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Abstract: It is argumented that the mysterious astronomical system traditionally attributed to Philolaus is in fact the result of a misunderstanding.

1. The astronomical system attributed to Philolaus

Philolaus, contemporary of Socrates and teacher of Archytas, is one of the main exponents of the Pythagorean school. Today few remember him, but the early modern age scientists had in great consideration his contribution to astronomy. Copernicus, in the dedicating letter of *De revolutionibus orbium caelestium*, cites Philolaus among the ancient scientists who suggested him to attribute motions to the Earth. Both Galileo and Newton quote him (erroneously) as an assertor of heliocentrism[1]. The inverse square law, playing an essential role in Newton's theory of universal gravitation, appears for the first time in the *Astronomia Philolaica*: the work in which Ismaël Boulliau believed to have reconstructed the astronomical theory of Philolaus[2].

According to the astronomical theory traditionally attributed to Philolaus (see, for example, Huffman 1993, 231-288) at the center of the universe there is a fire (having nothing to do with the Sun, just one of the bodies revolving around this center). The Earth generates the alternation of day and night through a circular motion around the central fire. In its motion the Earth always turns the same

[1] G. Galilei, *lettera a Cristina di Lorena*; I. Newton, *De mundi systemate liber*, 1.
[2] I. Boulliau, *Astronomia Philolaica*, Piget, Parisis, 1645.

face, opposite to the inhabited one, towards the fire, which is therefore always invisible to us. Around the same fire move in a circle not only the Moon, the planets and the Sun, but also (on an orbit of smaller radius of that of the Earth) the Counter-Earth (Ἀντίχθων), that is a body similar to the Earth but always on the opposite side of it with respect to the central fire, and hence being always invisible.

This theory has always appeared strange because almost completely unrelated to observable phenomena. The motion of the Earth, like the actual motion of the Moon around the Earth, consists of a rotation and a revolution with exactly the same period (of one day). To explain the alternation of night and day, however, only the rotation is sufficient and the revolution is therefore completely unmotivated. Burch, who thinks that Philolaus believed in the Earth flatness, associates the useless motion of revolution to this flatness (Burch, 276), but does not explain why, whence this association appears unjustified.

The central fire not only is not directly visible, but does not generate any observable effect; it is strange, in particular, that the phases of the Moon, already explained by Parmenides through the light coming from the Sun, are in any way not influenced by the light necessarily coming from the central fire[3]. Its introduction seems to be motivated only by aprioristic considerations, metaphysical or religious, which may suggest the idea of associating to the center of the universe, as the noblest place, the noblest element, namely fire[4].

The invisible Counter-Earth has no observable effects as the central fire and we do not even understand the aprioristic reasons that could have led Philolaus to introduce it. Burch assumed that the Counter-Earth had the purpose of balancing the Earth, bringing back to the center the baricenter of the system, but there is not the slightest indication that Philolaus possessed the concept of

[3] The absence of lighting effects by the central fire was noted by Graham.
[4] This argument is referred to by Aristotle in the passage given below as testimony H.

baricenter nor that he wanted to introduce mechanical considerations (foreign to Greek astronomy of his time) in his astronomical system. Moreover, Burch must assume that the Counter-Earth moves on the same orbit as the Earth, while the sources testify that the orbit of the Counter-Earth was of small radius (inner).

A passage by Aetius, quoting Aristotle[5], and one by Aristotle himself[6] hint at a possible role of the Counter-Earth in causing eclipses of the Moon, but Aristotle, not trusting this idea, argues that the Counter-Earth has no relation with observable phenomena and that the Pythagoreans introduced it only to let the bodies rotating around the central fire reach the number of ten, considered by them perfect (the other nine being the Earth, the Moon, the Sun, the five planets and the fixed stars sphere)[7].

Graham attempted to explain the role of the Counter-Earth in the eclipses showing that without this body the system of Philolaus would have been incompatible with the lunar eclipses visible at sunrise or sunset. Apart from the general hints already mentioned, however, there is no evidence in the sources to support Graham's complex argument, nor any evidence to support the hypothesis that Philolaus had devised complex arguments to explain rare phenomena such as twilight lunar eclipses. Admitting Graham's argument, however, we should deduce that Philolaus had introduced an invisible body to solve in a complex way a problem raised by his introduction of the invisible and useless revolution around an invisible and useless central fire. The Counter-Earth, even after Graham's ingenious contribution, thus remains “mysterious"[8], just as the central fire[9].

