have only the texts that appear in DK 59A and thus miss the same texts. Mansfeld 1986 has only Hippolytus' report (text F). Gemelli Marciano 2013 has only Aristotle's text (text A). Graham 2010 has Aristotle (text A, although tucked away between those on Democritus), Hippolytus (text F), and Olympiodorus (text C). Laks and Most 2016 have both Aristotle's (text A) and Hippolytus' text (text F), but miss that of Aëtius (text E) and all the others. Curd 2007 has Aristotle (text A), Aëtius (text E), and Hippolytus (Text F), and a short commentary. Kirk 2009, Barnes 1982, and McKirahan 2010 do not have any text at all about Anaxagoras and the Milky Way. Rechenauer 2013 refers shortly to DK 59 A 80. Guthrie 1965 is a positive exception; he mentions most reports: Aristotle (texts A and D), Alexander (text B), Aëtius (text E), Hippolytus (text F), and Diogenes Laërtius (cf. n. 19). Dicks 1970 refers shortly to Aristotle (text A). Cleve 1949 has only Aristotle (text A) with a short commentary. Graham 2013 has Aristotle (text A), Hippolytus (text F), and Olympiodorus (text C), but no commentary concerning the Milky Way. Alexander of Aphrodisias' interpretation (text B) is, apart from Gershenson and Greenberg 1964, 158 (287) and Dumont 1988, 791, not available in any other textbook I consulted.

is by Aristotle, who ascribes this explanation of the Milky Way not only to Anaxagoras but also to Democritus:

A. Arist. *Meteor.* 345 a 25–31 = DK 59 A 80

> Anaxagoras and Democritus posit that the Milky Way is the light of certain stars, (2) for the sun, in its course beneath the earth, does not see (οὐχ ὁρᾶν) [i. e. does not shine upon] some (ἔνια) of the stars. (3) Those (stars) (ὅσα μὲν) upon which the sun does shine in the round (περιορᾶται), of these the light is of course (μὲν οὖν) not visible, for it is prevented (κωλύεσθαι) by the rays of the sun. (4) But those (ὅσιος δ') which are screened (ἀντιφράττει) from the sun by the interposed earth so that it does not shine upon (μὴ ὁρᾶσθαι) them, the light proper to these (οἰκεῖον φῶς), they say, is the Milky Way.[4]

The optical theory behind this explanation of the Milky Way is that lights are more visible in the dark. This is why the stars lying in the band of the earth's shadow – the Milky Way – are seen to glow more brightly (see also the last lines of text B). Aëtius (text E) mentions only Anaxagoras and ascribes to Democritus the theory that the Milky Way is the combined light (συναυγασμός) of many stars that are close to one another (διὰ τὴν πύκνωσιν). So it would seem that Aristotle's ascription of the theory to Democritus was less accurate, as Diels has already remarked.[5]

I have divided Aristotle's text into four clauses, in order to make it easier for the reader to follow the complicated discussion. The usual reading of Aristotle's text is that it describes the situation at night and that the theory of the Milky Way is expressed in the clauses (1), (2), and (4). The problem is, then, the third clause: "Those (stars) upon which the sun does shine in the round, of these the light is of course not visible, for it is prevented by the rays of the sun", which is usually understood as having bearing on the stars at night on both sides of the Milky Way. This leads to the strange consequence that most of the stars at night would not be visible. Lee, for instance, comments on this interpretation: "what is not easy to understand is why, on Anaxagoras' theory, we see any stars outside the Milky Way".[6] The originator of this interpretation seems to have been Alexander of Aphrodisias:

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[4] Trans. Mansfeld 2010, 488.

[5] Diels 1879, 230. For Aëtius on Democritus and the Milky Way, see Ps.-Plut. *Plac.* 3.1.6 = DK 68 A 91.

[6] Lee 1962, 59 note d.

B. Alex. Aphrod. *In Arist. Meteor.* 37. 28 (ad 345 a 11) = DK 68 A 91

> Anaxagoras and Democritus say that the Milky Way is the light of certain stars. *They say that at night, when the sun goes under the earth, its rays shine upon some of the stars above the earth* (ὅσα περιλάμπει τῶν ὑπὲρ γῆς ὄντων ἄστρων)*, mask their light, and prevent them from being seen.* The stars shielded by the earth's shadow are hidden from the light of the sun and are not illuminated by it. These stars are visible, and their light is the Milky Way.[7]

However, while Aristotle (text A, second clause) says that the sun at night, when it is under the earth, does *not* shine upon some stars, Alexander (text B) says that the sun when it is under the earth, *does shine* upon some stars, and then he construes the nonsensical theory that the light of these stars at night is outshined by the sun. According to Alexander, "the sun's rays mask their light, and prevent them from being seen". As already remarked by Tannery, Gomperz, and Heath, this idea could easily have been disproved by simple observation.[8] Actually, Alexander combines, in a very confusing way, Aristotle's second and third clause. Olympiodorus' attempt to provide clarification is not very helpful either:

C. Olympiodor. *In Arist. Meteor.* 67. 33

> A third view is that of Anaxagoras and Democritus. They say the Milky Way is the proper light of stars not illuminated (μὴ φωτιζομένων) by the sun. *For they say that the stars have their own light on the one hand and the light obtained* (ἐπίκτητον) *from the Sun on the other*. And the Moon proves this. For its own light is of one sort, the light [that it receives] from the Sun is of another; for its own light is coal-like, as it is evident from its eclipse (ἔλλειψις). But, they say not all stars receive light [from the Sun]. The [stars] which do not receive [light from the Sun] produce the circle of the Milky Way.[9]

Olympiodorus introduces yet another confusing idea that is not in Aristotle's text, namely that the stars, in addition to their own light, have a light acquired from the sun. This is the opposite of what Aristotle was saying and was repeated by Alexander when they spoke of the sun's light preventing us from seeing the stars. Olympiodorus' explanation has the strange consequence that the stars outside of the Milky Way, having

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[7] Trans. Gershenson–Greenberg 1964, my italics. See also, e.g., Heath 1913, 83.
[8] Cf. Tannery 1887, 279; Gomperz 1896, 179; Heath 1913, 84.
[9] Trans. Baksa; my italics.

both their own light and additional light from the sun, would be brighter than those of the Milky Way, which have only their own light. Moreover, Olympiodorus uses the example of an eclipse of the moon as caused by the shadow of the earth, without observing that this is at odds with Anaxagoras' explanation of the Milky Way, as we shall see.[10] Graham, after having quoted both Aristotle's text (text A) and that of Olympiodorus (text C), follows Olympiodorus as if this were the right and only interpretation, and then he comments: "Aristotle distinguishes between the natural light of certain stars and reflected light".[11] There is, however, not a word on reflected light and this distinction in Aristotle's text.

