



UNIVERSITY
OF PATRAS



International Center for
Sciences and Hellenic Values

AN INTERNATIONAL CONFERENCE

**ANCIENT
GREECE**



**CONTEMPORARY
WORLD**

THE INFLUENCE
OF GREEK THOUGHT
ON PHILOSOPHY,
SCIENCE AND
TECHNOLOGY

Ancient Olympia,
28-31 August 2016

Editor:

STEPHANOS A. PAIPETIS

Professor Emeritus, University of Patras

An International Conference
ANCIENT GREECE AND CONTEMPORARY WORLD

The Influence of Greek Thought
on Philosophy, Science and Technology

Ancient Olympia, 28-31 August 2016



ANCIENT GREECE AND CONTEMPORARY WORLD

The Influence of Greek Thought
on Philosophy, Science and Technology

Editor: STEPHANOS A. PAIPETIS
Professor Emeritus, University of Patras

Consultant on issues of Philosophy and Epistemology:
CHRISTOS KEHAGIAS,
Lecturer, University of Athens

ATHENS
MARCH 2017

An International Conference

The Influence of Greek Thought on Philosophy, Science and Technology

Editor: STEPHANOS A. PAIPETIS

Professor Emeritus, University of Patras

Consultant on issues of Philosophy and Epistemology:

CHRISTOS KEHAGIAS, Lecturer, University of Athens

Copyright © 2017:

UNIVERSITY OF PATRAS

University Campus

26504 Rio, Achaia

Tel. 2610 991711

<https://www.upatras.gr>

Reproduction, reproduction, total, partial or summary, or reproduction or adaptation of the contents of the book in any way, whether mechanical, electronic, photocopying, recording or otherwise, is prohibited without the prior written permission of the publisher. Law 2121/1993 and rules of international law in force in Greece.

Production:

Avatar | Web and Print Solutions

Vardousion 5 Galatsi 111 47, Athens. Tel. : 210 2914778,

mail: admin@avatar.gr

<http://www.avatar.gr>

ISBN 978-960-530-171-2



9 789605 301712

B4. ASTRONOMY AND ASTRONOMICAL INSTRUMENTS

B4.1 Ancient Greece and Origins of the Heliocentric Theory

Milan S. Dimitrijević¹, Efstratios Theodossiou²,

Aris Dacanalīs², Petros Z. Mantarakis³

¹*Astronomical Observatory of Belgrade, Serbia*

²*University of Athens, Athens, Greece*

³*Las Vegas, Nevada, 89130, USA*

Abstract

Since early antiquity, the important question of philosophy and astronomy was, what occupies the center of the known world. According to the geocentric system, in accordance with the anthropocentric view, the Earth lies at the center of the world. For centuries this was the dominant theory, supported by the majority of philosophers and astronomers. However, the Ancient Greek world was also the cradle of the opposite view, the heliocentric theory of Aristarchus of Samos (c.310 -230 BC), which is generally credited to be the first to postulate a non-geocentric system. But, centuries before him, seeds of the heliocentric theory can be traced back to the Orphic Hymns and to the teachings of Anaximander and the Pythagoreans.

Here, the evolution of the heliocentric theory of Antiquity will be analyzed and discussed from the first mention of it in the Orphic Hymns. The theory was further advanced by the Pythagoreans, especially the “pyrocentric” system with a central fire, of Philolaus of Croton. Also contributing to the heliocentric theory were the views and ideas of Ictas, Ecphantus, Heraclides of Pontos, Anaximander, Seleucus of Seleucia, and finally of Aristarchus of Samos. Unfortunately, the heliocentric theory did not prevail over the geocentric view, which gained wide recognition due to the weight of Aristotle’s support, and later on due to the theories of the great astronomer Claudius Ptolemy (2nd century AD).

1. INTRODUCTION

For centuries, the geocentric system placed Earth at the center of the world, in accordance with the prevailing anthropocentric views. But long before Copernicus, in ancient Greece, Aristarchus of Samos (c.310-230 BC) formulated the heliocentric theory.

