

PYTHAGOREAN PHILOLAUS' PYROCENTRIC UNIVERSE: ITS SIGNIFICANCE AND CONTRIBUTION TO ASTRONOMY AND ASTROPHYSICS

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ABSTRACT. In this work, first, I reexamine the pyrocentric universe of the Pythagorean, Philolaus, who emphatically propounded that the center of the cosmos is neither the earth nor the sun, but a central fiery *hearth* that stands in the middle of the spherical universe. Second, I attempt to demonstrate the value and significance of this pyrocentric cosmic model by elaborating its novel revolutionary elements and its contribution to astronomy. Third, by underlining the diachroneity and timeliness of this cosmic model, I try to establish as to how the model served as a precursor to not only the ancient and modern heliocentric models, as widely believed, but also as much to the contemporary cosmic models and theories of astrophysics.

KEYWORDS. Philolaus, Pythagoreanism, cosmology, universe, astronomy, astrophysics

Introduction

Pythagoreans were the first, in the history of philosophy and science, to conceive that the earth does not form the center of the universe, but is an orbiting planet, a fact that is closer to the scientific truth. However, most of the historical accounts of science today wrongly project that astronomical revolution started from the 17th century onwards with the Copernican Revolution, by pioneers like Copernicus, Brahe, Kepler, Galileo, Newton, and others. Only when there is a reference to other associated ancient Greeks, the names of a few astronomers such as Aristarchus and Ptolemy are mentioned. The true pioneers of the astronomical revolution — Pythagoreans and the other Presocratics — find little or no mention in these accounts.

To set the facts right, in this work, first, I reexamine the pyrocentric universe of the Pythagorean, Philolaus, who emphatically propounded that the center of the cosmos is neither the earth nor the sun, but a central fiery *hearth* that stands in the middle of the spherical universe. Second, I attempt to demonstrate the value and significance of this pyrocentric cosmic model by elaborating its novel revolutionary elements and its contribution to astronomy. Third, by underlining the diachroneity and timeliness of this cosmic model, I try to establish as to how the model served as a precursor to not only the ancient and modern heliocentric models, as widely believed, but also as much to the contemporary cosmic models and theories of astrophysics.

Philolaus' Pyrocentric Universe: The Central Fiery *Hearth*

For an accurate reconstruction of the Philolaic cosmological system, one has to rely only on two genuine fragments and a few testimonia, as is usually the tragic case with all the Presocratics. The fragments that describe the cosmogony of Philolaus are B7 and B17.¹ In B7, Philolaus asserted that the cosmos begins first with the harmonizing and fitting together (*τὸ πρᾶτον ἀρμωσθέν*) within the middle of the spherical universe (*τὸ ἐν ἐν τῷ μέσῳ τᾶς σφαιράρας*), which is the central *hearth* (*ἐστία*). In B17, he regarded the universe as an ordered unity (*ὁ κόσμος εἷς*) that came to be at the middle (*ἤρξατο δὲ γίνεσθαι ἄχρι τοῦ μέσου*), and that it expanded and developed symmetrically around the middle, both upwards and downwards, thus implying that it is a sphere as affirmed in B7, with two similar but reversed hemispheres. Philolaus was perhaps influenced by Parmenides'² cosmic "well-rounded sphere which is from the center equally balanced in every direction," or by Empedocles'³ cosmic *Sphairos* under the reign of Love. From the testimonia, it can be inferred that this *hearth*, in the center of the universe, is a central fire.

Additionally, in fragment B1, Philolaus maintained that the harmonizing and fitting together of the ordered cosmos involves both unlimiteds and limiters (*ἀ φύσις δ' ἐν τῷ κόσμῳ ἀρμόχθη ἐξ ἀπείρων τε καὶ περαινόντων*), while in B6, he argued that for the cosmos to come into being, the unlimited and the limiters need to be first harmonized and fitted together. The unlimiteds (*ἄπειρα*) are continua without limit, such as water, air, or fire, which were used by other Presocratics as the first material cosmic principles. The limiters (*περαίνοντα*) are things that set the limits in a continuum, such as shapes or forms. These first principles are fitted together in a mathematical harmony. One can infer from B7 that fire is the unlimited element, and the center of the cosmic sphere is the limiter, in which fire is placed, thus, making fire limited. Thus, the unlimited and the limiter got harmonized and fitted together as the cosmos. Further, according to Aristotle,⁴ after the

¹ DK 44.

² DK 28 B8.43-44.

³ DK 31 B28, B29.

