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Aristarchus of Samos on Thales' Theory of Eclipses

Andrei V. Lebedev

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That the eclipses occur at noumenia is made clear by Aristarchus of Samos who writes: "Thales said that the eclipse of the sun occurs when it is screened by the moon; he inferred this [theory] from the day in which the sun is [regularly] eclipsed. This day is called 'the thirtieth' by some, 'noumenia' by others."

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LEBEDEV Andrei V., *Aristarchus of Samos on Thales' theory of eclipses*: Apeiron XXIII 1990 77-85. | On the quotation from Aristarchus in P. Oxy. 3710. The ascription of the ἐπιπρόσθεσις theory of eclipses to Thales was not first made in the 1st cent. B.C. by « Posidonian » doxography: Aristarchus of Samos knew it and his source was the Pre-Peripatetic tradition of the 5th cent. B.C. [243

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synonymous with τεκμαίρομαι ἐκ or ἀπό τινος.² The meaning of Aristarchus' evidence is clear: (a) Thales had observed that the eclipses of the sun usually occur at *noumenia*; (b) from this observation he inferred that on this day the moon is in conjunction with the sun and, consequently, is the cause of its occultation.³ The ἐπιπρόσθεσις theory of eclipses is now attested for Thales two centuries earlier: hitherto our earliest authorities have been Cicero and *Placita Philosophorum* (ca. mid-first century BC).⁴ The author of the Commentary on *Odyssey*, as it seems, quotes Aristarchus not directly, but via Diodorus of Alexandria, who was (as I believe) one of the main sources of *Placita* in astronomy.⁵ It is natural to conclude that the testimony of *Placita* also

2 See the instances cited in *LSJ*, s v σημειώω II 2 ('infer as from sign'), and add Sextus Empiricus *Adv Math* VII 365; VIII 270, etc. σημειοῦμαι ἐκ is more common, but cf. Cleomedes *de motu circ* 140 12 Ziegler σημειοῦται δὲ καὶ ἀπὸ σκιῶν μὴ εἶναι ποδιαῖον τὸν ἥλιον. Cf. a similar report on Thales' empirical inference: DL I 24 τεκμαιρόμενον ἐκ τῆς λίθου. A less probable supplement would be σημειοῦμε[νος ἴσως] ἀπό; cf. similar reconstructions of Thales' τεκμήρια in Aristotle *Metaph* 983b22 (= 11 A 12 DK) λαβὼν ἴσως ... ἐκ τοῦ κτλ. a22: ὁθεν ἴσως... The possibility of the reading -μενος did not escape the notice of Haslam: see his note on p.107; other proposals made there (τῇ κρύψει and τῇ συνόδῳ) are certainly wrong.

3 ἐπιπρόσθεσις (=ἐπίπροσθεν γίνεσθαι) is Aristarchus' *terminus technicus* for 'occultation': see περὶ μεγεθῶν 8; 382 5 Heath ἐπιπρόσθεσιν τῆς σελήνης ἐκλείπει (sc. ὁ ἥλιος). The variant ἐπιπρόσθησις first occurs in Aristotle, *de Caelo* 297b29; 293b22, cf. fr.204 Rose = 58 B 37 DK. It is worth noting that in the last two instances Aristotle relates Pythagorean theories, cf. W. Burkert, *Lore and Science in Ancient Pythagoreanism* (Cambridge, MA 1972), 338-44. Of the two synonymous (and often interchangeable) terms, ἐπιπρόσθεσις (ἐπιπροσθέω) and ἀντίφραξις (ἀντιφράττω), the first seems to be more abstract and 'scientific' (also used in geometry: Aristotle, *Top* 148b27), the second more concrete and informal. so one might guess that the first is of Academic (Pythagorean) and the second of Anaxagorean (Ionic) origin; but there can be no certainty: see indices to DK and *Dox Gr*, qq.vv.

4 *Placita* (Plutarch, Stobaeus) II 24 1 = A 17a DK. The source of the corresponding passages in Achilles *Isagoge*, 46 32 sq. and 50 2 sq. Maass is not 'Poseidonios' (contra DK I 78, note 23), but Eudorus-Diodorus. Cf. also the related *placita* II 28 5 = 11 A 17b (the moon illuminated by the sun) and II 29 6 (Stobaeus only): Thales, Anaxagoras, Plato, Stoics, μαθηματικοί on the eclipses and 'monthly occultations' of the moon (not in DK).

