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DID COPERNICUS OWE A DEBT TO ARISTARCHUS?

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During Copernicus's lifetime, in the early years of the sixteenth century, very little was known in western Europe of Aristarchus. Our best source for Aristarchus's heliocentric ideas, the *Sand-reckoner* of Archimedes, was not published until 1544, the year after Copernicus died.¹ In our modern era of library catalogues, reference indices, and data retrieval systems it is easy but anachronistic to imagine that Copernicus could have consulted a manuscript in Italy when he was beginning to learn Greek. In fact, Copernicus relied almost entirely on printed works for his information, and there is only a single case where we know for sure that he used a manuscript source.² Even the encyclopaedist Giorgio Valla, who published various translations of Archimedes, did not mention the *Sand-reckoner* in his *De expetendis et fugiendis rebus opus* (Venice, 1501).³

Of course, Copernicus profited indirectly from Aristarchus's work on the sizes and distances of the Sun and Moon: the basic idea of using the size of the Earth's shadow as measured during a lunar eclipse was transmitted through Hipparchus and is found, although in a drastically revised form, in Ptolemy's *Almagest*, and the diagram for this method appears in Book IV, Chapter 19 of Copernicus's *De revolutionibus*. However, the question of greatest interest is how much Copernicus might have known *directly* of Aristarchus, particularly concerning his heliocentric ideas.

In the autograph manuscript of Copernicus's *De revolutionibus*, still preserved at the Jagiellonian Library in Cracow, the name of Aristarchus of Samos appears six times.⁴ I shall first mention five relatively uninteresting entries in the part of his manuscript submitted for publication. In three places, Copernicus by mistake attributes to Aristarchus a value of the obliquity of the ecliptic that should have been credited to Erathosthenes. The mistake was due to his misinterpretation of the word "Archusianus" appearing in the 1515 *Almagest* (I.12, f. 9v), which was Gerhard of Cremona's attempt to render the Arabic transcription of Eratosthenes's name.⁵ In a fourth citation Copernicus originally mentioned Aristarchus in connection with the motion of precession, but before publication he correctly changed the entry to Aristyllus. The fifth citation includes Aristarchus in a list of those who believed that the year was exactly $365 \frac{1}{4}$ days long, a not very helpful and probably erroneous statement.⁶ Thus, the name of Aristarchus appears only four times in *De revolutionibus* as it was finally printed in 1543, and at least three of these are erroneous.

There is, however, a sixth reference to Aristarchus in the manuscript, far and away the most interesting one because it refers to the Greek astronomer's cosmology, but it was crossed out before publication. What Copernicus had written in the passage is as follows:

And if we should admit that the motion of the Sun and Moon could be demonstrated even if the Earth is fixed, then with respect to the other

wandering bodies there is less agreement. It is credible that for these and similar causes (and not because of the reasons that Aristotle mentions and rejects), Philolaus believed in the mobility of the Earth and some even say that Aristarchus of Samos was of that opinion. But since such things could not be comprehended except by a keen intellect and continuing diligence, Plato does not conceal the fact that there were very few philosophers in that time who mastered the study of celestial motions.⁷

The foregoing passage says very little about the Aristarchan cosmology. Had Copernicus known more, he surely would have been happy to mention it, since he needed all the support that he could muster for his own unorthodox views, and since he quotes with enthusiasm other possible geokineticists from Antiquity with less reputable credentials. In a curious way, Copernicus's intellectual heritage is closely rooted to the island of Samos, but to Pythagoras rather than Aristarchus; he repeatedly cites the Pythagoreans and he knew full well their geokineticism because of Aristotle's protests in *De caelo*. In order to examine the question of what debt, if any, Copernicus owed to Aristarchus, we must inquire about the reasons for this deletion and we must examine in detail what knowledge Copernicus had about his illustrious Greek predecessor.⁸

Throughout most of his life, Copernicus worked in comparative isolation on his astronomical system. By the time he was in his sixties, he had little hope, or intention, of publishing his voluminous manuscript. However, in the spring of 1539 a young astronomer from Wittenberg arrived, eager to learn more detail of Copernicus's radical cosmology. Inflamed with enthusiasm for the new system, Georg Joachim Rheticus urged the ageing Copernicus to put the finishing touches on his manuscript so that it could be taken to Germany for publication. In this process a number of editorial changes were made in the manuscript, including the one that had eliminated the earliest reference to Aristarchus.