⁴ Aristotle, *Metaphysics* 1091a15.

first unity of the central fire, the next part of the cosmogony was for the closest part of the unlimited to be immediately drawn in and limited by the limit (*εὐθύς τὸ ἐγγιστα τοῦ ἀπείρου ὅτι εἴλκετο καὶ ἐπεραίνετο ὑπὸ τοῦ πέρατος*). Furthermore, Aristotle⁵ also claimed that a series of three unlimiteds were brought in from the unlimited outside the cosmic sphere: time, breath, and void (*ἐπεισάγεσθαι δ' ἐκ τοῦ ἀπείρου χρόνον τε καὶ πνοήν καὶ τὸ κενόν*). Philolaus, who seemed to follow the usual Presocratic cosmological picture, first envisaged that the spherical cosmos with a central fire at its center is surrounded by an unlimited expanse, outside the spherical universe, from which the central fire drew in the three unlimited elements of time, breath, and void, to continue further construction of the cosmos. Thus, according to Philolaus' cosmogony, the interaction of the hot central fire with the cold breath, which seems to cool the cosmos, leads to the generation of the other materials of the cosmos, such as water and earth. Some pieces of the central fire may have been separated, from which, perhaps, the remaining heavenly bodies — the earth, the moon, the planets, the sun, and the stars — were formed. Aristotle believed that the void served to divide the places occupied by all the individual things created in space (*τὸ κενὸν ὃ διορίζει ἐκάστων τὰς χώρας αἰεὶ*). And time is most likely to serve the function of setting the temporal measures of all cyclical periods and revolutions of all heavenly bodies.⁶

However, to construct a fuller picture of the Philolaic pyrocentric universe, one must also take into account the genuine testimonia DK 44: A16, A17, A19,⁷ A20, A21, A22; DK 58: B37, B37a; and Aristotle's F203, which provide additional evidence about Philolaus' cosmological and astronomical system. According to these testimonia, Philolaus' universe is pyrocentric, that is, there is a central fire in the middle of the spherical cosmos, the fiery *hearth*, around which all the ten heavenly bodies are dancing in ten homocentric circles (A16: *πῦρ ἐν μέσῳ περὶ τὸ κέντρον ὅπερ ἐστὶν τοῦ παντός καλεῖ... περὶ δὲ τοῦτο δέκα σώματα θεῖα χορεύειν*). Beginning from the inside of the sphere, in the first circle around the central fire lies the counter-earth, in the second lies the earth, in the third lies the moon, in the fourth lies the sun, in the fifth up to the ninth circles lie the five known planets of antiquity in no specified order, and in the tenth, the outermost circle, lie the fixed stars (A16: *οὐρανόν, πλανήτας, μεθ' οὓς ἥλιον, ὑφ' ᾧ σελήνην, ὑφ' ἧ τὴν γῆν, ὑφ' ἧ τὴν ἀντίχθονα*). The earth moves around the central fire in an inclined circle, in the same way as the sun and the moon (A21: *τὴν γῆν... κύκλῳ περιφέρεσθαι περὶ τὸ πῦρ (κατὰ κύκλον λοξόν) ὁμοιοτρόπως ἡλίῳ καὶ σελήνῃ*). This probably indicates that the rest of the bodies also move in the same inclined circles around the center, from west to east, as the earth. The earth completes its revolution around the central fire in 24 hours. The moon completes its revolution in about a month, because its day is 15 times that of an earth day (A20: *πεντεκαίδεκαπλάσια... καὶ τὴν ἡμέραν τσαύτην τῷ μήκει*), and its night correspondingly 15 times that of an

⁵ Aristotle, F201; cf. also *Physics* 213b22.

⁶ See also Huffman 1993, 203-215; 2008, 14-15.

⁷ Cf. also Achilles, *Isagoga excerpta* 19 (46, 13 Maass).

earth night. The sun completes its revolution in a year of 364½ days (A22: *Philolaus annum naturalem dies habere prodidit CCCLXIII et dimidiatum*). The rest of the planets have their own revolution periods, whose number increase with their proximity to the periphery of the sphere. This indicates that the counter-earth and the earth, which move closer to the central fire, have the fastest motions. The other bodies that move farther from the central fire have slower motions; the farther they are the slower are their motions. Thus, the fixed stars have the slowest motion. The counter-earth always remains and moves opposite to the earth, as denoted by its name (*ἀντί + χθών*) (A17: *γῆν ἐξ ἐναντίας κειμένην τε καὶ περιφερομένην τῇ ἀντίχθονι*; B37: *ἀντίχθονα δὲ καλουμένην διὰ τὸ ἐξ ἐναντίας τῆδε τῆ γῆ εἶναι*), in such a way that the inhabited side of the earth is always turned away from it; hence, one can never see the counter-earth (B37: *ἡ δὲ ἀντίχθων... οὐχ ὁράται ὑφ' ἡμῶν διὰ τὸ ἐπιπροσθεῖν ἡμῖν ἀεὶ τὸ τῆς γῆς σῶμα*; A17: *παρ' ὃ καὶ μὴ ὁρᾶσθαι ὑπὸ τῶν ἐν τῆδε τοὺς ἐν ἐκείνῃ*; F203: *καὶ διὰ τοῦτο τοῖς ἐπὶ τῆς γῆς ἀόρατον εἶναι*). In addition, one can never see the central fire also, because as the earth rotates once on its axis around the center, its inhabited side always remains turned away from both the counter-earth and the central fire. Furthermore, the central fire remains hidden from the earth owing to the intervening counter-earth. This also implies that the revolution speed of the counter-earth must be identical to that of the earth.⁸