[5] The passage (Stobaeus, *Anthologium*, 1, 26, 3, 8-10) is quoted in section 7 as testimony G.
[6] Aristotele, *De caelo*, 293b, 21-25. Aristotle adds that, according to "some" not better specified, around the center would turn several bodies, all invisible to us, which interposing themselves between the Sun and the Moon would make the eclipses of the Moon are much more frequent than those of the Sun.
[7] Aristotle in *Metaphysica* (986a, 8-12) barely mentions this topic, which was developed in his lost work on the Pythagoreans and is referred to by Alexander of Aphrodisias (*In Aristotelis Metaphysica Commentaria*, 40, 27 - 41, 2) and Simplicius (*In Aristotelis quattuor libros de caelo commentaria*, 511, 25 - 512, 9).
[8] Such is considered, for instance, in Huffman 2020.
[9] Such is considered, for instance, in Huffman 1993, 243.

In summary, the astronomical system attributed to Philolaus has so far eluded any explanation attempt, helping to perpetuate the idea of Greek thinkers disinterested in the phenomena and willing to imagine any strangeness just to stick to aprioristic ideas.

2. The sources on the theory and its attribution to Philolaus.

Traditionally the Pythagoreans avoided transmitting their knowledge outside the school; for this reason neither Pythagoras nor his immediate successors wrote books. Diogenes Laertius' claim (*Vitae philosophorum*, 85) that Philolaus was the first Pythagorean to break with tradition by writing a book *On Nature* (*Περὶ φύσεως*) is considered credible (see, e.g., Huffman 2020). Fragments of this book have been transmitted, some of which are considered authentic by scholars (Burkert 1972, Huffman 1993), but only the following is relevant to our purposes.

A. The first thing fitted together, the one in the center of the sphere, is called the hearth.[10] (Translation by C.A. Huffman).

The astronomical system attributed to Philolaus has been reconstructed on the basis of the accounts of Aristotle, Aetius, Alexander of Aphrodisias, Simplicius, and Diogenes Laertius. It is believed that Aristotle was familiar with Philolaus' book and used it as a source in his lost work on the Pythagoreans, which is cited by Alexander of Aphrodisias and Simplicius. When in the *De caelo* he mentions the theory, Aristotle does not, however, attribute it to Philolaus, but generically to the Italic philosophers "called Pythagoreans (καλούμενοι Πυθαγόρειοι)"[11]; it seems therefore that he did not attribute the system to Philolaus alone nor did he trace it back to Pythagoras, but considered it a knowledge shared by the Pythagoreans of the fifth and fourth centuries BC. Important

[10] Τὸ πρᾶτον ἁρμοσθέν, τὸ ἕν, ἐν τῷ μέσῳ τᾶς σφαίρας ἑστία καλεῖται. (Stobaeus, *Anthologium*, I, 21, 8).
[11] Aristotle, *De caelo*, 293a, 20-21.

information on this astronomical theory can therefore also be drawn from evidence on other Pythagoreans.

3. Hicetas and Ecphantus

We know of two other Pythagoreans subsequent to Philolaus (but not to Aristotle) who had attributed motions to the Earth: Hicetas and Ecphantus. On their astronomical conceptions we have the following testimonies:

B. The Syracusan Hicetas, as Theofrastus asserts, holds the view that the heaven, sun, moon, stars, and in short all of the things on high are stationary, and that nothing in the world is in motion except the Earth, which by revolving and twisting round its axis with extreme velocity produces all the same results produced by a stationary Earth and a heaven in motion; and this is also in some people's opinion the doctrine stated by Plato in *Timaeus*, but a little more obscurely.[12] (Translation by H. Rackham).

C. Heraclides of Pontus and Ecphantus the Pythagorean make 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 centre.[13] (Translation by T. Heath)

D. [According to Ecphantus] the Earth moves about its own centre toward east.[14]

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[12] Hicetas Syracusios, ut ait Theophrastus, caelum solem lunam stellas, supera denique omnbia stare censet neque praeter terram rem ullam in mundo moveri, quae cum circum axem se summa celeritate convertat et torqueat, eadem effici omnia quae si stante terra caelum moveretur. Atque hoc etiam Platonem in Timaeo dicere quidam arbitrantur, sed paullo obscurius (Cicero, *Academica*, II, xxxix).