And before that, came the seeds of theories that it is not Earth at the unique center of rotation of all heavenly bodies, starting with the Orphic Hymns and progressing to the teachings of Anaximander and the Pythagoreans and their followers. To a large degree, due to the authority of Aristotle and of the great astronomer Claudius Ptolemy (2nd cent. AD), the heliocentric theory was not widely accepted until the so called Copernican revolution, and even then, opponents were numerous.

In this contribution, we will present the ancient Greek development of the ideas that led the heliocentric theory of great Aristarchus, reformulated again in the 16th century by Copernicus.

2. ORPHIC HYMNS

As pointed out by the Greek astronomer Constantinos Chassapis [1], and Maria Papaathanassiou [2, 3], the first indications of views, not in accordance with the geocentric Universe, the first seeds of the heliocentrism could be found in the ancient teachings of Orpheus, considered to be the basis of the first mystic Greek religion, e.g. the Orphic Hymns, consisting of 87 hexametric poems, consisting of 1200 verses in total, under the title *"Hymns of Orpheus to Musaeus"*.

These hymns, containing a variety of astronomical information (not always obvious in the poetic language), and interesting cosmological ideas, provided inspiration for many Greek philosophers and writers.

In the Orphic Hymns [4, 5], *"chaos"*, born from the cosmic egg, is what we would now call space. *"Gaia"* is not the planet but the earth-mother and *"Eros"* (love), is the creational force. Heaven, revolving around the Earth, is the ruler of the world:

*Great Heav'n [Ouranos], whose mighty frame no respite knows... Hear, world ruler,...,
forever whirling as a sphere around this earth
[III. TO HEAVEN: The Fumigation from Frankincense, verse 1]*

As stressed in [1-3], the suggestion that the first seed of the heliocentric system is present in the Orphic Hymns in the following verses:

*Hear golden Titan! Glowing like gold, you who strides above, oh heavenly light...
...you who combines the epochs ...You are the world ruler...
With your golden lyre, draw on the harmonious path of the world...
... [you] who wanders through fire and moves around in a circle
[VIII. TO THE SUN, verse 2]*

Namely, the phrase *"[you who attracts] draw on the harmonious path of the world"* could be an idea of the harmonious movement of the planets around the Sun. If one takes into account that the planets are in the meaning of the term world, as its part, then the *"golden"* Sun may represent the attractive center of their *"harmonious paths"* around him.

Moreover, in hymn 34 “To Apollo” is stated:

Loxias, the pure! ... You mixed in equal parts winter and summer...
[XXXIV. TO APOLO, verse 6,... and 20]

In fact, the Sun - “Loxias” (meaning “tilted”) mixed the parts of the year so that it is divided into two equal parts, summer and winter. This detail has drawn attention of the astronomical community, since it can help to the dating of Orphic Hymns. If we take this statement literally, and determine when in the past the duration of summer and winter was the same, we could assume, of course without further solid evidence, that the Orphic Hymns might originate near 1841 BC or 1366 BC [1,6].

In Hymn 84 (To Hestia) there is also an excerpt contributing to the heliocentric aspect, denying to the Earth the central position in Universe:

You who occupies the center of the home of the greatest and eternal fire.
[LXXXIV. TO HESTIA, verse 2]

In addition, a fragment in *Orphicorum Fragmenta* [5], concerns the rotation of Earth, stating that the round Earth rotates in equal times around its axis (Fr. 247 v. 24-26, pp. 261-262 [5]). Consequently, it appears that in the Orphic hymns all the elements of a heliocentric system can be found – a central sun, revolving celestial objects and a rotating Earth. Therefore, one may assume that the seeds of heliocentric view can be traced in the Orphic Hymns.