At the periphery of the spherical universe, Philolaus asserted that there is another fire at the uppermost place surrounding the entire cosmos (A16: *καὶ πάλιν πῦρ ἕτερον ἀνωτάτω τὸ περιέχον*), referring obviously to the fixed stars that are fiery. Thus, in the universe, all light and heat comes mainly from the central fire at the middle, which is the demiurgic force that generates life, light, and heat on all heavenly bodies (B37: *πῦρ μὲν ἐν τῷ μέσῳ λέγουσι τὴν δημιουργικὴν δύναμιν τὴν ἐκ μέσου... ζωογονοῦσαν καὶ... ἀναθάλλουσαν*), as well as from the fiery fixed stars at the periphery, which transmit their light and heat to all other heavenly bodies. In addition, the sun, which is a body-like glass, receives this cosmic light and heat reflected by the central fire and the fixed stars, strains it, and transmits it to the earth and other heavenly bodies (A19: *ύαλοειδῆ τὸν ἥλιον, δεχόμενον μὲν τοῦ ἐν τῷ κόσμῳ πυρὸς τὴν ἀνταύγειαν, διηθοῦντα δὲ πρὸς ἡμᾶς τὸ τε φῶς καὶ τὴν ἀλέαν*). However, the earth cannot receive its light directly from the central fire, because of the intervening counter-earth. Thus, the earth receives its light from the sun, which in turn receives it from both the central fire and the fiery fixed stars. Furthermore, the earth has its day and night depending on its position relative to the sun: it is day when the earth faces the sun and night when it moves away from the sun (B37: *τὴν δὲ γῆν... κατὰ τὴν πρὸς τὸν ἥλιον σχέσιν νύκτα καὶ ἡμέραν ποιεῖν... ἡμέραν μὲν γὰρ ποιεῖ τὸ πρὸς τῷ ἡλίῳ μέρος καταλαμπομένη, νύκτα δὲ κατὰ τὸν κῶνον τῆς γινομένης ἀπ' αὐτῆς σκιᾶς*).

Philolaus also considered 59 years as a 'great year' (A22: *est et Philolai Pythagorici annus ex annis LIX*), "in which the lunar and solar cycles were reconciled."⁹ This

⁸ See also Huffman 2003, 243-254; 2008, 16-19.

⁹ Huffman 2008, 18.

‘great year’ may be related to the doctrine of the periodical return of all things that Dicaearchus¹⁰ assigned to the Pythagoreans, and perhaps also to the Pythagorean doctrine of reincarnation.¹¹

So far, I tried to make an accurate reconstruction of Philolaus’ pyrocentric universe, based on the evidence drawn from the ancient fragments and testimonia. In the subsequent parts of my paper, I am not interested in discussing some of the controversies raised about the Philolaic universe, because they do not contribute to my theme. What comprises the main scope of my essay in the following sections is to show the novel nature of the Philolaic pyrocentric universe, thereby attempting to prove its great significance and contribution to the science of astronomy and astrophysics.

Value and Significance of Philolaus’ Pyrocentric Universe

By introducing the pyrocentric universe, Philolaus and the Pythagoreans were the first to consider the earth as being away from its traditional central fixed position in the universe and view it as a planet instead, which moves and orbits around a new fiery cosmic center. Although, this novel pyrocentric system did not win universal acclaim from contemporary scholars, it indeed was a revolutionary cosmic model that significantly contributed to the development of astronomical science. Any revolutionary proposal made during the birth of any science is seldom fully appreciated, as in the case of the scientific systems of many Presocratics, and therefore, the Philolaic pyrocentric universe will be evaluated against this backdrop.

In the realm of scholarly research,¹² in chronological order, some critics, such as Frank,¹³ Rehm – Vogel,¹⁴ Gundel,¹⁵ Wiersma,¹⁶ and van der Waerden,¹⁷ being impressed with Philolaus who did not consider the earth as the cosmic center, and being influenced by the false analogy of Philolaus’ system to that of Copernicus, believed that Philolaus’ system was so advanced that it does not belong to a scientist of the second half of the 5th century BCE such as Philolaus, but to some other scientist of the 4th century BCE, who was wrongly identified by Wiersma and van der Waerden, as Hicetas.¹⁸ On the other hand, Philip¹⁹ considered that Philolaus was not a

¹⁰ See Porphyry, *Life of Pythagoras* 19.

