

Heraclides of Pontus on the Solar Anomaly

Almagest

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Abstract

All scholars agree that Heraclides of Pontus affirmed the daily rotation of the Earth on its own axis. Almost all scholars also agree that he did not affirm the rotation of the Earth around the Sun. Nevertheless, there is a text which has been interpreted as asserting that Heraclides defended Heliocentrism. Geminus says: "And thus a certain person, Heraclides of Pontus, coming forward, says that even if the Earth moves in a certain way and the Sun is in a certain way at rest, the apparent irregularity with regard to the Sun can be saved". This text has been used to support that Heraclides held Heliocentrism because the diurnal rotation of the Earth cannot account for the solar anomaly (the apparent irregularity with regard to the Sun). Hence it seems that Heraclides must have introduced the annual revolution around the Sun. In this paper I offer a new interpretation of this text showing that it is possible to explain the non-uniform motion of the Sun through the Zodiac introducing some non-uniformity in the diurnal rotation of the Earth and, therefore, that there is no need to affirm that Heraclides held Heliocentrism, which is in clear contradiction to many other testimonies.

All scholars agree that Heraclides of Pontus affirmed the daily rotation of the Earth on its own axis.¹ Almost all scholars also agree that he did not affirm the rotation of the Earth around the Sun. The *Doxographi* explicitly speaks of this point:

“Heraclides of Pontus [...] make[s] the earth move, not in the sense of translation, but by way of turning as on an axle, like a wheel, from west to east, about its own center”. (Aët. iii, 13, 3; Diels 1879, 378, trans. taken from Heath 1913, 251)

Some other scholars also considered, based mainly on Calcidius commentary to the *Timaeus* 38D (Eastwood 1992, 239-240), whether one could attribute to Heraclides some sort of semi-Tychonic hypothesis according to which Venus and Mercury orbited the Sun, while the Sun, the Moon, and the outer planets orbited the Earth. This model was certainly known in Ancient times (Theon of Smyrna, *The Mathematical Useful...* iii, 33, Dupuis 1892, 301-303, Capella, *De Nuptiis* vii, 857, Stahl et al. 1977, 333), but it seems that the attribution to Heraclides was based on a misinterpretation of Calcidius' text (Neugebauer 1975, 694, Eastwood 1992).

In this paper I will offer an interpretation of another difficult text referring to Heraclides, which poses both philological and astronomical challenges. In his *Commentary on Aristotle's Physics*, Simplicius preserved in a more or less direct quotation a text from Geminus' lost work *Concise Exposition of the Meteorology of Posidonius*.² Not even Simplicius had access to this text, explicitly mentioning that he borrowed the quotation from Alexander of Aphrodisias (Evans and Berggren 2006, 250-252, Todd and Bowen 2009, 158-164). The quotation comes from the famous text in which Geminus distinguishes between the task of the physicists and that of the astronomers. When he is enumerating some examples of hypotheses that could save the phenomena even if they did not pretend to be causal (i.e. true) explanations, Geminus says:

«διὸ καὶ παρελθὼν τις φησὶν Ἡρακλείδης ὁ Ποντικός, ὅτι καὶ κινουμένης πως τῆς γῆς, τοῦ δὲ ἡλίου μένοντός πως δύναται ἢ περὶ τὸν ἥλιον φαινόμενη ἀνωμαλία σῶζεσθαι» (And thus a certain person, Heraclides of Pontus, coming forward, says that even if the Earth moves in a certain way and the Sun is in a certain

1 Simplicius, on De Caelo, ii.7 (289b 1); Heiberg 1984, 441.31-445.5; ii. 14 (297 a 2), Heiberg 1894, 541.27-542.2; c.13, 293b, Heiberg 1894, 519.9-519-11; Schol. in Arist. (Brandis), 505 b, 46-47; Proclus, in Tim. 281 E. All the testimonies are translated by Heath 1913, 254-255. Heraclides of Pontus might not have been the first to affirm the daily rotation of the Earth. We know of some Ecphantus the Syracusan also associated with this hypothesis (Aët. iii, 13, 3; Diels 1879, 378; and also Hippolytus *Refut.* i. 15; Diels 1879, 556). It is possible, however, that Ecphantus was simply a character created by Heraclides in one of his dialogues for advancing this theory in the voice of a Pythagorean (Tannery 1897, 136).