3. ANAXIMANDER

The first ancient Greek philosopher to talk in about the motion of the Earth around the center of the world, which may have been the Sun, was most likely the student and friend of Thales, Anaximander (c. 610 – 546 BC). He thought of the Earth as a drum-like cylinder, rotating separately from heaven, and revolving around the center of the Universe. It is also important that Anaximander assumed that even be the Sun might lie at the center.

The views of Anaximander are described for example by Theon of Smyrna (70-135 BC), who lived in the era of Emperor Hadrian, in his work “*Expositio rerum mathematicarum ad legendum Platonem utilium*” [7].

Some of Anaximander’s views were accepted by later Greek naturalists and philosophers like Empedocles of Agrigentum (490-430 B.C.), Parmenides of Elea (early 5th century BC), Aristarchus of Samos, Cleomedes (2nd or 3rd century BC) and several of the Pythagoreans.

4. THE PYTHAGOREANS

The next important contribution to the development of the heliocentric view was by

the Pythagoreans. Pythagoras' school of philosophy and mathematics was founded in Croton, Calabria (southern Italy) in c.540 BC. The students of Pythagoras were trained in astronomy, but by a rather mystical approach. Pythagoreans believed in mystical relations between numbers and different phenomena and also that planetary spheres create harmonious sounds (the "music and harmony of the spheres"). They believed that this, constantly created harmony is an eternal expression of divine harmony.

The School of Pythagoras, was in fact a brotherhood, organized in the way of the Orphic religious communities, with various degrees of initiation. It made an essential contribution to geometry, music, arithmetic and astronomy, all very important for the evolution of scientific thought. With the help of geometry and the harmony of sounds and numbers, they formulated the notion of perfection of the Universe, and described it as: "Cosmos", which comes from either "*cosmo*" - "to orderly arrange", or from "*cos-mema*" - "jewel" (ornament). According to the doxographer Aetius: "*Pythagoras was the first to name the place of all things Cosmos, due to its orderly nature*" [Aetius, De Vestutis Placitis, II, 1, 1 (D. 327, 8)]

According to Pythagoras, the Earth was spherical and immobile, *without being supported by anything*, in the center of the Cosmos, which was spherical as well. Also, D. Kotsakis stated that "Pythagoras was the first who taught that the apparent motion of the Sun on the celestial sphere from the east to the west, could be analyzed in two distinct motions: One daily from East to West, parallel to the equator, and one yearly from West to East on the ecliptic" ([9], p. 28).

It is of interest that in the 6th century BC, some followers of Pythagoras (Philolaus of Croton, Heraclides of Pontus, Ecphantus of Syracuse and others), believed that the Earth is not at the center of Universe and formulated a "pyrocentric" theory. Namely, they believed that the element of fire was the "first principle" of the Universe, which, after the Creation, has been accumulated at the center.

Teachings and views of Pythagoras and his students, their mysticism, as well as their aristocratic political tendencies, in addition to their innovative theories, caused the violent reaction of their adversaries in Croton. The leader of revolt was Cylon, who had been sent away from the school for failing to conform with its principles. When the followers were gathered together, he made an assault, and many of them were killed or exiled: "*Cylon of Croton... and those allied with him, hunted (killed) the Pythagoreans down to the man.*" ([10] (V.P.) 248-249 ff.

Philolaos, along with some other Pythagoreans like Lysias and Archippus, survived the revolt of Cylon. According to some accounts Philolaus' teacher was Pythagoras, but according to other sources his teacher was Lyssias.

4.1 The theories of Philolaus of Croton

Pythagorean Philolaus of Croton (c. 480 - 385 BC), spread the ideas of his master, by organizing and writing a synopsis of his philosophy. According to him, Cosmos is unique and its existence started from the centre, where fire was accumulated. Around the Centre revolved "Antichthon", (or Counter-earth – a hypothetical invisible Earth), the Earth, the Moon, the Sun, the five planets known at the time (Mercury, Venus, Mars, Ju-

piter and Saturn), and the sphere of the fixed stars. So, the number of heavenly bodies revolving around the central fire is ten, a sacred number for Pythagoreans. Some speculate that Antichthon was introduced just to raise the number of the celestial bodies to the sacred number ten.