Originally, Copernicus had laid out his treatise in seven major sections or books. The first dealt entirely with cosmology, ending with the fleeting reference to Aristarchus and with Copernicus's own longer Latin translation of the so-called "Letter from Lysis", a brief work dealing with Pythagorean philosophy. The translation may simply have been one of those youthful exercises used by Copernicus to improve his skill in Greek. In any event, upon second thought Copernicus decided that the "Letter from Lysis" was not really germane to his purpose, so the entire section was withdrawn and the original Book II on mathematical methods was joined directly onto Book I on cosmology.

Various suggestions have been advanced as to why Copernicus eliminated the "Letter from Lysis" (and therefore also the brief reference to Aristarchus) from his text, but it seems to me that no elaborate explanation is required. The "Letter from Lysis", emphasizing the desire of the Pythagoreans to keep their philosophy secret, may have been appropriate for a manuscript destined to gather dust on the shelves of the cathedral library, but in a printed treatise it offered an awkward and largely irrelevant digression. From an editorial viewpoint, it was eminently sensible to remove the material and to paraphrase some of the ideas in the introductory preface to the Pope. This is precisely what Copernicus did.⁹

When Copernicus reworked the omitted material into the dedicatory letter to Pope Paul III, he mentioned the "Letter from Lysis" in the first paragraph. However, at a later point where Copernicus mentions his precursors, he by then

felt it would be more authoritative to quote his source in the original Greek. Thus Copernicus set down several Greek sentences from the *Opinions of the philosophers*, a work attributed to Plutarch. In translation they read:

Some think that the Earth remains at rest. But Philolaus the Pythagorean believes that, like the Sun and Moon, it revolves around the Fire in an oblique circle. Heraclides of Pontus and Ecphantus the Pythagorean make the Earth move, not in a progressive motion, but like a wheel in a rotation from west to east about its own centre.¹⁰

That this passage is not really from Plutarch but from a pseudonymous work by Aetius Amidenus is of no consequence to us here – what matters is that Copernicus chose to quote this particular paragraph, probably because in the Latin edition it was conspicuously labelled “concerning the motion of the Earth”.¹¹ Because the name of Aristarchus simply did not appear here, the direct reference to Copernicus’s intellectual ancestor was quite inadvertently omitted. In fact, Aetius (Pseudo-Plutarch) had actually mentioned Aristarchus a few pages earlier in his *Opinions of the philosophers*, but in a place where he discussed eclipses. The text says: “Aristarchus counts the Sun among the fixed stars; he has the Earth moving around the ecliptic and therefore by its inclinations he wants the Sun to be shadowed.”¹² This vague and confusing passage may well have been the only hint Copernicus had about Aristarchus as an architect of a heliocentric system. Had Copernicus been able to search the literature more carefully, he might have found two other references to Aristarchus in genuine works of Plutarch, one of which clearly witnessed to the heliocentric idea in Antiquity. In the *Platonic questions*, Query VIII, Plutarch writes:

Ought the Earth ... be understood to have been devised not as confined and at rest, but as turning and whirling about in the way set forth later by Aristarchus and Seleucus, by the former only as an hypothesis, but by Seleucus beyond that as a statement of fact?¹³

In *On the face in the orb of the Moon*, Plutarch mentions Aristarchus of Samos three times, twice in connection with his treatise *On size and distances*, but in the third as follows:

Thereupon Lucius laughed and said: “Oh, sir, just don’t bring suit against us for impiety as Cleanthes thought that the Greeks ought to charge Aristarchus the Samian with impiety on the ground that he was disturbing the hearth of the Universe because he sought to save the phenomena by assuming that the Heaven is at rest while the Earth is revolving along the ecliptic and at the same time is rotating about its own axis.”¹⁴

Had Copernicus known of these references, particularly the latter one, he likely would have quoted it. But there is not a shred of evidence that Copernicus knew anything about Aristarchus as a heliocentrist except for the single rather cryptic passage on eclipses in the *Opinions of the philosophers*.