These attempts to make sense of Aristotle's rendition of Anaxagoras' theory of the Milky Way, are not very successful, to say the least. When we try to read Aristotle's text with an eye, unbiased by these confusing suggestions, I think it makes sense to assume that the second clause of text A, "The sun, in its course beneath the earth, does not shine upon (literally: "does not see" – οὐχ ὁρᾶν) some of the stars", explains in a general way why the stars shine at night. During the night, the sun under the earth is so far away from these stars that its light becomes too weak to prevent their visibility, although they are less bright than the stars in the shadow of the earth that form the Milky Way. More precisely, Aristotle says that at night the sun "does not shine upon *some* (ἔνια) of the stars", because it does shine upon ("sees") the other half of the stars which are under the earth. In other words, in the second clause, Aristotle refers to Anaxagoras' theory why it is dark at night.[12] Further, I think it makes sense to assume that Aristotle's third clause, "The light of the stars upon which the sun *does shine all around* (literally "sees all around", περιορᾶται) is *of course* (μὲν οὖν) not visible", has nothing to do with the stars at night, but should be read as an explanation of why we do not see the stars by day, namely because their light is overpowered by that of the sun above the earth.

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[10] It has been argued that Aristotle meant to say that the sun, by shining on the stars outside the Milky Way, causes their own innate light not to be seen, but instead the reflection of the sun's light from the stars, whereas the stars in the Milky Way shine with their own light (cf. Cleve 1949, 70). In that case, the own light is not added up to the reflected light, as in text C, but the own light is, so to speak, substracted from the reflected light. However, as far as I can see, since the reflected light should be brighter than the innate light of the stars in order to be able to outshine it, this would also lead to the situation that the stars outside the Milky Way are brighter than those of the Milky Way itself, which is the opposite of what is intended. Moreover, Aristotle's text does not speak of reflected light (see also my remarks at text C).

[11] Graham 2013, 131.

[12] It would need too long a digression to discuss here at length the problem of darkness at night in Presocratic flat earth cosmology.

During the day, the light of the sun is everywhere in the sky above us; this is what the metaphor of "seeing all around" says.[13] The interjection "of course" underlines that the third clause formulates something obvious and not some strange theory.

In this interpretation, the second and third clauses of text A are not specifically about the Milky Way, but sketch the general background of why the stars shine at night and not by day, against which the theory of the Milky Way must be understood. The first and fourth clauses of text A are about the stars visible in the shadow of the earth (the Milky Way). Generally speaking, the stars at night shine in the dark because they are not shined upon by the sun, but the stars of the Milky Way shine in the even deeper dark of the earth's shadow. Summarizing: according to Aristotle, Anaxagoras' theory is that the sun by day, when it is above the earth, outshines the stars (clause 3); when the sun is under the earth, the stars are visible because the sun does not "see" them (clause 2). A special category of stars that are not "seen" (μὴ ὁρᾶσθαι) by the sun are those stars which are in the shadow of the earth: together they make what we call the Milky Way (clauses 1 and 4).

Puzzling as Aristotle's text is, and even more puzzling as it has become by the intervention of its commentators, it does not interfere with the main argument of this paper. Whatever the interpretation of the second and third clause of text A, its kernel remains that the Milky Way results from the earth's shadow. Given that the earth's shadow covers about 30° of the sphere of the stars, the sun must be smaller than the earth (and relatively nearby). This observation is confirmed by Aristotle' argument that Anaxagoras' theory concerning the Milky Way cannot be right because actually the opposite is the case:

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[13] The anonymous reviewer remarks that the words ὅσα μὲν – ὅσοις δ' in Aristotle's text, clauses 3 and 4, suggest an opposition of two kinds of stars at night and exclude an opposition between stars by day and stars at night. This would entail that Aristotle expresses three times after another the theory of the Milky Way (in clauses 1, 2, and 4), and in between an ununderstandable theory of the stars outside the Milky Way (in clause 3). As explained above, I think it is possible to read the opposition between ὅσα μὲν – ὅσοις δ' as meaning "as many stars as are above the earth and of which the light is overpowered by the light of the sun – as many stars as are in the shadow of the earth and of which the light shines brightly". The reviewer further suggests that my interpretation of the second clause of Aristotle's text (namely, that the sun at night is so far away that its rays cannot reach the stars) could be taken as the meaning of the third clause in the usual interpretation of Aristotle's text. I am afraid that Aristotle's explicit statements that the light of the stars mentioned in clause 3 is "of course" "not visible" and "prevented" excludes this possibility.

D. Arist. *Meteor.* 345 b 1–8

> Astronomical researches have now shown that the size of the sun is greater than that of the earth (…) therefore the vertex of the cone formed by the rays of the sun will not fall very far from the earth, nor will the earth's shadow (…) reach the stars.[14]

When Aristotle claims that the sun is bigger than the earth (and thus relatively far away), throwing a conical shadow beyond the earth, he implies that in Anaxagoras' theory the earth's shadow must be widening in order to cover the width of the Milky Way, and thus the sun must be relatively near and smaller than the earth.[15] Fig. 1 gives an impression of how, in Anaxagoras' conception, the Milky Way is dependent on the earth's shadow. I also tried to imitate the diminution of the sun's rays.

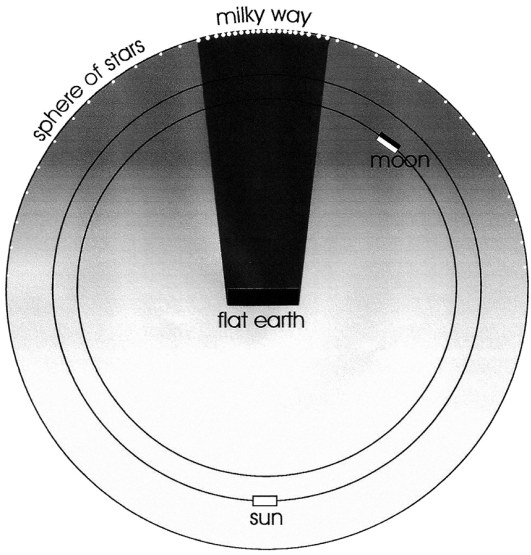

Fig. 1. The Milky Way caused by the shadow of the earth (approximately to scale)[16]

[14] Trans. Lee 1962.

[15] Cf. Guthrie 1965, 309: "He (sc. Aristotle) attacks it from the standpoint of greater astronomical knowledge, for it demands that the sun be smaller than the earth, whereas he knew it to be greater". The suggestion in O'Brien 1968, 124 that "the moon would be eclipsed night after night" is unwarranted because the moon does not cross the Milky Way night after night. Cleomedes more accurately says: "the moon would be duly eclipsed each month by falling into the shadow" (Trans. Bowen–Todd 2004, 158).

[16] I have drawn not only the earth but also the sun and the moon as flat disks, as was probably Anaxagoras' understanding.