[13] Ἡρακλείδης ὁ Ποντικὸς καὶ Ἔκφαντος ὁ Πυθαγόρειος κινοῦσι μὲν τὴν γῆν, οὐ μήν γε μεταβατικῶς, ≤ἀλλὰ τρεπτικῶς ≥ τροχοῦ δίκην ἐνηξονισμένην, ἀπὸ δυσμῶν ἐπ'ἀνατολὰς περὶ τὸ ἴδιον αὐτῆς κέντρον. (pseudo-Plutarch, *Placita philosophorum*, 896A, 5-8).

[14] τὴν δὲ γῆν μέσον κόσμου κινεῖσθαι περὶ τὸ αὐτῆς κέντρον ὡς πρὸς ἀνατολήν. (Hippolytus, *Refutatio omnium haeresium*, I, 15, 2, 5-6).

E. Thales and those who followed him said that the Earth was one; Hicetas the Pythagorean that there were two, our Earth and the Counter-Earth (ἀντίχθων).[15]

F. [Philolaus] was the first to declare that the Earth moves in a circle (κατὰ κύκλον), though some say that it was Hicetas of Syracuse.[16] (translation by R.D. Hicks)

The testimonies B, C and D leave no doubt that Hicetas and Ecphantus had attributed to the Earth only the motion of diurnal rotation. The testimony B by Cicero, in particular, despite the inaccuracies introduced by him (the Moon and the Sun do not maintain the same position with respect to the fixed stars), being based on Theophrastus, is certainly reliable.

The testimony E of Aetius, transmitted by the *Placita philosophorum* of pseudo-Plutarch, is particularly interesting, because it also attributes to Hicetas the use of the term Counter-Earth (ἀντίχθων). To understand what was meant by this term, it is useful to examine the meaning given to it by other authors.

4. Ἀντίχθων

Claudius Ptolemy, discussing in the *Almagest* the possible intervals between two solar eclipses, writes:

[…] in the regions south of the equator, among the so-called *antichtones*, […][17]

[15] Θαλῆς καὶ οἱ ἀπ’ αὐτοῦ μίαν εἶναι τὴν γῆν. Ἱκέτης ὁ Πυθαγόρειος δύο, ταύτην καὶ τὴν ἀντίχθονα. (pseudo-Plutarch, *Placita philosophorum*, 895C, 7-8).

[16] καὶ τὴν γῆν κινεῖσθαι κατὰ κύκλον πρῶτον εἰπεῖν· οἱ δ’ Ἱκέταν <τὸν> Συρακόσιόν φασιν. (Diogenes Laertius, *Vitae philosophorum*, VIII, 85, 1-3).

[17] … παρὰ δὲ τοῖς νοτιωτέροις τοῦ ἰσημερινοῦ τῶν ἀντιχθόνων καλουμένων, … (Ptolemy, *Syntaxis mathematica*, 498, 5-7).

The term *antichtones* thus had for Ptolemy the meaning of inhabitants of the southern hemisphere. The same meaning of the term was given in the commentaries to Ptolemy by Theon and Pappus[18], and also, for example, in the works by Pomponius Mela[19] and Pliny the Elder, who states that the name of *Taprobane*, which in his time indicated an island, anciently indicated the land of the *antichthones*, that is, the hemisphere opposite to ours[20]. Still in the sixth century AD. Cosmas Indicopleustes, exposing his primitive conception of a flat and rectangular earth, derides and accuses of impiety those who claim the existence of the *Antichtones*, pleople being upside down on the other side of the Earth[21]. Achilles Tatius, probably between the second and third century AD, illustrating the concepts of *perieci*, *antoichoi*, *antichtones* and *antipodes* clearly distinguishes the antipodes from the *antichtones*, which for him are the places on the same parallel but on opposite semimeridians[22]. The same explanation of the term is given by an anonymous commentator on Aratus[23]. Cleomedes uses the terms in a different sense[24] and Achilles Tatius states that on the concepts of *antichtones* and *antipodes* there was confusion[25].

All authors using the terms *antichton* and *antichtones*, however, always give them the meaning of a part of the Earth in some sense "opposite" to the one we inhabit (and of its inhabitants) and never the meaning of an external body, with the only exception of the passages that illustrate the astronomical system of Philolaus.