5 Diodorus (quoted by the Commentator in col II 47) is certainly the source of the Heraclitus quotation which cannot be separated from the preceding piece of Thales doxography (cf. note 21). It will be demonstrated elsewhere that the

derives from Aristarchus via Diodorus. This tradition certainly does not derive from Eudemus who ascribed the discovery to Anaximenes (?).⁶ Following the lines of Dielsian *Quellenforschung* one would inevitably conclude that we are dealing with an Alexandrian invention, i.e., that (b) is a conjectural inference from the story of prediction of the eclipse of 585 BC, which has been seriously discredited by O. Neugebauer's criticism.⁷ The knowledge of the true cause of eclipses is commonly denied to Thales on the ground that it was still ignored by Anaximander and Anaximenes.⁸ I do not intend to disprove the *communis opinio*, nor

main doxographical source of Achilles' *Isagoge* is not 'Plutarchus' (contra Diels), but Eudorus who relies on Diodorus (30 20 Maass). I suspect also that the lemma μαθηματικοί (i.e., 'astronomers') in *Placita philosophorum* stands for Diodorus of Alexandria who represents the Aristarchean tradition. Thus the combination of Thales and μαθηματικοί in *Placit* II 29 6 may be taken as a source reference to Diodorus who reports Aristarchus' evidence on Thales' astronomy.

- 6 Eudemus fr.145 Wehrli ap.Theo Smyrn., 198 14 Hiller = 13 A 16 + 11 A 17 DK. It has long been seen that 'Αναξιμένης is probably a misquotation of 'Αναξαγόρας; P. Tannery, *Pour l'histoire de la science hellène* (Paris 1887), p.153 of the Russian translation (St. Petersburg 1902); D. Lanza, *Anassagora* (Firenze 1966), 134. The vague expression εὔρε ... ἡλίου ἐκκλειψιν (of Thales) certainly does not imply 'the discovery of the true cause', but refers to the 'prediction' story. The meaning of Eudemus' report is misrepresented by G.S. Kirk (in Kirk-Raven-Schofield, *The Presocratic Philosophers* [Cambridge 1985²], 82) for he ignores the context: 'Αναξιμένης δὲ [sc. εὔρε πρώτος] ὅτι ἡ σελήνη ἐκ τοῦ ἡλίου ἔχει τὸ φῶς κτλ. Thus Kirk's imputation to Eudemus ('... was guilty of drawing a wrong conclusion', etc.) is absolutely unfounded: Eudemus can hardly be guilty of ignoring the fact that it is impossible to discover the cause of eclipses without knowing that the moon is a 'dark body' illuminated by the sun.
- 7 O. Neugebauer, *The Exact Sciences in Antiquity* (Oxford 1951), 136, 114 (p.144 of the Russian translation [Moscow 1968]) denies the very notion of *saros* as astronomical cycle. The *saros* theory is restated by L. Blanche, 'L'éclipse de Thalès et ses problèmes', *Revue Philosophique* 158 (1968) 153-99.
- 8 So already Tannery, 62 (of the Russian translation); J. Burnet, *Early Greek Philosophy* (London 1920), 41; W.K.C. Guthrie, *A History of Greek Philosophy*, vol I (Cambridge 1967), 48; Kirk-Raven-Schofield, *ibid.*; Diels-Kranz I 79 19 note. Another argument is the supposed inconsistency of Thales' cosmology with the ἐπιτρόσθεις theory which, as we are told, requires a spherical earth and geocentric system. This argument is inconclusive: Anaximenes, e.g., thought that the stars revolved not ὑπὸ γῆν, but περὶ γῆν (13 A 7, § 6; A 14) and nevertheless held a kind of ἐπιτρόσθεις theory: the sun is screened by

do I think that the new evidence is so strong and indisputable as to overthrow it. Yet the authority of Aristarchus allows us to depart for a moment from the negative dogma and to consider *ex hypothesi* the possibility of a more positive evaluation of the tradition.