How was it that Copernicus even saw the *Opinions of the philosophers*? It was printed in Greek in Venice in 1509 in the *Plutarchi opuscula*, a work that also contained both of the genuine Plutarchian references to Aristarchus’s cosmology. Professor Edward Rosen has assumed that Copernicus consulted this dense and bulky edition, noting only the passage from the *Opinions* and overlooking the other references to Aristarchus.¹⁵ There is, however, no firm evidence that

Copernicus either owned or had access to the 1509 Greek text, nor do we know how fluent he was in reading Greek. It seems to me more likely that he would have first found the information in a Latin source, and indeed, a 1516 Latin edition of the *Opinions of the philosophers* with numerous convenient subheadings was available in the library of the cathedral where Copernicus worked. Copernicus himself wrote: "I first found in Cicero that Hicetas supposed the Earth to move. Later I also discovered in Plutarch that certain others were of this opinion."¹⁶

Perhaps by "later" Copernicus meant "after 1518", when the nine items including the Latin Pseudo-Plutarch were bound together in the volume owned by the cathedral library.¹⁷ Because he had the idea for the heliocentric system by 1514 if not earlier, Copernicus would then have read Aetius's *Opinions of the philosophers* only *after* he had firmly and independently grasped the heliocentric hypothesis.

Much later, when Copernicus was making the final revisions of his *De revolutionibus*, he could have sought the original Greek text for the passage he knew in Latin from the Basel 1531 Greek edition of the *Opinions*.¹⁸ If this scenario is correct then Copernicus never saw the genuine Plutarchian references to Aristarchus.

What other evidence do we have concerning how and where Copernicus arrived at his heliocentric cosmology? We simply do not know if Copernicus accepted heliocentrism as an undergraduate in Cracow in the early 1490s, as a graduate student in Italy between 1496 and 1503, or after his subsequent return to Poland. Nor is there any clear-cut path that led Copernicus to his heliocentric cosmology. Like Aristarchus's conception nearly two millenia earlier, Copernicus's cosmology was a great adventure of the mind, a mental construction not forced by any observations and in fact contrary to the immediate senses.

Space does not permit an examination of the beautiful argument, based on one of the few extant early manuscript sources from Copernicus, that the Polish astronomer arrived at his heliocentric system through a Tychonic geo-heliocentric system.¹⁸ If, indeed, Copernicus groped his way to the heliocentric synthesis via an intermediate geocentric scheme, then it is all the more unlikely that knowledge of Aristarchus had any practical influence on his work. Copernicus, like most modern scientists, presents his finished plan and says almost nothing about the pathway to his discovery. Yet there is no question but that harmonious bonds of commensurability, linking the phenomena together "as if by a golden chain", were ultimately persuasive in Copernicus's mind: he liked the idea of placing the Sun, clearly a unique body among the planets, in a unique central place, and he was impressed by the rhythmic regularity possible with the heliocentric arrangement – with Mercury, the fastest planet, revolving nearest the Sun, with Saturn, the slowest, placed at the farthest position, and with the Earth falling in the natural sequence between Venus and Mars. The elegance of this arrangement he could not have discovered directly in any possible citations from Aristarchus. There is no question but that Aristarchus had the priority of the heliocentric idea. Yet there is no evidence that Copernicus owed him anything.¹⁹ As far as we can tell both the idea and its justification were found independently by Copernicus.

It is not really the task of the historian of science to assess the comparative originality of these two scientific giants. The heliocentric cosmology was convincing neither to the contemporaries of Aristarchus nor to those of

Copernicus, but Copernicus had the good luck to be born not only at a time when science was beginning to reach, so to say, a critical mass, but also at a time when scientific works were beginning to be printed; therefore his arguments survived and convinced a later generation of astronomers. For better or for worse, scientific credit goes generally not so much for the originality of the concept as for the persuasiveness of the arguments. Thus, Aristarchus will undoubtedly continue to be remembered as “The Copernicus of Antiquity”, rather than Copernicus as “The Aristarchus of the Renaissance”.