Returning to Hicetas, the testimony E of pseudo-Plutarch has been considered by several scholars to be in contradiction with the

[18] Theon of Alexandria, *Commentaria in Ptolemaei syntaxin mathematicam i-iv*, 402, 1-3; Pappus, *Commentaria in Ptolemaei syntaxin mathematicam v- vi*, 238, 5-6.
[19] Pomponius Mela, *Chorographia*, I, 3.
[20] Pliny, *Naturalis Historia*, VI, 81.
[21] Cosmas Indicopleustes, *Topographia Christiana*, I, sez. 14, 4-6.
[22] Achilles Tatius, *Isagoga excerpta*, 30.
[23] Anonymous, Ἐξ ἑτέρων σχολίων εἰσαγωγή, 6 (in E. Maass, *Commentariorum in Aratum reliquiae*, Berlin: Weidmann, 1898).
[24] Cleomedes, who does not use the term "antichtones," uses the term perieci to denote those whom Achilles Tatius and the anonymous call *antichtones* (Cleomedes, *Caelesti*a I, 1, 209-273, ed. Todd). Achilles Tatius and the anonymous instead use the term *perieci* for the inhabitants of the same place.
[25] Achilles Tatius, *Isagoga excerpta*, 31.

testimony B of Cicero[26]. Certainly it would be so if the ἀντίχθων of Hicetas was the body alien to the Earth and animated by a motion of revolution introduced in the theory attributed to Philolaus, but the contradiction disappears if we think that for Hicetas the word ἀντίχθων had the meaning given to it by all the authors mentioned, that is, that it was the hemisphere opposite to the one we inhabit. The fact that pseudo-Plutarch contrasts the conception of the Earth of Hicetas to that of Thales (who conceived it as a disk resting on water, with only one face walkable) provides a further element in favor of this interpretation.

5. A conjecture on the astronomical system of Philolaus

We have already noted that, according to Aristotle, all of the "so-called Pythagorean" philosophers (a category that certainly included Philolaus, Hicetas and Ecphantus) had shared the same astronomical theory. We also know that Philolaus and Hicetas both used the term Counter-Earth (ἀντίχθων). Furthermore, according to the testimony E of Diogenes Laertius, the motion of the Earth would have been the same circular motion (κατὰ κύκλον) for Philolaus and Hicetas. These testimonies suggest that even for Philolaus, despite the tradition attributes to him the strange theory already described, the Earth was animated by the sole motion of diurnal rotation and the Counter-Earth was nothing but the opposite hemisphere to ours. The possibility that the term ἀντίχθων was introduced by Philolaus to indicate a body outside the Earth and then used by all other authors in a radically different sense, to denote the face of the Earth opposite to ours, in itself implausible, it is even more so in light of its etymology. Indeed, the meaning of the term χθών is not "Earth", in the sense of our entire world, but "ground" and "underground".

[26] In order to eliminate the contradiction various amendments to the texts of the testimonies have been proposed (see Timpanaro Cardini 626-627).

We should therefore read the term ἀντίχθων not as “Anti-Earth” (or “Counter-Earth”) but as “Anti-underground”.

In addition, it can be noted that the term ἀντίχθων is also used in the singular to denote a single entity (as in Aetius' testimony E) and *antichtones*, unlike antipodes, for a population (as in Mela’s and Pliny’s testimonies); these circumstances suggest the possibility that the terms were introduced before the discovery of the sphericity of the Earth, to denote the face of the Earth opposite to ours hypothesized by Anaximander and its inhabitants. This would also explain why, when it was accepted the sphericity of the Earth and the need arose to distinguish various types of "opposites", such as those denoted antipodes and anthoichoi, the confusion recalled by Achilles Tatius on the use of the ancient term also arose.

Aristotle and Aetius state that according to Philolaus Earth and Counter-Earth would both rotate around a "central fire". What could it be? This fire, being central between Earth and Counter-Earth, if these terms referred to two hemispheres of our world, should have been at the center of the Earth. Is it possible that this was the original meaning of the "fire" of which Philolaus had spoken?