2 Eastwood (1992, 235) argues that the quotation is originally from Posidonius and that Geminus took it from Posidonius's *Meteorologica*.

way at rest, the apparent irregularity with regard to the Sun can be saved). (Evans and Berggren 2006, 254)

The text presents some difficulties in the translation itself,³ but the general meaning seems clear: Heraclides managed to explain the solar anomaly with a model that makes the Earth move in a certain way and the Sun rest in a certain way. The certain way in which the Earth moves for Heraclides is well-known: the Earth rotates around its own axis. The way in which the Sun is at rest, on the contrary, is less clear. One obvious possible solution would be to suppose that, while the Sun rotates around the Earth one turn per year –and, therefore, it is not at rest *simpliciter*– it is at rest so far as its daily rotation – and, therefore, it is at rest *in a certain way*. Böckh (1852, 135-140) defended this interpretation. This configuration explains the apparent daily rotation of the fixed stars and planets, including the Sun, but it forces Böckh to interpret the expression “the apparent *irregularity* with regard to the sun” as implying the Sun’s apparent daily rotation. This is a certainly odd interpretation, since the daily motion is a uniform motion, and cannot be considered an irregular one in any possible sense (Schiaparelli 1926, 184, Heath 1913, 277).

In a geocentric model, the solar anomaly –i.e., the irregularity in the motion through the zodiac that produces the unequal duration of the seasons– could be explained adding some device to the solar mean motion, like two additional spheres in Callipus’s model or an epicycle or eccentric in Hipparchus’s or Ptolemy’s models. Nevertheless, if the Earth rotates around the Sun, one could still account for the solar anomaly by transferring the same device to the Earth’s motion. Bergk (1883, 151), who put forth this interpretation, suggested that Heraclides proposed a heliocentric model in which the Earth rotated around the Sun in a non-uniform motion. Both Schiaparelli and Heath object that this interpretation makes it “impossible to get any plausible sense out of the passage. For the problem of explaining the irregularity of the sun’s motion presents precisely the same difficulties on the one hypothesis as it does on the other; the substitution of one hypothesis for the other does not advance the question in any way, and it explains nothing” (Schiaparelli 1926, 185, Heath 1913, 277). This objection, however, does not seem too fair if we bear in mind that Geminus introduced this case when giving examples of astronomers who could explain the same phenomena with different hypotheses. What Schiaparelli and Heath criticized in Bergk’s suggestion is a necessary condition for being a suitable case for being included in Geminus’s enumeration: both models *must* explain the phenomena with the same success in order to be good examples. This is precisely what happens with Geminus’ remaining example: epicycles and eccentrics. Still, Bergk’s proposal has some

3 There is a problem with the *tís* attributed to Heraclides for it is really odd that a historian of science such as Geminus could have used the word *tis* to refer to a so important philosopher as Heraclides (Schiaparelli 1926, 182-183, Heath 1913, 279). There are also problems in the exact meaning of *παρηθών* (see Heath 1913, 279).

difficulties of its own. First, even if it is clear why the text says that the Sun is at rest, it is not clear at all why the text adds "in a certain way" if for Bergk the Sun would be at rest *simpliciter*. Second, and more important, it is inconsistent with all the other testimonies which only attribute to Heraclides the daily rotation of the Earth and to Aristarchus of Samos the Earth's rotation around the Sun.⁴