Concerning the cosmological views of Philolaus, the doxographer Aetius ([8] I 3, 10), informs us (citing Theophrastus): *Philolaus believes that there is fire around the center of the Universe, which he calls "hestia of all" and "house of Zeus"; "mother of the Gods", "altar, constraint and measure of nature". There is another fire which dwells in the outer region of the Universe. The center, he says, came first by nature, and around it dance ten heavenly bodies: The sphere of fixed stars, then the five planets, then the Sun, then the Moon, followed by the Earth and Antichthon, and after all these the fire of "hestia", which lies around the center. The outer region, which surrounds the whole Universe, is a place where the elements are in their pure state, unmixed, and that place he calls "Olympus". All that lies beneath Olympus, namely the part where the five planets along with the Sun and the Moon lie, he calls "cosmos", while the area beneath those, the sublunar space ...he calls "heaven". Wisdom is related to the order which holds in the heavenly bodies, while virtue is relevant with the disorder of the things which are subject to birth. The first is perfect while the second is imperfect* ([8] II 7, 7 (D. 336, probably excerpt of Theophrastus in Posidonius)).

In another passage Aetius writes: *The Pythagorean Philolaus places the fire in the center (for it is the Universe's focal point), secondly he places the Antichthon, then, our habitat, the Earth, comes third, placed opposite [to the Antictchon] and moving in a circle, that being the reason for the beings of Antichthon being invisible to the beings of the Earth. The ruling power of the Universe lies in the central fire, which God placed, like a keel, to base the foundation of the sphere that makes up the world*. ([8] III 11, 3 (D. 337 of Theophrastus)).

We can see that, according to Philolaus, all what is in "Olympus" and "Cosmos" never changes, while in the areas below the Moon, everything born, ages, and dies eventually. The Earth and all other planets revolve around central fire Hestia, in the same direction but distances and speeds are different. The Sun shines not by its own light, but by the fire obtained from Hestia, which is invisible since it always shines to the antipodes of the Earth.

We can see that Philolaus, disputing the central role of Earth in the Universe, and introducing the idea of "central fire", certainly set the basis for Aristarchus' heliocentric theory, even without the Sun in the center. Professor Stavros Plakides (1983-1990) assumed that Philolaus, refrained from placing the Sun at the center of the Cosmos, fearing for his life, after experiencing the violence in Croton.

Aetius, also informs us, that concerning the motion of the Earth, the view of Philolaus is: *Others believe that the Earth is immobile. Philolaus on the contrary, believes that the earth is moving in a circle around the fire, tracing a tilted circle, just like the Sun and the Moon does* ([8] III, 13, 1. 2. (D 378)). So, Philolaus is not in accordance with his teacher, and states that the Earth is not immobile in the center of the Universe, but revolves around the "Central Fire".

It is interesting that, according to Diogenes Laertius, Plato bought a copy of the

work of Philolaus for a very high price: *Some authorities, amongst them Satyrus, say that he wrote to Dion in Sicily instructing him to purchase three Pythagorean books from Philolaus for 100 mnae* ([12], III 9).

Plutarch inform us that Plato studied carefully the work of Philolaus, and, in his late years, was persuaded that the Earth is indeed revolving around the Sun: *As Theophrastus informs us, Plato, near the end of his days had regrets for his older opinion, by which he unfittingly placed the Earth at the center of the Universe* ([13] *Platonicae Quaestiones* H1 915, vol. XIII, 76-78). Probably due to the study of Philolaus, there is another change in the views of Plato: *"In Republic he identifies the celestial equator with the ecliptic, an idea different from that expressed in Timaeus"* [14].