Our knowledge of sixth-century astronomy is too defective to allow dogmatic conclusions; the history of Greek science is by no means throughout progressive;⁹ and there are cases when the Alexandrian tradition about early φυσικοί, though independent of the Peripatos, is nevertheless reliable.¹⁰ Suppose, for example, that Aristarchus got his notice from an early writer (most probably Democritus)¹¹ overlooked

the earth, the moon by 'invisible bodies'. No ancient source says that Thales regarded the earth as a *flat* disc (though this is repeated again and again in modern handbooks). Thales may have conceived the earth as a hill or a mountain floating on the boundless Ocean: the heavenly bodies would revolve *περι γῆν* as in Anaximenes' cosmology without *λοετρῶν Ὠκεανοῖο* (contra M.L. West, *Early Greek Philosophy and the Orient* [Oxford 1971], 211). Thus it is precarious to credit the father of the rational science with the curious notion of 'semi-orbits' (?) as G.S. Kirk does, KRS, 83.

- 9 E.g., Anaximander's great discovery of the Southern Celestial Hemisphere and antipodes was rejected by Anaximenes who revived in a rationalized form Hesiod's 'windy Tartarus' (cf. B. Gladigow, 'Pneumatik und Kosmologie', *Philologus*, III (1967) 1-20).
- 10 Eratosthenes is the only source on Anaximander as geographer: 12 A 6 DK; W.A. Heidel, 'Anaximander's Book the Earliest Known Geographical Treatise', *Proceedings of the American Academy* 1921, Nr.7
- 11 I believe that the meaning of Hippias as a Pre-Aristotelian source on Thales' doctrines has been somewhat exaggerated (for a recent discussion of the Hippias question see J. Mansfeld, *Mnemosyne* 38 (1985) 109-29). In particular, though Hippias was interested both in Thales and astronomy, there is no positive evidence that he ever said something about Thales' astronomy. DL I 23 cites as early authorities on Thales' astronomy Xenophanes (= 21 B 19 DK), Heraclitus (= B 38 DK = 63 b Marcovich), Democritus (= B 115a DK = 156 Luria). Democritus must have been most informative of all; he was also interested in Thales' biography and reported details on Thales' Phoenician ancestry (DL I 22), appreciated by Hellenistic *diadochai* writers as a first-hand Ionian tradition. Since Democritus wrote no biographical works, this last notice probably derives from a 'scientific biography' of Thales sketched in one of Democritus' astronomical treatises. The list of Pre-Eudoxan astronomers in Vitruvius IX 6 3 (Thales, Anaxagoras, Pythagoras, Xenophanes), ending with Democritus himself, is probably quoted from Democritus' Ἀστρονομίη; see 68 B 14, 1 DK

by Eudemus. Another reputed εὑρετής of the cause of eclipses, Anaxagoras, was accused by Democritus of 'having stolen his theories about the sun and the moon' from the ancients, i.e., from the Milesians.¹² Both the true nature of φωτισμοὶ τῆς σελήνης and (I believe) the true cause of solar eclipses were known to Parmenides ca. 500-490 BC.¹³ Parmenides probably got his knowledge from the Pythagorean tradition, and so another line of convergence leads us from Pythagoras to the Milesians. The Orphic Derveni Theogony (about the same time or

= 424 Luria. If so, Democritus certainly regarded Thales as the father of scientific astronomy and physics long before Aristotle. Though Theophrastus wrote 'On Democritus' astronomy' (DL V 43), it is far from certain whether the Peripatetics possessed the whole of 'Corpus Democriteum'. But the Alexandrians certainly possessed it in its integrity and studied Democritus' language and style (68 A 32). It is a priori improbable that a man like Aristarchus of Samos, an Ionian in blood and spirit, never unrolled Democritus' μαθηματικά (tetral VII-IX).