Aristotle's testimony is repeated by several authors. Aëtius replaces the confusing clause discussed with words that appear to confirm the interpretation given above:

E. Aët. in Ps.-Plut. *Plac.* 3.1.5 = DK 59 A 80

> Anaxagoras (holds) that the shadow of the earth rests upon this section of the heaven [viz. where the Milky Way is visible] *when the sun*, having arrived under the earth, *no longer illuminates everything*.[17]

I read the clause "when the sun, having arrived under the earth, no longer illuminates everything" as simply referring to the sky at night (whereas by day, the sun "illuminates everything"), while the shadow of the sun is supposed to rest on a special section of the night sky. Hippolytus mentions Anaxagoras' explanation of the Milky Way just after a text in which he refers to Anaxagoras' ideas concerning eclipses of the moon, which we shall discuss in the next section:

F. Hippol. *Refut.* 1. 8. 10 = DK 59 A 42 (10)

> The Milky Way is the reflection (ἀνάκλασις) of the light of stars that are not illuminated by the sun.[18]

Hippolytus' word "reflection" is inaptly chosen for stars that are not illuminated by the sun, although Diogenes Laërtius uses the same term.[19] Mansfeld remarks that Aëtius' text does *not* speak of reflection,[20] and neither does Aristotle's.

In all these texts (B, C, E, and F) we find the same kernel as in Aristotle (text A): the Milky Way is the result of stars shining more brightly in the shadow of the earth. Anaxagoras' theory was already criticized by Aristotle, who argues that the position of the Milky Way among the stars is always the same but that, if it were the result of the earth's shadow, it would change with the sun's changes of position.[21] Moreover, the shadow of Anaxagoras' flat earth would not be a band across the sky but should show the shape of a circular disk, high in the sky at midnight,

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[17] Trans. Mansfeld 2010, 488, my italics.

[18] Trans. Graham 2010.

[19] Cf. Diog. Laert. 2. 9 = DK 59 A 1(9). Diogenes Laërtius' text is almost identical to that of Hippolytus; apparently, they referred to the same source.

[20] See Mansfeld 2010, 489 n. 40. Cf. Ferguson 1968, 100: "This cannot mean 'reflection' unless the doxographers have wholly misunderstood Anaxagoras".

[21] Arist. *Meteor.* 345 a 33–38.

moving during the night and changing its shape into an elliptical disk and eventually into a straight stripe at dawn.[22] The implication of Anaxagoras' explanation of the Milky Way is that he has no idea where in reality the sun is during the night. In the context of this paper, however, it is not our concern whether this theory is strange or wrong but that it is well documented and ascribed to Anaxagoras by a witness as early as Aristotle. The fundamental problem with Anaxagoras' explanation of the Milky Way is that he is also accredited with the explanation of lunar eclipses as being caused by the earth's shadow.

Introductory remarks on eclipses

Heavenly bodies sometimes disappear from sight. These disappearances can be divided in regular and irregular as well as in partly and totally. The sun, the moon, the planets, and the stars set in a regular way and when set, they disappear totally out of sight. There is some regularity in eclipses, because solar eclipses always occur during new moon and lunar eclipses during full moon. For the Presocratic Greeks, however, the precise date and the magnitude of an eclipse remained unpredictable. Stars and planets can be occulted by the moon, but since we do not possess reports of such occultations from the ancient Greeks we can leave them out of account. During the month, the moon shows phases, in which it disappears, is out of sight for a few days, and gradually appears again until it is completely visible.

The first attempts aimed to give one uniform explanation of as much as possible of these disappearances. Anaximander considered the eclipses of the sun and moon and the moon's phases as the partly or totally closure of the aperture in their celestial wheels. Since he imagined the celestial wheels of sun, moon, and stars to turn around the earth, we may surmise that he considered their settings as their becoming invisible under the earth. In this regard, Xenophanes who explained settings, eclipses, and phases all alike as quenchings, is the most consequent thinker. Another tendency was to make eclipses more like settings. Some unnamed thinkers explained solar eclipses by invisible condensations of clouds passing in front of the sun (text K). A similar explanation of (some) lunar eclipses is also ascribed to Anaxagoras (texts G and I). The Pythagoreans seem to have been the first to state that an eclipse of the sun occurs when the

[22] Another theoretical possibility would be to imagine Anaxagoras' earth not as a disk but as an oblong, which would better fit the shape of the Milky Way (cf. Heath 1913, 84). This would, however, not affect the argument of this paper.

moon is between the earth and the sun. In these explanations of eclipses, some heavenly body (an invisible body, or the moon) comes between the observer and the eclipsed body, while in the case of settings the earth is between the observer and the heavenly body that has set.

Before we start the investigation of Anaxagoras' theory of lunar eclipses, we must pay attention to an important *phenomenological* distinction between two kinds of disappearances of heavenly bodies. The first kind comprises eclipses of the sun, but also occultations of stars or planets, and the settings of the sun, moon, stars or planets. In solar eclipses, occultations, and settings, a heavenly body, usually the moon but in settings the earth, happens to be between the observer and the eclipsed, occulted or setting body, blocking the sight of the observer.[23] In solar eclipses, occultations, and settings, the order is always: observer – blocking body – eclipsed or occulted body, all the three of which must be aligned. Shadow does not play an explanatory role in these phenomena.

The second kind of disappearances consists of only one species, namely that of lunar eclipses. During lunar eclipses, it is not a heavenly body between the observer and the eclipsed body that blocks his sight of the eclipsed moon, but the shadow of the earth on the moon when the earth blocks the light of the sun. The order is also different and requires four instead of three items: light source (the sun) – shadow-throwing body (the earth) – observer – eclipsed body (the moon). Moreover, in this case only the three heavenly bodies must be aligned, but there is no direct need of alignment of the observer. This can be easily shown in comparison with ordinary shadows that fall on objects. When I observe the shadow of a tree, I do not have to be in line with the sun, the tree, and the object on which the shadow falls, and usually I am not. Similarly, a lunar eclipse can be observed from outside the alignment of sun, shadow-throwing body, and moon. Pythagoreans used this argument when they argued that lunar eclipses could also be caused by the counter-earth.[24] From this analysis we learn that, for the ancients, the understanding of the true cause of lunar eclipses must have been much more complicated than that of solar eclipses.[25] It also helps us understand why Anaxagoras tried to explain

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[23] Similarly, the sight of a heavenly object and, for that matter, any other object, can be blocked by another object, for instance a bird, a tower, our own hand, or whatever. Usually, we do not call these events 'eclipses' or 'occultations', although we may say, for instance, that the sun is obscured by a cloud or by volcanic dust.

[24] See Arist. *Cael.* 293 b 25–29.

[25] Bakker 2013, 686, points to the fact that Aristotle and Aëtius used the Greek term ἔκλειψις for eclipses and not for the waning of the moon. The difficulty is, however, in how far their knowledge of the difference between the two (and other

(some) lunar eclipses in the same way as solar eclipses and occultations, by imagining invisible heavenly bodies between us and the moon. However, let us not anticipate the conclusions of this paper.