¹¹ See Riedweg 2005, 63.

¹² For early accounts of Philolaus’ cosmology, also see A. Boeckh, *Philolaus des Pythagoreers Lehren nebst den Bruchstücken seines Werkes* (Berlin 1819); T. H. Martin, ‘Hypothèse astronomique de Philolaus’, in *Bolletino di bibliografia e di storia delle scienze matematiche e fisiche* 5 (Rome 1872) 127-157; G. V. Schiaparelli, *Die Vorläufer des Copernicus im Alterthum*, trans. F. M. Kurze (Leipzig 1876).

¹³ Frank 1923, 35ff., 207ff.

¹⁴ Rehm–Vogel 1933, 47.

¹⁵ Gundel, *RE* XX, 2056f.

¹⁶ Wiersma 1942, 25ff.

¹⁷ van der Waerden 1951, 49ff., 54.

¹⁸ DK 50.

great thinker and that his interest was peripheral. He thought that his book was “unscientific and without real understanding of the doctrines it reports.” Dicks²⁰ and Burkert²¹ showed that the Philolaic system was not as sophisticated as the former scholars thought, and that it had elements similar to those of other cosmological systems of the 5th century BCE, such as those of Empedocles and Anaxagoras. By asserting that Philolaus' cosmology “is not a scientific astronomy,” but a “mélange of myth and *φυσιολογία*,” Burkert²² went to the opposite extreme and considered it as a mere “mythology in scientific clothing, rather than an effort, in accord with scientific method, to ‘save the phenomena.’” Accordingly, he drew a parallel between Philolaus' system and that of Herodorus of Heraclea, who was an interpreter of myth in the same era as that of Philolaus. He also linked the counter-earth to the widespread folklore myth of a “counter-world” where everything is opposite of what is known and related it to the realm of the dead. Similarly, von Fritz²³ unfairly criticized Philolaus' system as “a superficial conglomeration of heterogeneous elements and naive speculation, not an attempt to find a deeper penetrating explanation of the phenomena.” Refuting all these judgments as unfair, Barnes²⁴ rightly considered “that Philolaus is a philosopher of some merit.” He further asserted that “his revolutionary astronomy” was “admirable,” and that despite the “naive elements... there are elements of bold originality, both in speculative science and in philosophy,” such as the significant “discovery of Aristotelian ‘form,’” which rendered a unique and important role to Philolaus in the development of philosophy. Later on, Furley²⁵ considered that Philolaus' system, on the whole, had very little astronomical sense, and as certain a priori features, like the existence of life on the moon (A20), appeared absurd to him, he concluded that “the whole scheme lapses into fantasy.” However, other prominent 5th century BCE Presocratic rationalists, such as Anaxagoras²⁶ and possibly Democritus, supported the existence of life on the moon, and there were similar indications during the 4th century BCE as well.²⁷

Kingsley²⁸ also opined that the Philolaic system has religious and mythological implication. Elaborating on this, he added that the counter-earth is linked to the “counter” realm of the dead, the realm of Hades, and that the central fire is Tartarus, which is below Hades. He further argued that Philolaus conceived these ideas by interpreting — following the Homeric ideas — that Hades and Tartarus are below the earth. He also misinterpreted Aristotle's account that the central fire was named *Διὸς*

¹⁹ Philip 1966, 32, 116.

²⁰ Dicks 1970, 65ff., 70, 72.

²¹ Burkert 1972, 337-350.

²² Burkert 1972, 342, 346-348, 350.

²³ von Fritz 1973, 474.

²⁴ Barnes 1982, 378, 383-384, 388, 391, 396.

²⁵ Furley 1987, 58.

²⁶ See DK 59 A77; D.L. II 8.

²⁷ See Huffman 1993, 271-273; 2008, 18.

²⁸ Kingsley 1995, 172-213.

φυλακή (58 B37), by wrongly translating it as *prison of Zeus*, and used it as a proof that the central fire must be finally Tartarus, the prison in which Zeus punished the Titans and the humans. However, in the 5th and 4th centuries BCE, *Διὸς φυλακή* did not denote the *prison*, but *the watch-tower of Zeus*, the *guard-house of Zeus*;²⁹ and, as the other testimonia of Simplicius and Aetius testify, the central fire was also named as the *tower of Zeus*, the *guard-house of Zeus*, the *throne of Zeus* (58 B37: *Ζανὸς πύργον... Διὸς φυλακὴν... Διὸς θρόνον*), and the *house of Zeus* (44 A16: *Διὸς οἶκον*). Hence, from the possible religious and mythical implication in Philolaus' cosmological system, as can be seen from these testimonia, as well as from the fact that Philolaus also called the central fire as *hearth* (*ἑστία*), which is the religious center of the house and the state, one must infer that Philolaus did not draw any parallel between the central fire and any prison for punishment, but rather to the palace where Zeus guarded his sacred fire in the center of the cosmos.³⁰ Kahn,³¹ considering that Philolaus' system is more of a symbolic speculation than scientific astronomy, claimed that Philolaus did not make any important contribution to observational astronomy or accurate theory.