The idea that at the center of the Earth there is fire can be suggested by volcanic eruptions and is certainly present in Greek thought. Plato, in particular, in the *Phaedo*, speaks of the fiery river *Pyriphlegethon*[27] that would flow in the depths of the Earth, rivulets of which would be the lavas emitted by volcanoes[28]. Since, according to many scholars, Plato had been particularly influenced by Philolaus, and two of the characters in the *Phaedo*, Simmias and Cebes are students of Philolaus, who is mentioned several times in the dialogue, this testimony is particularly significant. We may also recall that Plutarch, when speaking, in the *De Facie*, of a body in motion near the center of the Earth, specifies that it is an "incandescent mass" (μύδρος)[29]. Later we will find other evidence

[27] This river already appears in Homer's *Odyssey* (X, 513).
[28] Plato, *Phaedo*, 111-113 (in particular 113 B).
[29] Plutarch, *De facie quae in orbe lunae apparet*, 924A.

on fire that, according to a Pythagorean doctrine, would be at the center of the Earth.

Ultimately, we are led to the conjecture that the original astronomical theory of Philolaus (and other Pythagoreans) could have simply stated that Earth and Counter-Earth, i.e. the hemisphere we inhabit and the opposite one, both rotated around the center of the Earth, in which there was a fire.

This theory is consistent with the fragment A (considered authentic) and it would be capable of explaining both the most basic astronomical observations (the diurnal motion of fixed stars and the rising and setting of the Sun and Moon) and the origin of volcanic phenomena and, while accepting in all likelihood the sphericity of the Earth, should have placed particular emphasis on the discovery, dating back to Anaximander, of parts of the Earth opposite to us[30]. it would become obvious that both the anti-earth and the central fire are invisible and there would be no longer any mysterious element not suggested by the phenomena and foreign to the tradition of Greek thought.

It remains to explain the origin of the strange theory transmitted by the tradition as belonging to Philolaus, and to verify the compatibility of the conjecture with the existing testimonies.

6. Possible origin of the misunderstanding

To accept the conjecture just proposed we must assume that Aristotle (possibly preceded by others[31]) had misunderstood the astronomical system of Philolaus. I believe that two considerations make this hypothesis less unlikely than it may appear at first glance.

Iamblichus, referring to the Pythagoreans, writes:

[30] This point is highlighted in the (authentic) fragment of Philolaus' book, where it is emphasized the symmetry between up and down (Stobaeus, *Anthologium*, 1, 15, 7).

[31] It cannot be excluded, for example, that to start the misunderstanding was Speusippus, who had written a book *On the numbers of the Pythagoreans* based primarily on Philolaus, in which the decade was also studied in relation to cosmic events (*Theologoumena arithmetica*, 82 = Philolaous test. A13 Diels-Kranz).

To those out of their walls, and as I may say, to the profane, if they happened to be present, these men spoke obscurely to each other through symbols […].[32] (Translation by T. Taylor).

At least two accounts suggest that Philolaus, adhering in part to the tradition of his school, had expressed himself in a particularly obscure way.

In Plato's *Phaedo* there is this exchange of lines between Socrates and Philolaus' student Cebes:

[Socrates]: How is this, Cebes? Have you and Simmias, who are pupils of Philolaus, not heard about such things?
[Cebes]: Nothing clear, Socrates.[33]

A scholium to Plato's work is more explicit:

[Philolaus] also taught by riddles, according to their [the Pythagoreans'] tradition.[34]

If Philolaus had expounded his astronomical system in a few partially enigmatic sentences, a misunderstanding could certainly not be ruled out.

The second consideration concerns the origin of the misunderstanding, which can likely be traced in the different meanings of the Greek term γῆ, which can refer both to the Earth in the sense of the world we inhabit and to one of the four elements that, according to many philosophers, beginning with Empedocles, constitute the universe: earth, water, air and fire.

Philolaus, accepting geocentrism and stating the only diurnal rotation of the Earth, could have alluded to a fire placed at the center of the Earth writing that at the center of the cosmos (and therefore,

[32] ἐπὶ δὲ τῶν θυραίων καὶ ὡς εἰπεῖν βεβήλων, εἰ καί ποτε τύχοι, διὰ συμβόλων ἀλλήλοις οἱ ἄνδρες ἠνίττοντο… (Iamblichus, *De vita Pythagorica*, 227, 3-5).
[33] Τί δέ, ὦ Κέβης; οὐκ ἀκηκόατε σύ τε καὶ Σιμμίας περὶ τῶν τοιούτων Φιλολάῳ συγγεγονότες;- Οὐδέν γε σαφές, ὦ Σώκρατες. (Platone, *Fedone*, 61D, 6-8).
[34] ὃς καὶ δι’αἰνιγμάτων ἐδίδασκε καθάπερ ἦν ἔθος αὐτοῖς (test. 1A Diels Kranz).

implicitly, of the Earth) there was not the "earth element" (γῆ), but the "fire element" (πῦρ).