The doxographical evidence on Anaxagoras and lunar eclipses

The most often quoted report of Anaxagoras and lunar eclipses is in a text of Hippolytus, just before he mentions Anaxagoras' explanation of the Milky Way:

G. Hippol. *Refut.* 1. 8. 6, 9 and 10 = DK 59 A 42 (6, 9, and 10)

> (Anaxagoras says) there are below the stars certain bodies invisible to us which are carried around with the sun and moon. (…) *The moon is eclipsed when the earth blocks it*, or sometimes one of the bodies below the moon. (…) *He first correctly explained eclipses*.[26]

According to Hippolytus, Anaxagoras has two explanations of lunar eclipses. In this section, I will discuss what Hippolytus, in the italicized lines above, presents as Anaxagoras' main theory concerning eclipses of the moon. This looks like the well-known explanation which we still adhere to: the moon is eclipsed when it enters partially or totally into the shadow of the earth, because at that time the earth is between the sun and the moon, as shown in Fig. 2.

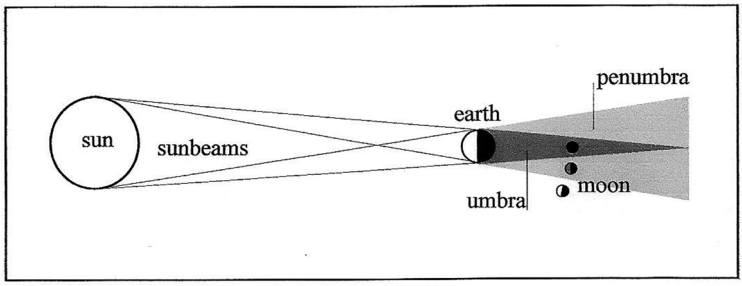

Fig. 2. The standard explanation of a lunar eclipse (not to scale)

phenomena of occultation) prevented them to understand and render truthfully the opinions of the Presocratics who were not yet able to make these differences and even tried to explain as many as possible of these events by the same theory. The confusion between eclipses and phases of the moon in Aëtius 2. 29 are also due to this misunderstanding.

[26] Trans. Graham 2010.

As regards this representation, we must make seven reservations, from which can be concluded that the drawing in Fig. 2 does not reflect the explanation attributed to Anaxagoras:

1) In ancient Greek writings there are no reports of the earth's penumbra and of penumbral eclipses.

2) Anaxagoras believed that the earth is flat. The shadow of a spherical earth on the eclipsed moon will always show the curve of a portion of a circle, whereas the shadow of a flat earth would show a variety of shapes, depending on the positions of the sun and the moon in relation to the earth's surface: a portion of a circle high in the sky, a portion of an ellipse halfway to the horizon, and a straight line at the horizon.

3) When the earth is conceived of as flat, one implication is that the heavenly bodies are nearby and, accordingly, are relatively small. The belief that the sun is nearby is implied in the report, attributed to Anaxagoras (see Diog. Laert. 2. 10 = DK 59 A 1 [10]), that the stone that fell from heaven in Aegospotami had broken off from the sun. The reports of Anaxagoras maintaining that the sun is bigger than the Peloponnesus suggest that the sun is smaller than the earth.[27] With a flat earth, the fact that the sun is nearby (and thus smaller than the earth) can easily be shown by extending Thales' measurement of the height of a pyramid to the measurement of the sun's distance: In Athens, at noon on the summer solstice, the length of a gnomon is roughly four times its shadow. Accordingly, on a flat earth, the distance of the sun to the sub-solar point (on the Tropic of Cancer) is calculated as roughly four times the distance from Athens to the Tropic of Cancer.

4) When the sun is smaller than the earth, the flat earth's shadow will widen rather than be conical. As seen in the previous section, Anaxagoras' explanation of the Milky Way also presupposes that the earth's shadow is widening and thus that the sun is smaller than the earth.

5) A widening shadow would produce other shadow lines (sections of a bigger circle) on the partially eclipsed moon than a conical shadow does.

6) A widening shadow would involve that the moon is more often and during a longer time eclipsed than is the case with a conical shadow.

7) Anaxagoras, in all probability, believed that the sun and the moon were flat disks. I have tried to draw how eclipses of the moon would look from this interpretation.

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[27] See Aët. in Ps.-Plut. *Plac.* 2. 21. 3 = DK 59 A 72; Hippol. *Refut.* 1. 8. 8 = DK 59 A 42(8); Diog. Laert. 2. 8 = 59 A 1(8). Cf. Dreyer 1953, 31: "the sun (…) greater than the Peloponnesus, and therefore not at a very great distance from the earth".

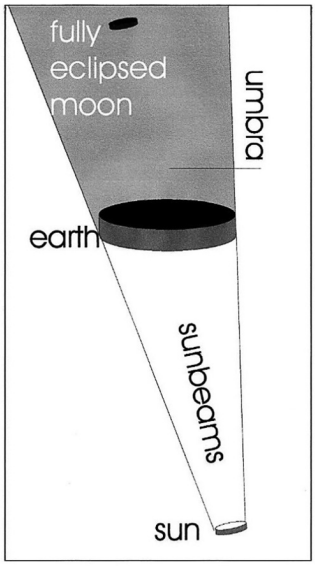

Fig. 3a. (Total) lunar eclipse at night (approximately to scale)

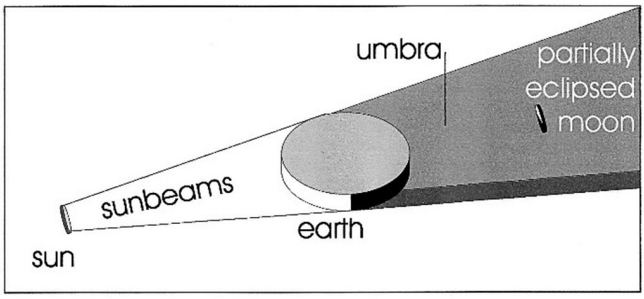

Fig. 3b. Partial eclipse at dawn
(approximately to scale)[28]

Fig. 3a shows the situation of a totally eclipsed moon in the widening shadow of the earth. Fig. 3b shows that the shadow line on the partially eclipsed moon at the horizon should be a straight line.

[28] This picture is inspired by Graham 2013, 130, Figure 4. 2. Graham draws parallel instead of widening shadow lines, although he draws the sun nearby and smaller than the earth. Elsewhere, however, when he discusses a solar eclipse, he (wrongly) argues that "Anaxagoras must presume that (…) the sun (is) relatively far away" (Graham 2013, 148 and 151). See also Graham–Hintz 2007, 321: "Assuming that the sun was far distant from the earth". But when the sun is far away it must be much bigger than the earth and the shadow of the earth must be conical.