In the most recent research, Huffman³² aptly asserted that all these interpretations of Philolaus' system, such as mythical, religious, or fantastical, are "misguided." He argued that Philolaus' system was not solely of mythical or religious significance, because other ancient thinkers, such as Aristotle, held that the system was consistent with the phenomena. Huffman successfully showed that Philolaus was "as much a Presocratic as a Pythagorean," because his system, though not a mathematically sophisticated account of planetary motion, is clearly a product of traditional Presocratic thought on the cosmos. Furthermore, despite some of its peculiarities, such as the central fire and the counter-earth, he presumed that Philolaus' system satisfactorily explains the cosmos equally to the systems of other great Presocratics such as Empedocles, Anaxagoras, and Democritus. He considered though Philolaus' system to be even more sophisticated than their systems, because it discovered the correct order of the five known planets of antiquity. Thus, Huffman rightly concluded that "it is in fact the most impressive example of Presocratic speculative astronomy and establishes Philolaus as an important precursor of Plato."³³

My thesis in this essay is that the Philolaic pyrocentric model of the universe is a truly revolutionary cosmic model, although it remained overlooked. I argue that Philolaus' pyrocentric universe is of great significance, because he and the Pythagoreans were the only ancient Greek philosopher-scientists who, in the very beginning of the

²⁹ See Plato, *Protagoras* 321d.

³⁰ See also Huffman 2007; 2008, 19.

³¹ Kahn 1974, 180; 2001, 26-30.

³² Huffman 1993, xiii-xiv, 202-288; 2007, 57-94; 2008, 14-19.

³³ See also Furley 1987, 60, who similarly asserted that the Pythagorean School was the precursor of Plato's cosmology, and that this was the reason why Plato chose the name of the Pythagorean Timaeus for his sole cosmological dialogue.

scientific era in ancient Greece, came remarkably close to the scientific truth about the cosmic reality than the rest of the philosophers and scientists, not only of the ancient but also of the medieval and early modern times. This is because Philolaus and the Pythagoreans did not adopt in their cosmology either the usual geocentric cosmic model — a model adopted almost by the entire ancient Greek philosophic and scientific tradition, and followed throughout the medieval times until the Copernican Revolution in the 17th century —, or the heliocentric cosmic model — a model adopted by Aristarchus of Samos later in the Hellenistic era and readopted by Copernicus in the modern era —, but a pyrocentric cosmic model that indeed had significant novel and revolutionary elements, which I will try to show next.

Among the significant innovations of Philolaus was that he was the first philosopher-scientist who explored the role of the spherical structure of the universe with the symmetrical notions of up and down. Even more important was the fact that he was the first to combine the structural elements of the limiters — the center of the spherical universe — with the traditional material elements of the unlimited — fire —, and to consider both as the first principles of the cosmos. Thus, “the fact that the central fire is in the center of a spherical cosmos is just as important as that it is fiery.”³⁴ Earlier Presocratics believed that the cosmos originated from a material starting point, such as Thales' water, Anaximander's unlimited, Anaximenes' air, Heraclitus' fire, but none of them specified the location of their material starting point. This was first carried out by Philolaus who placed fire in the center of the universe, thus, exploring the consequences of the cosmogony's spherical shape, and justifying why the fiery “material starting point of the world should be in the center.”³⁵ Furthermore, Philolaus was the first to attribute spherical shapes to both the earth and the heavenly bodies. Additionally, he and the Pythagoreans, according to Eudemus,³⁶ assigned for the first time the correct order of the positions of the five known planets in antiquity: Mercury, Venus, Mars, Jupiter, and Saturn.

Philolaus was again the first to emphasize the cyclical motions of the heavenly bodies around a center, and to conceive that the planets closest to the center have the fastest motions. He also distinguished the planets from the fixed stars, but attributed motion to the fixed stars too, besides attributing orbits to the planets that are inside the outer sphere of the fixed stars. Philolaus also explained that the alternation of day and night is due to the revolution of the earth around the central fire, which takes place in the correct time-period of 24 hours. He clearly alluded to the existence of extraterrestrial life on the moon and the counter-earth, a research subject which evokes great interest and enthusiasm in contemporary astrophysical science. In addition, Philolaus and the Pythagoreans conceived a cyclical time and a cyclical motion for all the heavenly bodies around the center of the universe. This led them to the theory of the periodical return of all things, where after each ‘great year’ all the

³⁴ Huffman 1993, 214-215.

³⁵ Huffman 2007, 89-90.