Schiaparelli agrees with Bergk's heliocentric interpretation of the text, but changes the phenomenon that both models try to explain. Given that the greatest advantage of Heliocentrism over Geocentrism is the explanation of the anomaly of the planets (i.e., the retrograde motion), Schiaparelli proposes to interpret the expression "the apparent *irregularity* with regard to the sun" not referring to the solar anomaly but to the planetary anomaly. In his *Almagest*, given that the first planetary anomaly is related to the longitude of the Sun, Ptolemy often uses the expression "the irregularity *relatively* to the Sun". So, even if there is no mention of the planets in the text, this interpretation could be inferred by context. Thus, for Schiaparelli, the text shows that Heraclides, and not Aristarchus, could have been the Ancient Copernicus.

Heath followed Schiaparelli in every step but the last. Following Tannery (1899, 305-311), he showed that the best way to solve the oddity of Geminus referring to Heraclides as *τίς* is to suppose that the name of the philosopher does not belong to the original text but was interpolated by a later copyist.⁵ In this way, Geminus would not have been talking about Heraclides. Heath says:

"if it is asked whom Geminus had in mind when using the expression *τίς φησιν*, we can have no hesitation in answering that it was Aristarchus of Samos". (Heath 1913, 282)

One cannot but wonder how far we have been carried by small interpretative steps: starting by supposing that the text meant that Heraclides of Pontus explained the solar anomaly making the Earth to rotate on its own axis and the Sun to rest in some way, we are currently assuming that Geminus was actually thinking that Aristarchus of Samos suggested Heliocentrism for explaining the retrograde motion of the planets! Probably the most audacious of these small interpretative steps is the change of the phenomenon to save, from solar to

4 Martin (1883, 23ss) suggested that, besides the daily rotation, the Earth rotates around the center of the Cosmos one turn per year in a small circle for producing by parallax the solar anomaly. The Sun, on the other side, rotates uniformly around also the center of the Universe. But Schiaparelli (1926, 187-188) and Heath (1913, 278) showed strong objections against this proposal.

5 Gottschalk (1980, 64-66), instead, asserts that "whatever acceptable correction is proposed, there is no avoiding the facts that Heraclides's name is a genuine part of the text". Eastwood 1992, 236.

planetary anomaly. Ptolemy often uses the formula ἡ παρὰ /πρὸς τὸν ἥλιον ἀνωμαλία when referring to the first anomaly of the planets.⁶ In both cases, it indicates not an anomaly *of* the Sun, but an anomaly *related to* the Sun (to the solar elongation). Nevertheless, every time Ptolemy uses the formula ἡ περὶ τὸν ἥλιον ἀνωμαλία, he is unambiguously talking about the solar anomaly.⁷ Accordingly, Geminus also uses περὶ in his expression.

I want to offer a new and different interpretation of Geminus's text that would make astronomical sense and, at the same time, remain close to the original meaning of the text. According to the plain reading of the text, Heraclides found a way of explaining the solar anomaly making the Earth to rotate on its own axis and the Sun to rest in some way. The question to answer, thus, is the following: Is there a way in which the Earth's daily rotation can be responsible for the solar anomaly? The short answer is "yes, there is". If the Sun were to rotate around the Earth in a uniform motion centered on the Earth, we could explain the Sun's annual motion, but without an anomaly. The solar anomaly is evidenced by the different lengths of the seasons. For Callippus spring lasted 94 days, summer 92, autumn 89, and winter 90 (Tannery 1893, 294). To account for the anomaly one could keep the Sun rotating uniformly around the Earth, but accelerate or decelerate the daily rotation of the Earth. During summer one could assume that the Sun goes over one quadrant of the ecliptic in uniform motion, but the Earth rotates on its own axis a bit faster than average, making 94 rotations with respect to the Sun. Then, the spring would last 94 days, not because the Sun moves faster, but because the days are "shorter". If during summer the Earth rotated 92 turns, in autumn 89 turns, and in winter 90 turns, then one would have the solar anomaly transferred to the Earth's rotation: the seasons would be longer or shorter in days not because the Sun changed its speed, but because the days are longer or shorter, i.e. the daily rotation of the Earth is faster or slower. If the speed of the Earth's rotation is uniform during each season and the change is abrupt during equinoxes and solstices, one would arrive to a kind of Babylonian system A, but transferring the changes of speed from the Sun to the Earth rotation. If the speed of daily rotation is changing smoothly day by day, one would arrive to a Hipparchian model, exemplified by the concentric calendars of astrolabes. These astrolabes have two concentric rings, one representing the zodiac, with 360 marks uniformly divided, and one representing the civil calendar with 365 marks. This calendar