The correct explanation of lunar eclipses is also given in Pseudo-Plutarch's version of Aëtius, in which Anaxagoras is not mentioned:

H. Aët. in Ps.-Plut. Plac. 2. 29. 6

> Plato, Aristotle, and the Stoics agree with the astronomers (…) that eclipses of the moon occur when it enters the earth's shadow, when the earth comes between the two heavenly bodies.[29]

In Stobaeus' version, however, the name of Aristotle has disappeared and is replaced by those of Thales and Anaxagoras. Moreover, Stobaeus attributes to Anaxagoras a second explanation of lunar eclipses, which we shall discuss later:

I. Aët. in Stob. *Anth.* 1. 26. 3 = DK 59 A 77

> Thales, Anaxagoras, Plato and the Stoics agree with the astronomers (…) that eclipses of the moon occur when it enters the earth's shadow, when the earth comes between the two heavenly bodies. Theophrastus says that Anaxagoras held that eclipses also occur when bodies below the moon happen to obstruct it.[30]

Given these two versions, it is a matter of debate whether Anaxagoras was mentioned at all in Aëtius' original text in relation to the theory that the shadow of the earth produces eclipses of the moon. When we look at the matter within the context of Anaxagoras' other astronomical ideas, Ps.-Plutarch's version (text H) makes more sense.[31] He mentions

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[29] My trans. See also Diels 1879, 360.

[30] My trans. Bakker 2013, 685, n. 5 mentions a minor difference between the versions of Ps.-Plutarch and Stobaeus, but overlooks the major difference in the names mentioned in the two versions.

[31] Here, my conclusion differs from that of Mansfeld–Runia 2009, 613–623, who state that "Not only (…) does P(seudo-Plutarch) delete the names of Thales and Anaxagoras (perhaps to avoid the doublet), but he also adds that of Aristotle" (617) and finally offer a text with all the names mentioned by Ps.-Plutarch and Stobaeus combined (621–622). The reasons they adduce have to do with text-critical considerations about the usual methods of the doxographers. My attempt tries to see which of the two versions makes more sense in the context of what we know about Anaxagoras' other astronomical opinions and intends to show that it is not "somewhat unexpectedly" that "the first two names Thales and Anaxagoras are dropped" (Mansfeld–Runia 2009, 615). Moreover, the "standard explanation" of a lunar eclipse as caused by "the moon sink into the *conical* shadow of the earth (*ibid*. 616, my italics) cannot be said of Anaxagoras, nor from any other Presocratic flat earth cosmologist.

three schools that were convinced that the earth is spherical and in which, understandably, Anaxagoras is not included. The concept of a spherical earth fits very well with the standard explanation of eclipses of the moon. The curved shape of the earth's shadow can thus be easily explained, which is not the case with Anaxagoras' supposition of a flat earth. Aristotle builds the question of the shadow lines into one of his proofs that the earth is a sphere.[32] Moreover, if the earth is spherical, the sun must be much bigger than the earth and at a great distance, which would result in the earth's shadow being conical, as Aristotle already concluded, and not widening (see text D and Fig. 2). The earth's shadow on the moon shows a width of about 1.5°. This is at odds with the widening shadow of a flat earth, which would cover roughly 30° of the night sky and cause the Milky Way, as was Anaxagoras' opinion.

Theon of Smyrna says that it was Anaximenes who discovered the way in which the moon is eclipsed:

J. Theon Smyrn. *Expos.* 198. 14 – 199. 3 = DK 13 A 16 = fr. 145 Wehrli

> [Eudemus reports that] Anaximenes [was the first] to discover that the moon has its light from the sun and how it eclipses.[33]

Several scholars, and most recently Panchenko, have argued that we should read "Anaxagoras" instead of "Anaximenes".[34] I prefer to follow O'Brien, who suggests that "Eudemus said simply that Anaximenes gave *an* interpretation of the moon's eclipse", perhaps as caused by invisible bodies, which would be compatible with his idea of a fiery moon, and that Theon inaccurately turned this into the suggestion that Anaximenes gave the correct explanation of the moon's eclipse.[35]

The incompatibility of Anaxagoras' theory of the Milky Way with the explanation of lunar eclipses as caused by the earth's shadow

The Milky Way is a permanent phenomenon, visible every night. Lunar eclipses, on the contrary, are rare phenomena. During Anaxagoras' lifetime, 31 of them were visible in Athens. The inevitable conclusion of

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[32] Arist. *Cael.* 297 b 23–31.
[33] My trans.
[34] See Panchenko 2002, 324–326. He mentions others scholars in n. 6.
[35] O'Brien 1968, 117.

the combination of the theories that the moon is eclipsed by the shadow of the earth on the one hand, and that the Milky Way is caused by the earth's shadow on the other hand, is that the eclipsed moon would always be seen against the background of the Milky Way. In reality, this is not the case, as can be seen by simply observing lunar eclipses. Of the 31 eclipses of the moon that took place during Anaxagoras' lifetime, only eight took place when the full moon was in conjunction with the Milky Way.[36] In the section on Anaxagoras and the Milky Way, it was already remarked that his explanation of the Milky Way implies that he had no idea of the real position of the sun during the night. In other words, the theory of the Milky Way as caused by the shadow of the earth is irreconcilable with the theory that eclipses of the moon are caused by the shadow of the earth.

I am not the first to note that these two theories involving the earth's shadow are incompatible. More than a century ago, several scholars noted that it is impossible for the two theories involving the earth's shadow to coexist. Tannery remarks: "la lune aurait dû s'éclipser toutes les fois qu'elle traverse la voie lactée, conséquence dont il était également facile de verifier la fausseté".[37] Gomperz writes: "und warum tritt nicht eine Verfinsterung des Mondes ein so oft dieser über die Milchstraße hingeht?"[38] And Heath comments: "if the theory were true, an eclipse of the moon would have been bound to occur whenever the moon passed over the Milky Way and it would have been easy to verify that this is not so".[39] In more recent times, Fehling also concludes, that "seine (…) Erklärung der Milchstraße (…) mit der richtigen Erklärung der Mondfinsternisse (…) unvereinbar ist".[40] Panchenko remarks about the attribution of this theory of the Milky Way to Anaxagoras: "But this is incompatible with other evidence on Anaxagoras' views".[41]

As far as I know, nobody has thus far drawn the conclusion that we must try to determine which of the two theories of the earth's shadow was actually proposed by Anaxagoras. It is hard to imagine that he would have defended the two conflicting theories at the same time, unless we want to depict him as a confused fool. If we refuse to accept that Anaxagoras was completely confused only two options remain: either

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[36] I used the computer program RedShift 8 Premium.

[37] Tannery 1887, 279.

[38] Gomperz 1896, 179.

[39] Heath 1913, 84.

[40] Fehling 1985, 211. I thank Dmitri Panchenko for drawing my attention to this text.

[41] Panchenko 2013.