³⁶ Eudemus, F146 = Simplicius, *Commentarius in De Caelo*, 471, 4 = DK 12 A19.

events in the universe are repeated cyclically for eternity. Also, by applying mathematics to the physical world, Philolaus conceived that the cosmos is mathematically structured. By considering all the heavenly bodies of the cosmos in terms of numbers and shapes, which exhibit special ratios as in music, Philolaus proposed the famous theory of the ‘harmony of the spheres’. Thus, Philolaus and the Pythagoreans were the first to perceive the *kosmos* in tune with its etymology, as an aesthetic adornment with perfect mathematical and harmonious orderliness. Interestingly, the concept of Philolaus that all heavenly bodies in the cosmos were most probably separated off and expanded from the central fire is in tune with the contemporary astrophysical theory of the Big Bang, which asserts something similar.

The most revolutionary contribution of Philolaus, though, was that he and the Pythagoreans were the only ancient Greek philosopher-scientists — along with Aristarchus — who rejected the traditional geocentric system, which continued to be followed wrongly for thousands of years before and after them, and replaced it with a novel pyrocentric one. Their doctrine that the earth was just another planet moving around a center of the universe other than around itself, though considered outrageous by the ancient scholars, was indeed revolutionary, regardless of it being familiar to all today. The earth was considered incorrectly as the center of the cosmos for thousands of years, most likely out of respect for the mother-goddess Earth (*Γαῖα*), and also because this cosmic picture ‘saved the phenomena’. Hence, anybody venturing to propose a different cosmic model was vulnerable to be accused of impiety and atheism.

However, the reason for Philolaus to reject the traditional geocentric model, and instead, adopt a pyrocentric one remains conjectural, because unfortunately there are no recorded statements of Philolaus. Perhaps, as Aristotle³⁷ testified, the Pythagoreans visualized the earth as not being the center, because they considered fire as the most honorable of all elements (*εἶναι δὲ πῦρ μὲν γῆς τιμιώτερον*), which they presumed deserves to be placed at the center of the universe — the most honorable and significant part of the cosmos — and guarded more than any (*τῷ γὰρ τιμιωτάτῳ οἴονται προσήκειν τὴν τιμιωτάτην ὑπάρχειν χώραν... τὸ μάλιστα προσήκειν φυλλάτεσθαι τὸ κυριώτατον τοῦ παντός*). Perhaps, Philolaus adopted the concept of ‘central fire’ from Heraclitus’ *πῦρ ἀείζων*,³⁸ who was the first to consider the ‘ever-living fire’ as the primary substance of the universe. Or, perhaps, Philolaus adopted it from his older Pythagorean, Hippasus,³⁹ who also regarded fire as the cosmic principle, or even from Parmenides,⁴⁰ who considered the central fire as a feature of his cosmology, though as an obscure and vague one.⁴¹

Nevertheless, the most important fact is that the basic premise of Philolaus’ theory was proven to be scientifically accurate: the earth is an orbiting planet and not

³⁷ Aristotle, *De Caelo* B13 293a30-b2 = DK 58 B37.

³⁸ DK 22 B30.

³⁹ DK 18, 7.

⁴⁰ DK 28 A37.

⁴¹ See KRS 1983, 259, 344.

the center of the universe. And this fact alone is of unique significance and is a great contribution to the development of astronomical science.

Precursor of Modern Astronomy and Contemporary Astrophysics

By rejecting the geocentric system, Philolaus did not adopt the heliocentric system either. However, there has been some misunderstanding on this issue regarding a false association between Philolaus and Copernicus, perhaps, at the instance of Copernicus himself. In ancient Greece, there were only two scientists who rejected the traditional geocentric system: Philolaus was the first one in the 5th century BCE, who replaced it with a pyrocentric system, and Aristarchus of Samos was the second one in the 3rd century BCE in the Hellenistic era, who replaced it with a heliocentric system. Unfortunately, both these novel cosmological systems were not accepted either by the common Greek people or the famous Greek philosophers and scientists, such as Plato, Eudoxus, Callippus, Aristotle, Apollonius, Hipparchus, Ptolemy, as the traditional geocentric system was too deep-rooted to be abandoned. Therefore, the geocentric system unfortunately continued to hold sway for more than 2000 years through the medieval times up to the early modern times.

Nevertheless, in the modern era, Copernicus was the first scientist to have been deeply dissatisfied with the traditional geocentric cosmological model. Therefore, he reported in his work *On the Revolutions of the Heavenly Spheres*,⁴² published in the year of his death, 1543, that he found in (pseudo-) Plutarch⁴³ about Philolaus⁴⁴ who “held that the earth moved in a circle... and was one of the planets,” and hence, he immediately started “to meditate on the mobility of the earth.” Thus, Copernicus considered Philolaus as his precursor, but ignored the fact that Philolaus’ system was pyrocentric, and not heliocentric, as his system. He seemed to be concerned only about the mobility of the earth, and not about Philolaus’ system considering fire as the center of the universe, as against the sun, which he considered to be the center of the universe.⁴⁵ And this misunderstanding led the Copernican heliocentric system to be originally known as *astronomia Pythagorica* or *Philolaica*.⁴⁶ Besides misunderstanding Philolaus’ system as heliocentric, Copernicus ignored his real precursor, Aristarchus, who first asserted, as Copernicus did later, that the sun is at the center of the universe and that the earth is a planet orbiting around the sun. Even though he knew of Aristarchus, he “consistently concealed this knowledge,” considering that

⁴² Copernicus, Preface, I. 5.