In this case his statement could have easily been misrepresented by imagining that with γῆ he had meant not the earth element, but our world and had therefore abandoned geocentrism. Since the motion of the Earth κατὰ κύκλον asserted by Philolaus (according to testimony F) could be understood as either a motion of rotation or a motion of revolution along a circumference, the misunderstanding would have forced the second interpretation. Furthermore, the obvious statement that the Counter-Earth was below us, in the new setting, would be interpreted as the assertion that the orbit of the anti-Earth was of smaller radius, leading just to the astronomical theory traditionally attributed to Philolaus.

7. Other testimonies

Some testimonies are consistent both with the theory traditionally attributed to Philolaus and with our reconstruction. Consider, for example, the following passage by Aetius, which is at the origin of the idea that the Counter-Earth plays a role in the eclipses of the moon.

> G. Some of the Pythagoreans, according to the research of Aristotle and the assertion of Philip of Opus, [say that the moon is eclipsed] by the interposition sometimes of the earth and sometimes of the counter-earth which reflects [the sun's light].[35] (Translation by C. A. Huffman).

The original meaning of this sentence can be that sunlight directed towards the moon can be intercepted both from our

[35] Τῶν Πυθαγορείων τινὲς κατὰ τὴν Ἀριστοτέλειον ἱστορίαν καὶ τὴν Φιλίππου τοῦ Ὀπουντίου ἀπόφασιν ἀντιφράξει τοτὲ μὲν τῆς γῆς, τοτὲ δὲ τῆς ἀντίχθονος. (Stobaeus, *Anthologium*, 1, 26, 3, 8-10).

hemisphere and from the other one (of course only in the second case the eclipse is visible from us).

Other accounts preserve traces of the original astronomical theory. Let us read, for example, this passage from Aristotle:

H. These [the Pythagoreans] reason that the most honourable body ought to occupy the most honourable place, that fire is more honourable than earth, […] Arguing from these premises, they say it must be not the earth, but rather fire, that is situated at the centre of the sphere. The Pythagoreans make a further point. Because the most important part of the universe - which is the centre - ought more than any to be guarded, they call the fire which occupies this place the Watch-tower of Zeus [...].[36] (Translation by C.A. Huffman).

It is clear here that the comparison between earth and fire concerns the two elements and not two astronomical bodies. Moreover, the idea that the central fire is particularly well guarded certainly fits better with a fire at the center of the Earth than with an igneous mass at the center of the cosmos.

A passage from pseudo-Plutarch's *Placita philosophorum* provides more direct support for the conjecture:

I. Philolaus the Pythagorean [says] that fire is in the middle (for this is the hearth of all), and that the counter-earth (ἀντίχθων) is second, the earth we inhabit is third and lies opposite to and moves around with the counter-earth. Accordingly, those on the counter-earth cannot be seen by those on this earth.[37] (Translation by C.A.J. Huffman).

[36] Τῷ γὰρ τιμιωτάτῳ οἴονται προσήκειν τὴν τιμιωτάτην ὑπάρχειν χώραν, εἶναι δὲ πῦρ μὲν γῆς τιμιώτερον, […]· ὥστ' ἐκ τούτων ἀναλογιζόμενοι οὐκ οἴονται ἐπὶ τοῦ μέσου τῆς σφαίρας κεῖσθαι αὐτήν, ἀλλὰ μᾶλλον τὸ πῦρ. Ἔτι δ' οἵ γε Πυθαγόρειοι καὶ διὰ τὸ μάλιστα προσήκειν φυλάττεσθαι τὸ κυριώτατον τοῦ παντός, τὸ δὲ μέσον εἶναι τοιοῦτον, [ὃ] Διὸς φυλακὴν ὀνομάζουσι τὸ ταύτην ἔχον τὴν χώραν πῦρ· (Aristotele, *De caelo*, 293a, 30 – 293b, 4).
[37] Φιλόλαος ὁ Πυθαγόρειος τὸ μὲν πῦρ μέσον, τοῦτο γὰρ εἶναι τοῦ παντὸς ἑστίαν· δευτέραν δὲ τὴν ἀντίχθονα,

The fact that the ἀντίχθων is here opposed not to the earth, but to "the earth we inhabit (ἣν οἰκοῦμεν γῆν)," i.e., the ecumene, and that both turn together facing opposite sides, indicates clearly enough the astronomical theory we have conjectured was the original Pythagorean one.