Anaxagoras was not the author of the idea that the phenomenon of the Milky Way is caused by the earth's shadow, or he was not the author of the accepted explanation of eclipses of the moon as caused by the shadow of the earth.[42]

The results of the textual arguments indicate that Anaxagoras' explanation of the Milky Way is well documented, but that the attribution to him of the accepted explanation of lunar eclipses depends mainly on the report of Hippolytus. The result of the contextual and observational arguments is that Anaxagoras' theory of the Milky Way harmonizes with his astronomy, but his alleged theory that lunar eclipses are caused by the earth's shadow is hard to bring into accord with the rest of his astronomical ideas and especially with that of a flat earth. If these considerations are right, it seems plausible that Pseudo-Plutarch's version, in which Anaxagoras is not named, represents Aëtius' original. In that case, Hippolytus remains the only authority to rely on for the attribution of the accepted theory of lunar eclipses to Anaxagoras.[43] We may wonder how trustworthy his report is, since he mentions it in the same breath with Anaxagoras' explanation of the Milky Way, without noticing that the two are mutually exclusive. My conclusion is that the right explanation of lunar eclipses must have been mistakenly attributed to Anaxagoras.

Two questions remain, the first of which is whether we are able to trace the origin of this mistaken attribution. The other question is, how to understand the completely different explanation of lunar eclipses that is also ascribed to Anaxagoras. These two questions will appear to be intertwined. We will start our discussion with the second question.

Invisible heavenly bodies below the moon

In text I, Stobaeus introduces bodies below the moon that can bring about eclipses when they move in front of the moon. Hippolytus (text G) also refers to a theory of lunar eclipses caused by bodies below the moon, in

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[42] Perhaps someone would argue that another possible solution for this dilemma could be that, in his youth, Anaxagoras defended the idea of the Milky Way as the shadow of the earth and that, at a later stage, he discovered the true cause of lunar eclipses and abandoned his former idea of the earth's shadow. However, the sources do not give any indication of such a scenario. Even so, the right explanation of lunar eclipses would conflict with his conception of a flat earth.

[43] Cf. Guthrie 1965, 308 n. 1: "For Anaxagoras on the cause of eclipses the authority is Hippolytus".

which the shadow of the earth does not play a role. The word "invisible" obviously means that such an object is invisible until it betrays itself when it partially or totally covers the moon.

The idea of invisible heavenly bodies was not new in Presocratic cosmology. Anaximander conceived of the celestial bodies as huge wheels of condensed air filled with fire that we see through an opening. The wheels themselves we do not see because they are made of air, just like the medium in which they orbit around the earth.[44] Another kind of invisible heavenly body is mentioned in the doxography on Anaximenes. He is said to believe that the heavenly bodies are of a fiery nature but that some of them are earthy (γεώδη) and invisible (ἀόρατα).[45] Since this is all that is said about them, it is hard to understand how earthy bodies could be invisible, and impossible to decide whether or not they were thought to play a role in lunar eclipses.

According to Anaxagoras, the heavenly bodies are fiery stones.[46] This makes it difficult to imagine how the invisible bodies below the moon could remain invisible. Moreover, the invisible bodies that were able to eclipse the moon must have been much bigger than the stone of Aegospotami, and probably bigger than the moon itself, in order to produce the size of eclipses we observe on the moon, which makes it even harder to understand how they could remain unnoticed. Furthermore, the moon is sometimes faintly visible during an eclipse, which would be impossible if a huge stone were blocking its light.

A hypothetical explanation, which could cope with these difficulties and which I consider plausible, is that Anaxagoras' invisible bodies are an exception to his theory that the celestial bodies are fiery stones because they are made of an airy substance. In text G, Hippolytus distinguishes between invisible bodies below the stars and invisible bodies below the moon. We can imagine that invisible heavenly bodies *above* the moon are fiery stones, which become temporarily visible when they are kindled (like comets and shooting stars), or when they are driven off course (like meteorites), but that the invisible heavenly bodies *below* the moon were conceived of as a kind of meteorological objects that consisted of condensed air and became temporarily visible during lunar eclipses.

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[44] Hippol. *Refut.* 1. 6. 4 and 5 = DK 12 A 11 (4 and 5), Aët. in Ps.-Plut. *Plac.* 2. 13. 7 = DK 12 A 18, 2. 20. 1 and 2. 24. 2 = 12 A 21, 2. 25. 1 and 2. 29. 1 = DK 12 A 22.

[45] Aët. in Stob. *Anth.* 24. 1 = DK 13 A 14.

[46] Aët. in Ps.-Plut. *Plac.* 2. 13. 3 = DK 59 A 71; Hippol. *Refut.* 1. 8. 6 = DK 59 A 42(6). This item will be discussed thoroughly in another paper, "Anaxagoras on the Light and Phases of the Moon" (forthcoming in *Hyperboreus* 24: 1).

Aëtius mentions a similar explanation in an anonymous account of eclipses of the *sun*:

K. Aët. in Ps.-Plut. *Plac.* 2. 24. 5

> Some (thinkers declare that it is) a condensation of clouds invisibly passing in front of the (sun's) disk (τῶν ἀοράτως ἐπερχομένων τῷ δίσκῳ νεφῶν).[47]

The expression "invisibly passing" (ἀοράτως ἐπερχομένων) is somewhat unfortunately chosen, because these invisible cloudy objects make themselves visible when passing the sun's disk. Although Aëtius' item falls under the heading "eclipses of the sun", Bicknell rightly states that "the cloud theory of eclipses is as applicable to lunar as it is to solar eclipses".[48] As regards Anaxagoras, there is no cogent reason to doubt the reports that say the sun is eclipsed when the moon blocks it.[49] But in the case of lunar eclipses, the hypothesis of invisible bodies of an airy nature, which become visible in a cloud-like way during an eclipse, would fit his ideas very well. These airy bodies must be sufficiently condensed to cause an eclipse of the moon. Sometimes, however, at the occurrence of a blood moon, they are so thin as to let the moon's own light shine through. This would also explain why they do not produce a sharp borderline when they move before the moon, as a body of stone would do.

Attempts to understand the invisible bodies as an additional cause of lunar eclipses

The difficulty with the theory of invisible objects, however, is that both Stobaeus and Hippolytus (texts I and G) tell us that it was *in addition to* the accepted explanation of lunar eclipses. Some authors have tried to argue that the invisible bodies as additional causes of lunar eclipses were introduced to explain specific events. More than a century ago, Schaefer,

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47 Trans. Mansfeld–Runia 2009, 354 (not in DK, but see Diels 1879).

48 Bicknell 1969, 65. See also Wöhrle 1993, 71, who calls Bicknell's idea "nicht unüberzeugend".

49 Hippol. *Refut.* 1. 8. 9 = DK 59 A 42(9). Cf. Val. Max. 8. 11, text 1 (not in DK), where it tells how Pericles, quoting what he had learned from Anaxagoras concerning the courses of the sun and moon, tried to appease the citizens of Athens who panicked because of an eclipse of the sun.