⁴³ DK 44 A21 = Aetius III, 13, 1.2 (D. 378).

⁴⁴ Copernicus, I. 5, also mentioned Hicetas, Ecphantus, and Heraclides of Pontus among the ancient scientists, who also claimed that the earth moved around its axis, but they placed it traditionally at the center of the cosmos without considering it as a planet.

⁴⁵ Cf. Huffman 2007, 57-58.

⁴⁶ See Martin 1872, 128f.; Schiaparelli 1876, 17ff.; Burkert 1972, 337.

“Aristarchus was no radical innovator, but a link with the supposed master of all true astronomy, Pythagoras of Samos.”⁴⁷

Regardless of all these issues, it is important to note that Philolaus adopted a totally novel pyrocentric system that was more sophisticated in so far as the cosmic center is concerned. Thus, in one way, Philolaus can be considered as the precursor of heliocentrism, as both Aristarchus and Copernicus rejected geocentricism and adopted his view of the mobile earth as a planet. However, at the same time, Philolaus cannot be considered as a real precursor of heliocentrism, because his pyrocentric model was more sophisticated than the heliocentric one, as it has been scientifically proven that the sun is not after all the center of the universe, thus, finally proving that Aristarchus and Copernicus were both wrong. It is true that some ancient Greek geocentric cosmic models, such as those of the aforementioned philosophers and scientists, as well as both the ancient and the modern heliocentric cosmic models of Aristarchus and Copernicus, were more sophisticated than Philolaus' model, in that they explained the motions of the planets and other astronomical phenomena in better way. However, Philolaus' system is more sophisticated than all of them with regard to the cosmic center. By rejecting both the earth and the sun as being the centers of the cosmos, he was the first to come closer to the scientific truth, namely, that both the earth and the sun are mobile bodies in the heaven. Furthermore, he proposed an unobservable fire as the center of the universe, and that all the known heavenly bodies of his epoch orbit around it. Thus, to consider Philolaus as the precursor of heliocentrism is both right and wrong: right, because in heliocentrism, the geocentricism was rejected, and the sun is considered as a fiery body; wrong, because he envisioned the sun as a mobile body orbiting fourth around the central fire, thus, offering a much more sophisticated theory closer to the scientific truth, which surpassed heliocentrism even before it was proposed by Aristarchus, 150 years later. Hence, the pyrocentric model of Philolaus and the Pythagoreans is a pioneering and significant contribution to astronomy, in that they first envisioned accurately that the universe is neither geocentric nor heliocentric, and that the earth and the sun are merely two heavenly bodies orbiting around a central fire.

However, the greatest significance of this pyrocentric model, according to my thesis in this paper, is that it is the precursor of models and theories of contemporary astrophysical science as well. Today, contemporary astrophysics denies the notion, at least till date, that the universe has a center somewhere where the Big Bang started. This is explained by the fact that the Big Bang could not have happened at any specific place in the universe, simply because there was no universe before the Big Bang, and its explosion was not a conventional explosion expanding from a central point, but an explosion of space and time, expanding uniformly in all directions.⁴⁸ Nevertheless, even though scientists could not establish, up to now, whether the universe

⁴⁷ Africa 1961, 406.

⁴⁸ See Gibbs 1997.

had a center, Philolaus' pyrocentric model is still timely and diachronic, in the sense that it forms the core of many contemporary astrophysical theories and models, which I will attempt to show next, being thus still valid, to a certain extent, in the passing of time.

If one observes the structural models of many cosmological phenomena and heavenly bodies within the universe, according to contemporary astrophysics, one can discover that they all have a similar pyrocentric nature. For example, if one studies the nature and the structure of the smallest heavenly bodies, such as the planets and their moons, it can be observed that they all form material spheres that have fiery centers, which are remnants that originate from the primordial cosmic fire of the Big Bang, to which they owe their pyrocentric nature. Subsequently, if one observes the solar systems, in the next level of the cosmic scale, then it can be seen again that they all have fiery stars at their centers, around which all the planets and moons of the solar systems move in orbits that are ellipses of generally low eccentricity, which are again remnants that originate from the primordial cosmic fire of the Big Bang, to which they owe their pyrocentric nature. Going further up to the higher level of the cosmos, if one observes the nature and the structure of the galaxies, it can be seen once again that they also have fiery centers in the middle, with such great densities of fiery astral matter that usually show up as black holes, around which all nebulae, stars, planets, moons, and all other celestial bodies within each galaxy move again in orbits that are ellipses of generally low eccentricity, which are again remnants that originate from the primordial cosmic fire of the Big Bang, to which they owe their pyrocentric nature.