One of the chief evidences of the strange theory attributed to Philolaus is the following passage from Aristotle:

J. Most of those who hold that the whole universe is finite say that it [the Earth] lies at the centre, but this is contradicted by the Italian school called Pythagoreans. These affirm that the centre is occupied by fire, and that the earth is one of the stars, and creates night and day as it travels in a circle about the centre. In addition they invent another earth, lying opposite our own, which they call by the name of "counter-earth". [38] (Translation by C.A. Huffman).

Simplicius' commentary on this passage provides, in my opinion, a decisive confirmation of the conjecture. After setting forth Aristotle's interpretation of the Pythagorean astronomical system, Simplicius adds:

K. This, then, is the way he [Aristotle] understands the Pythagoreans doctrines. But those who share in them in a more genuine way say that the fire in the centre is the demiurgic power which generates living things from the centre of the whole Earth and heats its parts which have grown cold. This is why some of them call fire the tower of Zeus, as [Aristotle] recounts in his *Pythagorica*, others the guardpost of Zeus, as

τρίτην δ'ἣν οἰκοῦμεν γῆν ἐξ ἐναντίας κειμένην τε καὶ περιφερομένην τῇ ἀντίχθονι· παρ' ὃ καὶ μὴ ὁρᾶσθαι ὑπὸ τῶν ἐν τῇδε τοὺς ἐν ἐκείνῃ. (pseudo-Plutarco, *Placita philosophorum*, 895E, 4-8).

[38] τῶν πλείστων ἐπὶ τοῦ μέσου κεῖσθαι λεγόντων, ὅσοι τὸν ὅλον οὐρανὸν πεπερασμένον εἶναί φασιν, ἐναντίως οἱ περὶ τὴν Ἰταλίαν, καλούμενοι δὲ Πυθαγόρειοι λέγουσιν· ἐπὶ μὲν γὰρ τοῦ μέσου πῦρ εἶναί φασι, τὴν δὲ γῆν, ἓν τῶν ἄστρων οὖσαν, κύκλῳ φερομένην περὶ τὸ μέσον νύκτα τε καὶ ἡμέραν ποιεῖν. Ἔτι δ' ἐναντίαν ἄλλην ταύτῃ κατασκευάζουσι γῆν, ἣν ἀντίχθονα ὄνομα καλοῦσιν. (Aristotele, *De caelo*, 293a, 18-24).

> he says in this work, and others the throne of Zeus, as others say. They [the Pythagoreans] called the Earth a star on the grounds that it too is an instrument of time, since it is the cause of day and night – it makes day the part illuminated facing the sun, night because of the cone which is produced from its shadow. And the Pythagoreans called the moon counter-earth […] (translation by I. Mueller).[39]

A scholium to the same passage in *De caelo* also corrects Aristotle in a similar way to what Simplicius does, stating that for the Pythagoreans there is a fire at the center of the Earth[40]. The two texts are too similar to be independent of each other, but unlike Simplicius, the scholiast explicitly writes that the Earth produces days and nights because it is a "moving star (ἄστρον φερόμενον)," evidently referring to rotational motion.

It is not easy to understand the origin of the idea that the name Counter-Earth was given to the Moon[41], but otherwise Simplicius and the scholiast describe quite clearly the system that we have argued to be the original Pythagorean one: the Earth at the center of the cosmos has a fire at its center and its rotation produces the alternation of day and night.

On the basis of the previous passages, this theory has been identified as Pythagorean since the nineteenth century by various scholars, who, however, not taking into account the possibility of a misunderstanding by Aristotle, have considered it a theory different from that (hopelessly obscure) of Philolaus and posterior to him[42]. To support this thesis, however, it is necessary to deny reliability