6 IX,2 (Heiberg 1898-1903, 2; 208, Toomer 1988, 420); IX,2 (Heiberg 1898-1903, 2, 211; Toomer 1988, 422); IX,6 (Heiberg 1898-1903, 2, 225; Toomer 1988, 444); X,6 (Heiberg 1898-1903, 2; 317, Toomer 1988, 480); XII, 1 (Heiberg 1898-1903, 2, 450; Toomer 1988, 555); XII, 1 (Heiberg 1898-1903, 2, 451; Toomer 1988, 555); XIII,1 (Heiberg 1898-1903, 2, 524; Toomer 1988, 597), and also when referring to the second anomaly of the Moon (IV, 5 (Heiberg 1898-1903, 1, 294; Toomer 1988, 181); IV, 5 (Heiberg 1898-1903, 1, 295; Toomer 1988, 181); V, 1 (Heiberg 1898-1903, 1, 350; Toomer 1988, 217); V,3 (Heiberg 1898-1903, 1, 361; Toomer 1988, 222).

7 Heiberg, 1898-1903, 1, 200, 232, 525; Toomer 1988, 136, 153, 309.

marks are non-uniformly divided with the aim of producing the solar anomaly (Webster and Webster 1998, 31). One could interpret the different lengths of two consecutive day marks as different durations of the days. But I do not think that Heraclides went so far, it would be enough for him to show that, from a qualitative point of view, one could explain the daily motion of the fixed stars and planets by making the Earth to rotate on its own axis, as well as the solar anomaly. It is possible that Heraclides offered his model within the research program of Eudoxus's concentric spheres. Once he realized that Eudoxus needed eight spheres turning in exactly the same way for producing the daily rotation of the heavens and planets, he should have noted that he could spare these eight spheres making the Earth to rotate. Therefore, when Callippus introduced two more spheres for explaining the solar anomaly, Heraclides could show that without introducing new motions, but only suggesting a non-uniformity in the daily rotation of the Earth, he could spare these two new spheres. One might object referring to the oddity of introducing in the context of Ancient Greek astronomy a non-uniform motion which in itself cannot be decomposed into uniform motions. The objector must bear in mind, however, that in my interpretation, Heraclides is introducing non-uniformity in the Earth's motion, not in Heavens. Finally, Geminus's text also affirms that for Heraclides the Sun is at rest 'in a certain way'. Compared with Callippus's model, in Heraclides's the Sun is at rest, i.e. it is not moving, in two important motions: it is at rest with regard to the daily motion and with regard to the anomalistic motion.⁸

Certainly, there is not enough evidence for affirming that this was Heraclides's model. Even more, as Todd and Bowen assert since the whole "body of evidence tell us virtually nothing about the original form and scope of Heraclides' theory, it offers an insecure basis for reconstruction" (2009, 157). But, at least, I have given an alternative interpretation of Geminus text which does not change neither the subject of the text (from Heraclides to Aristarchus) nor the phenomenon to be saved (from the solar to the planetary anomaly).

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⁸ If this interpretation seems a bit forced, you can still have the Sun absolutely at rest and still save the phenomena if you make the sphere of the fixed stars rotate one turn per year from east to west on an axis perpendicular to the ecliptic.

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