Moving further up the cosmic scale, if one observes the structure of the area that the scientists now call the 'Local Universe' — our local region within the entire cosmos — it can be seen again that a gigantic fiery astral area, called the 'Great Attractor', remains inside it, which somehow acts as its fiery center. The theory of the Great Attractor⁴⁹ was discovered in the 1980s, by a group of astrophysicists, called the 'seven samurai',⁵⁰ who studied the topography of the universe. The Great Attractor has the largest gravitationally bound concentration of the fiery astral mass. It is a gigantic filamentary or wall structure with a huge density of tens of thousands of older galaxies and clusters, many of which collide among themselves, and has a diameter of about 300 million light-years. It is centered behind the galactic plane in the direction of the Hydra and Centaurus constellations in the southern sky, lying at a distance of between 150 and 250 million light-years from our Milky Way. It has been observed that all the other adjacent superclusters and clusters of the galaxies within our Local Universe, including the Milky Way, the solar system, and the earth, are gravitationally attracted and keep moving towards the Great Attractor with enor-

⁴⁹ See Dressler 1995.

⁵⁰ The following astrophysicists comprised the group 'seven samurai' who discovered the theory of the Great Attractor: D. Burstein, R. Davies, A. Dressler, S.M. Faber, D. Lynden-Bell, R.J. Terlevich, and G.A. Wegner.

mous velocities, which then appears to act as a sort of fiery center within our Local Universe. This hotter gigantic area of denser concentration of mass is not amenable to observation, like Philolaus' central fire, as it lies in the 'zone of avoidance', that is, in that region of the night sky that remains obscured by the Milky Way galaxy. Thus, the Great Attractor can be observed only by its gravitational effect on the motion of the superclusters and clusters of the galaxies over the region of hundreds of millions of light-years across our Local Universe.⁵¹

Recent research has indicated an even greater concentration of mass behind the Great Attractor, the Shapley Supercluster, lying 500 million light-years away, which contains the most massive association of galaxies and clusters in the Local Universe, attracting and pulling the Local Universe towards it, including perhaps, the Great Attractor itself.⁵² However, it is not yet clear whether it is the Great Attractor or the Shapley Supercluster, or perhaps both, which attract the Local Universe. Nevertheless, the most significant finding is that the Local Universe is attracted and moved towards both of them, which then seem to act as a kind of fiery center within it. And furthermore, if this cosmic phenomenon happens to our Local Universe and appears as a kind of fiery center within it, then it might as well happen to the other Local Universes with their own Great Attractors, as they follow uniform structures like our Local Universe within the entire cosmos, originating all from the primordial cosmic fire of the Big Bang, to which they owe their pyrocentric nature.

Finally, if one also observes the origin and the beginning of the universe, it can be seen again that it was a Big Bang of an inconceivable gigantic fiery explosion of space and time, which generated the entire expanding universe with all its evolving life. And this theory, of course, is similar, to a certain extent, to the Philolaic origin and beginning of the universe that started out of a central fire which generated all the cosmos.

Hence, as we see the universe follows a rather pyrocentric pattern in the formations and structures of its cosmic phenomena, from its smallest to the largest structure, that is, from its planets, solar systems, and galaxies, up to its Local Universes, all of them appearing to have a similar pyrocentric structure with a fiery center of denser and hotter astral matter in the middle, which originates from the primordial cosmic fire of the Big Bang. And this, of course, indicates that the Pythagorean and Philolaic pyrocentric cosmic model is also a precursor of contemporary astrophysics, and thus still has the value of diachroneity and timeliness, which further proves its significant contribution to contemporary science as well.

Scientists have not yet discovered any center of the universe, and most deny that there is one. If the theory that the cosmos follows an eternal circle of Big Bangs and Big Crunches is finally valid, then this might signify the existence of a cosmic center, where the universe possibly originates as a Big Bang and perishes as a Big Crunch in its eternal circles. However, most importantly, it should be noted that scientists have not ruled out the possibility of the existence of a center for the universe on larger

⁵¹ See Kraan-Korteweg, Lahav 2000.

⁵² See Kocevski, Ebeling 2006; Kocevski, Ebeling, Mullis, Tully 2007.

scales beyond the observable universe.⁵³ So, who knows? One day we may finally discover that the universe has after all a center, possibly a fiery center, following the usual pyrocentric pattern that we observe everywhere in the cosmos, and whose pioneer precursor was Philolaus and the Pythagoreans.

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⁵³ See Gibbs 1997.

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