12 DL IX 43 35 = Favorinus fr.44 Mensching = Anaxagoras A 5 DK = Democritus fr 159 Luria. Diels' identification of ἀρχαῖοι (DK II 50 n.2) with 'Leucippus', the supposed teacher and older contemporary of Democritus, is surprising. It has been rightly refuted by Mensching, *Favorin von Arelate* I (Berlin 1963), 135; Lanza, *Anaxagoras*, 16-17; Luria, *Democritea* (Leningrad 1970), 459. Anaximenes with his theory of 'invisible bodies' (A 7, § 5; A 14, cf. Anaxagoras A 42, § 9; A 77) is probably meant. But the expression αἱ δόξαι αἱ τε περὶ ἡλίου καὶ σελήνης is too general and there is no evidence that Anaxagoras (like Anaximenes) applied the theory to the eclipses of the sun. The core of Anaxagoras' 'opinions about the sun and the moon' is that they are 'stones'. Since neither Anaximander nor Anaximenes held such a doctrine, it was natural to conclude that by ἀρχαῖοι Democritus meant Thales. Democritus himself accepted the theory of stars as 'ignited stones' (A 84 87 DK = 393, 396 Luria). Since he was offended by Anaxagoras (DL IX 35, cf. II 14 where Δημοκρίτῳ) his aim was to diminish the originality of Anaxagoras and to reject the potential charge of plagiarism against himself by pointing out to Thales as the true author. There is an interesting echo of the Democritus-Anaxagoras scandal in Plato's *Cratylus* 409a9 (noticed by J. Mansfeld, *Mnemosyne* (1980), 90, n.333) ἔοικε δηλοῦντι παλαιότερον κτλ. (cf. 59 A 76 DK): Anaxagoras' theory of the moon illuminated by the sun turns out to be pre-historical, expressed already by ὀνοματοθέτης in the name σελήνη! Note the hyperbolic and humorous charge of plagiarism which sounds as a parody. The *Cratylus* passage is decisive for the determination of ἀρχαῖαι δόξαι 'stolen' by Anaxagoras.

13 Parmenides B 14; B 10 3 ἐργ' αἰδήλα of the sun = eclipses; cf. A 42 (demonstratur). I regard Parmenides' meeting with Socrates in Plato's *Parmenides* as fiction, and follow the chronology of Appollodorus (*recte* Jacoby).

somewhat earlier) alludes to the spherical moon conceived as 'another earth' which presupposes that it shines by 'reflected light'.¹⁴ It is worth noting that the 'Placita' consistently ascribe to Thales the doctrine of the earthen nature of the moon and the stars.¹⁵ It can be explained away as a doxographical reconstruction from the ἐπιπρόσθεσις theory (which presupposes a non-transparent moon), i.e., from another reconstruction(!). But the new evidence allows another explanation: these astrophysical *placita* of Thales, interconnected with those on φωτισμοί and eclipses, also derive via Eudorus-Diodorus from Aristarchus who got them from an ancient source unknown to or unnoticed by the Peripatetics. The sceptic may object that even if Aristarchus was the source, he simply inferred the whole complex from Democritus' accusing Anaxagoras of plagiarism by attributing the ἀρχαῖαι δόξαι to Thales as 'the true author' of Anaxagoras' doctrines.¹⁶ But the traditionalist will reply that even in this case (which is far from certain) Aristarchus' inference may have been partly correct.¹⁷

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- 14 col XXI = ll 41-2 West (*Orphic Poems* [Oxford 1983], 115) who plausibly combines these lines with Orpheus fr 91 Kern.
- 15 *Placit* II 13 1 (ἄστρα γεώδη); II,20,9 (γεοειδῆ τὸν ἥλιον; II 25 8 (γεώδη τὴν σελήνην). It is not easy to see why Kranz (11 A 17a DK) includes the first two *placita* and omits the third: they must stand or fall together.
- 16 It is remarkable that Anaxagoras' theory of eclipses is derived directly from Thales in Cicero, *Rep* I 16 25; In *Placit* II 29 5 Thales and Anaxagoras are the only Pre-Platonic philosophers combined with μαθηματικοί (i.e., the Diodorus and Aristarchean tradition, cf. note 4 above); *Placit* II 28 5 Θαλῆς πρῶτος ἔφη ὑπὸ τοῦ ἡλίου φωτίζεσθαι ... Ἀναξαγόρας ὁμοίως. Cf. also the combination Thales, Anaxagoras... Democritus in Vitruvius (note 11 above).
- 17 The case becomes more complicated if Democritus went so far as to derive Anaxagoras' theory from pre-historical sages (cf. the *Cratylus* passage, note 12 above) whose views can be reconstructed by means of etymology and allegorical interpretations of myths: 68 B 25 = 397a, 821 Luria proves that Democritus practiced such interpretations. The Anaxagoreans themselves were leading proponents of such methods in the last third of the fifth century: Metrodorus of Lampsacus, the Derveni Anonymus, Euripides, who in particular interpreted Tantalos' 'stone' as an Anaxagorean μύδρος of the sun, (59 A 20a DK). Even in Aristotle it is uncertain sometimes (e.g., *de Caelo* 284a1) whether ἀρχαῖοι refers to a Pre-Platonic philosopher or to anonymous sages of *Urzeit*. The charge of plagiarism in this case, however, would be very weak: the conformity of a philosophical theory to *Urweisheit* was usually desirable, like the argument *e consensu omnium*.