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[39] Καὶ οὕτω μὲν αὐτὸς τὰ τῶν Πυθαγορείων ἀπεδέξατο· οἱ δὲ γνησιώτερον αὐτῶν μετασχόντες πῦρ μὲν ἐν τῷ μέσῳ λέγουσι τὴν δημιουργικὴν δύναμιν τὴν ἐκ μέσου πᾶσαν τὴν γῆν ζῳογονοῦσαν καὶ τὸ ἀπεψυγμένον αὐτῆς ἀναθάλπουσαν·διὸ οἱ μὲν Ζηνὸς πύργον αὐτὸ καλοῦσιν, ὡς αὐτὸς ἐν τοῖς Πυθαγορικοῖς ἱστόρησεν, οἱ δὲ Διὸς φυλακήν, ὡς ἐν τούτοις, οἱ δὲ Διὸς θρόνον, ὡς ἄλλοι φασίν. ἄστρον δὲ τὴν γῆν ἔλεγον ὡς ὄργανον καὶ αὐτὴν χρόνου· ἡμερῶν γάρ ἐστιν αὕτη καὶ νυκτῶν αἰτία·ἡμέραν μὲν γὰρ ποιεῖ τὸ πρὸς τῷ ἡλίῳ μέρος καταλαμπομένη, νύκτα δὲ κατὰ τὸν κῶνον τῆς γινομένης ἀπ’αὐτῆς σκιᾶς. ἀντίχθονα δὲ τὴν σελήνην ἐκάλουν οἱ Πυθαγόρειοι, […]. (Simplicius, *In Aristotelis quattuor libros de caelo commentaria*, 512, 9-18.

[40] Scholia in Aristotelem (Brandis), pp. 504b 42 – 505a 5.

[41] It is possible that Simplicius has altered the statement of the source that according to genuine Pythagorean theory the innermost of the bodies revolving around the center (which in the theory transmitted by Aristotle is the Counter-Earth), is actually the Moon.

[42] Boeckh 96, Schiaparelli 404, Timpanaro Cardini 859-861. Burkert 232-233, Huffman 1993 242-243.

not only to Simplicius and to the scholiast (who, by attributing the doctrine generically to the "Pythagoreans", evidently intends to allude to the same ones Aristotle speaks of in the passage he is commenting), but also to Aristotle, who attributes a single astronomical theory to all philosophers "called Pythagoreans"[43].

We know that Simplicius (who had also been in Persia) was familiar with Hellenistic texts unknown to other authors[44]: among these could have been works that had corrected Aristotle's interpretation of Pythagorean astronomical theories.

It is very difficult to identify the source used by Simplicius, but it is easily understandable that the growing authority attributed to Aristotle ended up setting aside alternative interpretations of Pythagorean astronomical theories.

References

Boeckh A., "Untersuchungen über das kosmische System des Platon", Berlin, Veit & Comp., 1852.

Burch, G. B., "The Counter-Earth", *Osiris*, 11: 267-294, 1954.

Burkert W., "Lore and Science in Ancient Pythagoreanism", E. Minar (trans.), Cambridge, Mass.: Harvard University Press, 1972, 1st German edition 1962.

Graham D. W., "On Philolaus' astronomy", *Archive for History of Exact* Sciences, Vol. 69, No. 2, pp. 217-230, 2015.

Huffman C. A. 1993, "Philolaus of Croton: Pythagorean and Presocratic", Cambridge: Cambridge University Press.

Huffman C.A. 2008, "Philolaus and the Central Fire", in S. Stern Gillet, K. Corrigan (eds.), "Reading Ancient Texts. Presocratics and Plato", vol. 1, Brill Studies in Intellectual History, 161, Leiden: Brill, pp. 57-94.

[43] The possibility that the Pythagorean doctrine mentioned by Simplicius is posterior to Aristotle is ruled out by the considerations that the purely rotary movement of the Earth is attributed to Icetas, Hecphanthus, and Heraclides of Pontus (none of whom is later than Aristotle), and fire inside the earth is attested in Plato.

[44] Simplicius, for example, is the only source we have on Hipparchus' work on gravity.

Huffman C.A. 2013, "Philolaus critique of Heraclitus", in D. Sider, D. Obbink (eds.), “Doctrine and Doxography”, Berlin: De Gruyter, pp. 121-44.

Huffman C. A. 2020, "Philolaus", *The Stanford Encyclopedia of Philosophy* (Fall 2020 Edition), Edward N. Zalta (ed.), URL = <https://plato.stanford.edu/archives/fall2020/entries/philolaus/>.

Schiaparelli G., “I precursori di Copernico nell’antichità”, in “Scritti sulla storia dell’astronomia antica”, Parte I, tomo I, Bologna, Zanichelli, 1925.

Timpanaro Cardini M., “Pitagorici antichi. Testimonianze e frammenti”, Milano, Bompiani, 2010.

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