REFERENCES

1. The famous passage in the *Sand-reckoner* reads: “But Aristarchus brought out a book consisting of certain hypotheses, wherein it appears, as a consequence of the assumptions made, that the universe is many times greater than the universe just mentioned. His hypotheses are that the fixed stars and the Sun remain unmoved, that the Earth revolves about the Sun in the circumference of a circle, the Sun lying in the middle of the orbit, and that the sphere of the fixed stars, situated about the same centre as the Sun, is so great that the circle in which he supposes the Earth to revolve bears such a proportion to the distance of the fixed stars as the centre of the sphere bears to its surface.” The translation is from Sir Thomas Heath, *Aristarchus of Samos* (Oxford, 1913), 302.
2. These are the three observations of Mercury by Bernard Walther, not published until 1544.
3. Even though Valla failed to mention the *Sand-reckoner*, he did in fact own the oldest and most complete manuscript of Archimedes, namely Greek manuscript A, which is the source for our text of the *Sand-reckoner*. Furthermore, Valla had seen a translation made by Jacobus Cremonensis around 1450; Jacobus’s own copy of the translation went to the Marciana in Venice in 1468, where it remains today (Marciana f.a.327). A copy of this translation was sent to Nicholas of Cusa, and Regiomontanus made another copy around 1462 which was the basis for the printed Basel edition of 1544. I am indebted to Marshall Clagett for these details, found in his *Archimedes in the Middle Ages*, iii, part III, *The medieval Archimedes in the Renaissance, 1450-1565* (Philadelphia, 1978), chap. 2.
4. This is established with a complete word-in-context index prepared by Heribert Nobis at the Copernicus Forschungsstelle in Munich, and with the index and notes in Edward Rosen’s translation, Nicholas Copernicus, *On the revolutions* (Warsaw-Cracow, 1978). The references are found in Book III, chaps. 2, 6, and 13.
5. See N. M. Swerdlow and O. Neugebauer, *Mathematical astronomy in Copernicus’ De revolutionibus* (New York, 1984), n. 11 on p. 133.
6. Probably taken from Censorinus, *De die natali liber*, chap. 19; this small work appeared in at least eight collections printed during Copernicus’s lifetime.
7. Based on the translation on p. 513 in Owen Gingerich, “From Copernicus to Kepler: Heliocentrism as model and reality”, *Proceedings of the American Philosophical Society*, cxvii (1973), 513-22.
8. This task is rendered much easier by the article and notes of Rosen cited in refs 4 and 15, and by the review by Byron Emerson Wall, “Anatomy of a precursor, The historiography of Aristarchos of Samos”, *Studies in the history and philosophy of science*, vi (1975), 201-28.
9. I feel that it is unfortunate that the two most recent English translators of Copernicus’s book, A. M. Duncan (1976) and Edward Rosen (1978), have disregarded his decision and have inserted the cancelled “Letter from Lysis” directly into the text rather than into an appendix.
10. Aetius Amidenus [Pseudo-Plutarch], *De placitis philosophorum* III.13; Hermann Diels, *Doxographi Graeci* (Stuttgart, 1929); translation from Rosen, *On the revolutions*, 5.
11. *De motione terrae*, f. 20v, *De philosophorum placitis* (Strassburg, 1516); I am indebted to Jerzy Dobrzycki for access to a microfilm of the Uppsala copy of this rare edition – see below, ref. 17.
12. *Ibid.* f. 14, *Aristarchus solem haerentibus stellis annumerat terram vero circulum solis orbem versat itaque eius inclinationibus obumbrari solem voluit*. The Greek text (from Diels, *Doxographi Graeci*, 355) is: Ἀρίσταρχος τὸν ἥλιον ἴστησι μετὰ τῶν ἀπλανῶν, τὴν σὲ γῆν κινεῖ περὶ τὸν ἡλιακὸν κύκλον καὶ κατὰ τὰς ταύτης ἐγκλίσεις σκιαῖζεσθαι τὸν δίσκον.
13. Harold Cherniss (trans.), *Plutarch’s Moralia*, xiii (Loeb Library, Cambridge, Mass., 1976), 77, 79.
14. Based on Harold Cherniss and William C. Helmbold (trans.), *Plutarch’s Moralia*, xii (Loeb Library, Cambridge, Mass., 1957), 55.

15. Edward Rosen, "Aristarchus of Samos and Copernicus", *Bulletin of the American Society of Papyrologists*, xv (1978), 85-93, esp. pp. 89-90.
16. Rosen translation, *On the revolutions*, 4.
17. This collection of short works is still found in the Uppsala University Library – see item 42, p. 380, in Pawel Czartoryski, "The library of Copernicus", pp. 355-96 in *Science and history: Studies in honor of Edward Rosen (Studia Copernicana, xvi)* (Wroclaw, 1978).
18. See Noel M. Swerdlow, "The derivation and first draft of Copernicus's Planetary theory", *Proceedings of the American Philosophical Society*, cxvii (1973), 423-512.
19. After I presented this paper in Samos in 1980, Prof. L. Biermann pointed out Eugen Brachvogel's "Nikolaus Koppernikus und Aristarch von Samos", *Zeitschrift für die Geschichte und Altertumskunde Ermlands*, xxv (1935), 703-67. Brachvogel's conclusions, more philosophically based, are similar: "Kein Faden, nichts, führt da von Aristarch zu Koppernikus. Was dieser an der Weite des Himmels erschaute, hat er für sich allein erspäht."

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