Boll and Heath have tried to show that Anaxagoras' invisible bodies would explain the phenomenon of both the sun and moon being visible during a lunar eclipse, on opposite horizons to one another, during a so-called "selenelion".[50] Graham maintains that the invisible bodies were introduced to explain all lunar eclipses at the horizon, or as he calls them, "crepuscular eclipses".[51]

These attempts suffer from two fundamental mistakes. In the first place, eclipses at the horizon are made into a special type of lunar eclipses that can be distinguished from the other ones and thus be thought to originate from another cause (from invisible heavenly bodies instead of the earth's shadow). So-called "crepuscular eclipses" and "selenelions" are, however, just normal eclipses that have started higher in the sky, to reach the horizon at a later time in the course of their existence.[52] The eclipse of March 25, 542 BC, for instance, started at 5.30 am, at an altitude of about 23°. At about 7.06 am, it was almost full (altitude about 5°), and when it set at 7.36 am, the moon was still partially eclipsed, with most of the eclipsed part being already under the horizon. It would have been very strange indeed, if we must suppose that Anaxagoras believed that when the eclipse had reached the horizon, all of a sudden an invisible heavenly body would have taken over the role of the earth's shadow.

In the second place, none of these authors seems to be aware of the discrepancy between the idea that the moon is lighted by the sun and the idea of invisible bodies as an additional cause of lunar eclipses. If the moon is lighted by the sun, it is hard to understand why the bodies that partially or totally cover the full moon, especially when they are supposed to be stony as these authors do, should be invisible or dark and not lighted by the sun, just like the moon before which they move.[53]

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[50] See Schaefer 1873, 19 n. 1; Boll (1909) 2351; Heath (1913) 80.

[51] Graham 2013, 128–130.

[52] All lunar eclipses visible at the horizon during Anaxagoras' lifetime were visible at dawn and none at dusk.

[53] This problem does not rise with the counter-earth of the Pythagoreans that is also said to be an additional cause of lunar eclipses. Of course, there are other problems with the counter-earth as a cause of lunar eclipses. However, the counter-earth does not dwell between the earth and the moon, but is invisible because it orbits between the earth and the central fire, while the part of the earth on which we live is supposed be always turned away from it.

Invisible bodies as Anaxagoras' only theory of lunar eclipses

Earlier, I concluded that Anaxagoras cannot have been the discoverer of the accepted explanation of lunar eclipses, because this is irreconcilable with his well-documented theory of the Milky Way. From the previous section, we may conclude that there seems to be no reasonable explanation of how the invisible bodies could function as a *supplementary* cause of lunar eclipses. If this analysis is right and the correct explanation of lunar eclipses was mistakenly ascribed to Anaxagoras, there is no reason to call his explanation by means of invisible objects "additional". Moreover, to me it seems probable that if a defender of the flat earth like Anaxagoras had seen the phenomena of the shapes of the eclipsed moon during so-called crepuscular eclipses, he would have argued: "the earth is flat, and thus the shapes of the eclipses that can be seen at the horizon cannot be caused by the earth's shadow; and since these eclipses were some hours ago just normal lunar eclipses this indicates that, generally speaking, eclipses of the moon are not caused by the shadow of the earth".[54] And if Anaxagoras had seen the phenomenon of a selenelion in which both the sun and the eclipsed moon were seen, he would have been convinced once more that the earth's shadow cannot be the cause of a lunar eclipse.

My proposal is, then, that the right explanation of lunar eclipses was incorrectly ascribed to Anaxagoras and that the invisible bodies must be considered as Anaxagoras' one and only way to explain eclipses of the moon. We might say that this explication is part of a universal theory that also holds for solar eclipses, star occultations, and risings or settings, in all of which a body (the moon, or the earth), lying between an observer and the celestial object, blocks the sight of that object and in which no shadow is involved. This explanation of lunar eclipses is compatible with Anaxagoras' conception of a flat earth and would solve the problems which arise, as we have seen, with the standard interpretation of lunar eclipses.[55] We might visualize this explanation of lunar eclipses as shown in Fig. 4.

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[54] I have generated pictures of all 13 lunar eclipses that were visible at the horizon during Anaxagoras' lifetime. They can be seen on my page in Academia.edu (https://zcu.academia.edu/DirkCouprie).

[55] Interestingly, Neugebauer 1975, 550 wrote: "One could invent the existence of a special object, a dark 'disk' that obscures the moon, moving always at 180° elongation from the Sun. The mathematics of the ephemerides would allow for this interpretation". Neugebauer is commenting here on the Pythagorean counter-earth, but his remark makes more sense when applied to Anaxagoras.

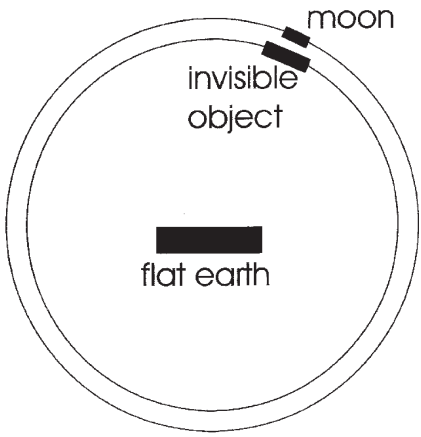

Fig. 4. Lunar eclipse caused by an invisible object
(approximately to scale)[56]

The possible origin of a misunderstanding

I think the origin of the misunderstanding in calling the explanation of lunar eclipses by means of invisible bodies "additional" is a cryptic text of Aristotle on lunar eclipses in the Pythagorean cosmological system. The Pythagorean system counts one invisible heavenly body, called the counter-earth, which is thought of as another earth, orbiting opposite to the earth around the central fire. But next to this, Aristotle states that some think that there are invisible *bodies* (in the plural), causing eclipses of the moon:

L. Arist. *Cael.* 293 b 21–25

> Some even think it possible that there are a number of such bodies [like the counter-earth] carried round the center, invisible to us owing to the interposition of the earth. This serves them too as a reason why eclipses of the moon are more frequent than eclipses of the sun, namely that it [sc. the light of the sun] is blocked by each of these moving bodies, not only by the earth.[57]

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[56] In Fig. 4, I did not draw the sun because, as stated before, the shadow of the earth does not play a role in this explanation of lunar eclipses, and Anaxagoras' explanation of the Milky Way implies that he had no idea of the sun's real position during the night.

[57] Trans. Guthrie 1939, my additions between square brackets (not in DK).

Aristotle speaks about heavenly bodies that are "invisible to us owing to the interposition of the earth". This would exclude Anaxagoras' invisible bodies, which are said to be below the moon, meaning between the earth and the moon, as Burkert rightly remarks.[58] Yet, it is tempting to think that Aristotle was not hinting at some unknown Pythagoreans but at Anaxagoras. In modern times, this suggestion has been made several times, and recently by Graham.[59] My guess is that already in ancient times, Theophrastus, and in his footsteps Stobaeus and Hippolytus, misunderstood Aristotle's words as having bearing on Anaxagoras' invisible heavenly bodies.