The οἱ μὲν in the last sentence of Aristarchus' quotation almost certainly refer to Thales: cf. Diogenes Laertius I 24 πρῶτος δὲ καὶ τὴν ὕστ<ατην ἡμ>έραν τοῦ μηνὸς τριακάδα εἶπεν (suppl. Scaliger). Diogenes' report (together with I 27 on the 365-day year) is the only explicit evidence of Thales' dealings with the lunisolar calendar, and the main *Belegstelle* for Nilsson's theory which connects the origin of Greek calendar with the astronomical achievements of the Milesians. As it is now attested more than five centuries earlier, the theory itself gains some fresh support.¹⁸ The notice does not mean, of course, that Thales 'first used'¹⁹ the name τριακάς (which is known from Hesiod *OD* 766); it means that Thales first introduced (apparently in a calendar reform) the artificial custom to call τριακάς last day of any month irrespective of whether it was 'hole' (29) or 'full' (30 days).²⁰ Heraclitus (who is credited with some knowledge of Thales' astronomy) speaks about the alternation of 'incomplete' (ὑπόμετρος) and complete months in the new fragment cited immediately after Aristarchus.²¹ Thales and Solon are connected by legend, and both are credited with the regulation of the calendars in their cities. Solon is said to have named the last day of the month ἔνη καὶ νέα (which is Attic) and Thales to have named it τριακάς (which is Ionic and common Greek).²² This looks to be a later construction, the two σοφοί being εὔρεταί of the local calendars; but if εἶπεν is interpreted as 'fixed in official usage', there is nothing unhistorical in this tradition.

18 M.P. Nilsson, 'Die Entstehung und die religiöse Bedeutung des griechisches Kalenders', *Scripta minora* (Lund 1960). Nilsson thought the reform was patronized by the Delphic Oracle (doubted by E.J. Bickerman, *The Chronology of the Ancient World* [London], p.23 of the Russian translation [Moscow, 1975]).

19 As is inaccurately stated in *LSJ*, s v τριακάς II, 1. Diogenes' report cannot mean that Thales defined the length of the month as 30 days, either, *contra* C.J. Classen, *Thales*, Suppl X, (1965), col 943 63; first, because of the formulation ('gave the name of triakas'); second because Thales must have been acquainted with the variability of the synodal month.

20 G. Unger, 'Zeitrechnung der Griechen und Römer', *Handbuch des Altertumswissens* Bd I (Nördlingen 1886), 563; A.C. Samuel, 'Greek and Roman Chronology', *Hand. d. altertumswiss.* I 7 (München 1972), 60, 115. τριακάς is attested in Milesian inscription of the fourth century B C: *SIG* 286 13.

21 So I understand ἄλλοτ' ἐλάσσονος μεταβάλλεται (sc. ἡμέρας), ἄλλοτε πλεῦνας (col II, 46-7).

22 Plutarch *Sol* 25; *DL* I 59. On ἔνη καὶ νέα see M.L. West, *Hesiod's Opera*, 770.

The connection of eclipses with *noumenia* must have been apparent to anyone who understood their true cause, and is emphasized in the parallel report of Cicero, *Rep* I 16 25 Z (not in DK): [Pericles heard from Anaxagoras] ... certo illud tempore fieri et necessario, cum tota se luna sub orbem solis subiecisset; itaque etsi non omni intermenstruo, tamen id fieri non posse nisi intermenstruo tempore ... quod Thaletem Milesium primum vidisse dicunt.' The easiest way to explain the riddle of Thales' prediction would be to suggest that according to his πρόγνωσις solar eclipses must necessarily occur *certo tempore*, i.e., τῇ τριακάδι (at astronomical *noumenia*), for this is what is meant by the 'prediction' of eclipses in the case of Anaxagoras;²³ cf. also Geminus 5 τοῦ κατὰ σελήνην ἄγειν ἀκριβῶς τὰς ἡμέρας παράδειγμά ἐστι τὸ τὰς τοῦ ἡλίου ἐκλείψεις γίνεσθαι τῇ τριακάδι· τότε γὰρ συνοδεύει ἡ σελήνη τῷ ἡλίῳ. Aristarchus may have known this from tradition (divergent from that of Herodotus I 74 οὐρον προθέμενος ἐνιαυτὸν τοῦτον) and interpreted τριακάς as Thales' σημεῖον for the supposed ἐπιπρόσθεσις theory, though in fact the connection of eclipses with *noumenia* may have been empirically established long before the discovery of their true cause. Aristarchus' report on Thales may have been continued by something like ὁ μὲν γὰρ Θαλῆς προεῖπε τῇ τριακάδι ἐκλείψειν τὸν ἥλιον τριακάδα λέγων τὴν νομηνίαν καὶ τὴν σύνοδον. And I wonder if Herodotus' ἐνιαυτὸν τοῦτον arose from the misunderstanding (or misreading) of ἔτην ταύτην, ἐν ᾗ δὲ καὶ ἐγένετο, i.e., 'just that *noumenia* in which it actually occurred'.²⁴

Yet, is it probable that Thales was so ἀξύνετος as not to realize what he actually knew (οὐδὲ μαθόντες γινώσκουσιν Heraclitus B 17)? ἐπιπρόσθεσις is Aristarchus' own term, but τριακάς is not (cf. καλοῦσιν). The latter term alone proves that Thales predicted eclipses (whatever was his exact method, and whether he could determine τὴν ἐκλειπτικὴν τριακάδα or not) – that is, like an astronomer, by

23 Cf. DL II 8 33 προεῖπεν and II 16 25 νομηνίαις.

24 Diels' suggestion (a.p. Guthrie, *HGP* I 47, n.2) that ἐνιαυτός is used here in its 'original' sense of solstice is based on Brugmann's false etymology (from ἐνιαύω): see P. Chantriane, *Dictionnaire étymologique de la langue grecque*, 348 (connects with δί-ενος etc.). The word probably had its classical meaning already in the Mycenaean (*eniiausijo*), cf. V.P. Kazanskene and N.N. Kazanskij, *Predmetno-ponyatijnyj slovar' grečeskogo jazyka. Krito-mikenskij period* (Leningrad 1986), 158. Besides, eclipses have nothing to do with solstices.

calculating the precise dates of *noumeniai*, not like a lucky charlatan, manipulating 'Babylonian records'.²⁵ Thales *knew* that solar eclipses had to do something with the moon cycle, that the moon somehow 'participated' in them and even *determined* them; Was it then so inconceivable for a clever Greek and the originator of the *ratio naturalis* to visualize this mysterious participation as physical intervention?

To answer this question in affirmative we must wait for another scrap of papyrus, e.g., from Democritus' 'Astronomy'. Meanwhile, one thing is absolutely certain: the ascription of the ἐπιπρόσθεσις theory of eclipses (which presupposes the 'earthen' nature of the moon) to Thales was not first made in the first century BC by 'Posidonian' doxography, as one might think hitherto. Aristarchus of Samos knew it and, as I have tried to demonstrate above, his source was the Pre-Peripatetic tradition of the fifth century BC.

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²⁵ The hypothesis of 'Babylonian records' was first developed by Tannery, 62 sq. Since then it has been restated many times, quite recently in Kirk-Raven-Schofield, 82. Such records, however, could only be used by a professional astronomer.