Let us look once more at the relevant texts. Pseudo-Plutarch (text H) has nothing at all to say about Anaxagoras concerning lunar eclipses. Stobaeus (text I) invokes the authority of Theophrastus to attribute the explanation of lunar eclipses by means of invisible bodies to Anaxagoras. Stobaeus may have found the theory of invisible bodies in Aëtius, but I think it is more plausible that he found it in another source that referred to Theophrastus. Actually, Hippolytus seems to have used the same source, for both he and Stobaeus use the same words when they mention that, according to Anaxagoras, the moon is eclipsed "by invisible bodies below the moon" (τῶν ὑποκάτω τῆς σελήνης σωμάτων). And since Theophrastus, misunderstanding Aristotle, spoke of *Anaxagoras' additional* explanation, both Stobaeus and Hippolytus also presented it as additional to the accepted explanation of lunar eclipses. Consequently, Stobaeus inserted Anaxagoras into the list of names of adherents to the accepted explanation. Finally, Aristotle's suggestion that invisible bodies were introduced to explain the surplus of lunar over solar eclipses is probably his own interpretation of why invisible heavenly objects were introduced. Neither Aëtius nor Hippolytus mention it in their reports on the Pythagoreans and Anaxagoras.

Concluding remarks

If my analysis in this paper is right, Anaxagoras was not the revolutionary astronomer as presented by modern scholars, but, in several regards, a defender of ancient views. Of course, the results of my investigation are less spectacular than those of scholars who think they can ascribe to Anaxagoras the discovery of the real cause of eclipses of the moon,

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[58] Cf. Burkert 1972, 344 n. 34.

[59] Graham 2015, 226. See also DK II, 16, note at line 18; Dicks 1970, 66; Guthrie 1962, 286, and Bakker 2013, 693, all of whom overlook the crucial point.

and think they can explain why he needed an additional theory for some special eclipse. At least, however, they should justify why they neglect the conflicting theory of the Milky Way, or they should show that it is not irreconcilable with the right theory of lunar eclipses. It has been suggested that this kind of discrepancy is due to the state of astronomical theorizing being still in its infancy. I would rather say that some ideas and theories of Presocratic astronomy seem strange or even weird to us, but that often, when we look more carefully, they make sense within their contemporary context. What is at stake here, however, is not that the ideas involved are strange, but that they are overtly conflicting. I am convinced that some Presocratic thinker who discovered the right cause of lunar eclipses must necessarily have thoroughly studied the shadow of the earth on the moon. Therefore, he cannot have defended at the same time a completely other and conflicting theory of the shadow of the earth as causing the phenomenon of the Milky Way. To the best of my knowledge, these two theories are irreconcilable.

In my opinion, the textual, conceptual, and observational evidence does not support the conclusion that Anaxagoras discovered or adhered to the right explanation of lunar eclipses. Anaxagoras was a great cosmologist, who ingenuously defended conceptions that have since become obsolete, such as the earth being flat and the Milky Way resulting from the earth's shadow, conceptions which did not allow him to discover or accept the true theory of lunar eclipses. His also erroneous solution was to explain eclipses of the moon as analogous to eclipses of the sun and occultations of a star or planet, assuming that invisible heavenly bodies come between us and the moon. I started my investigation by stipulating that we must be cautious of ascribing too much astronomical knowledge to the ancient Greek thinkers. This holds especially true for those Presocratics who adhered, like Anaxagoras, to the conception of a flat earth. Flat earth cosmology regularly leads to consequences that look surprising and even strange to us, who believe that the earth is a sphere.

A serious problem remains that has to do with the question of what happens to the moon when it is in conjunction with the Milky Way. The band of the Milky Way is inclined by about 60 degrees in relation to the ecliptic. This means that the moon sometimes passes the Milky Way and thus, according to Anaxagoras' theory that the Milky Way is caused by the earth's shadow, it cannot receive there its light from the sun. Nevertheless, the moon is still visible and shows its phases when it is passing in front of the Milky Way. We met this problem already in the quotations of Tannery and others, who wondered why the moon was not eclipsed whenever the moon passed over the Milky Way. This leads to the question of what could be meant by the moon receiving its

light from the sun, or in other words, what could have been, according to Anaxagoras, the origin of the moon's light. In that context, the question of the invisible bodies must be paid attention to once more. I will discuss the problem of the origin of the light and phases of the moon according to Anaxagoras in a separate paper.

Dirk L. Couprie
University of West Bohemia
dirkcouprie@dirkcouprie.nl

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Anaxagoras is commonly known as the discoverer of the true explanation of eclipses of the moon as caused by the earth's shadow. Anaxagoras is also said to have explained the phenomenon of the Milky Way as caused by the earth's shadow. In this paper, the two theories are described, it is shown that and why they are incompatible, and it is argued which of the two most likely can be ascribed to Anaxagoras. This is first studied by exploring which of the two theories is best documented. After that, it is examined which of the two fits best with Anaxagoras' other astronomical ideas. It is argued that both procedures point to the theory of the

Milky Way as Anaxagoras' actual conception of the role of the earth's shadow. Consequently, the earth's shadow has nothing to do with lunar eclipses, and Anaxagoras is mistakenly honored as the discoverer of the true theory of lunar eclipses. It is also argued that invisible heavenly objects that move before the moon, which are mentioned in the doxography on Anaxagoras as an additional explanation, must have been his one and only explanation of lunar eclipses, and it is tried to explain how this theory has come to be called additional. Finally, the unanswered question of Anaxagoras' conception of the moon's light and phases points forward to a sequel of this paper.

Анаксагора обычно считают автором верного объяснения лунного затмения, причиной которого является тень от Земли. Ему же приписывают понимание Млечного пути как явления, вызванного тенью Земли. В настоящей статье рассматриваются две этих теории, причем демонстрируется и объясняется их несовместимость, а также ставится вопрос, которая из них с большей вероятностью восходит к Анаксагору. Вначале разбирается, какая из двух теорий лучше документирована, а затем – какая из них лучше согласуется с другими астрономическими взглядами Анаксагора. Оба этих подхода указывают на то, что Анаксагор действительно объяснял Млечный путь воздействием тени от Земли. Следовательно, он не мог связывать с ней лунные затмения и, таким образом, получил лавры первооткрывателя их причины незаслуженно. Далее высказывается предположение, что невидимые небесные тела, движущиеся перед Луной, которые упоминаются в доксографических свидетельствах об Анаксагоре как дополнительное объяснение лунных затмений, в действительности служили у Анаксагора их единственным объяснением; при этом автор статьи пытается объяснить, почему эту теорию стали называть дополнительным объяснением. Вопрос о взглядах Анаксагора на природу лунного света и фаз луны будет рассмотрен в последующей публикации.

CONSPECTUS

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