The world-view described by Philolaus was indeed revolutionary for the scientific thought of the 5th century BC. As cited in [9], the Italian astronomer Giovanni Schiaparelli (1835-1910), wrote the following, concerning the system proposed by Philolaus: *The system of Philolaus was not a fruit of some restless imagination, but came through the torque and pull of one who sets the outcomes of observation in accordance with a predetermined principle, which exists above the nature of things...Appreciating this, and combining it to the fundamental theorems of the Pythagorean Philosophy, the system of Philolaus naturally appears as one the most wonderful creations of human genius. His critics are incapable of appreciating the power of necessary research, in order to unify the ideas of the roundness of the Earth, its levitation in space, and its motion. Indeed, without these ideas, there would have been no Copernicus, neither Kepler or Galileo and Newton* ([9], p. 30).

4.2 The views of Ictas, Ecphantus and Heraclides of Pontus

It should be mentioned that not only Philolaus, but also other Pythagoreans, like Ictas and Ecphantus of Syracuse and Heraclides of Pontus (c. 5th century BC), developed new ideas.

So, Ictas of Syracuse taught that Heaven, Sun, Moon and the stars were immobile, and that only the Earth is moving. Cicero describes his views in the following way: *As Theophrastus says, Ictas of Syracuse was of the opinion that the heaven, the Sun, the moon and the stars (i.e. the planets) and all that is high above are immobile, and nothing in the world is moving, apart from the Earth. But as it rotates around its axis with the greatest possible speed, its motion causes all these phenomena to appear, which would have appeared were the Earth immobile and heaven rotated instead of it* ([15] II, xxxix, 123).

It appears that this theory was accepted and by Ecphantus and Heraclides. They believed that the Earth rotates in space, "just like a wheel around its axis".

Hippolytus writes that the Pythagorean Ecphantus believed that the Earth spins around its axis with an eastern direction, but does not change its place in space. ([16] *Ref. I* 15 (D. 566W. 28)). This is also mentioned by doxographer Aetius, who states also that Heraclides agrees with Ecphantus. ([8] III, 13, 3 (D. 378)).

Heraclides of Pontus (c. 390 – 310 BC), a student of Plato, lived and died in Heracleia Pontica (a city on the coast of Bithynia in Asia Minor). He also believed in the rotation of the Earth around its axis and considered that the Sun might even be the center of rotation of Mercury and Venus.

5. ARISTARCHUS OF SAMOS

After the Pythagoreans, the great astronomer Aristarchus of Samos (310-230 BC), developed the heliocentric theory. This is mentioned by Archimedes ([17] I 4-6 (3, 180-182), manuscript 2, Cod. Laurent. Gr. 28) and Plutarch ([18] II, 24 (7, 355a)). Aristarchus' hypothesis was so original, that he was accused of atheism. In order to avoid consequences, Aristarchus escaped from Alexandria, with the help of his teacher Straton of Lampsacus ([8] book 7, 313b, 16-17).

Unfortunately, the heliocentric theory of Aristarchus was not accepted, and the geocentric system of Claudius Ptolemy (2nd century AD), reigned for centuries, supported by Aristotle, the indisputable authority during the Dark Ages.

6. HELIOCENTRISM AFTER ARISTARCHUS

A follower of Aristarchus, who supported a heliocentric theory of his own, was Seleucus of Seleucia on Tigris in Mesopotamia (c. 190 BC - active around 150 BC). All of the original work of Seleucus has been lost, but fragments are found in the works of Plutarch, Strabo, Aetius and Hippolytus. So, Hippolytus writes about his views that the Earth is moving around the Sun, and that the Moon influences its axial rotation and revolution ([16] Book C, 897C, 14-16), mentioning also his belief that the Cosmos was infinite ([16] Book B, 886C, 6). Seleucus also correctly explained that the Moon is responsible for tides.

A strong supporter of the heliocentric theory was Emperor Julian of Byzantium (336-363 AD), who studied carefully the works of Greek philosophers and astronomers, and believed that *"world order was influenced by a heavenly and divine hierarchy, in which everything originated from One God, the illuminating Sun"* [14]. In his book *Hymn to King Helios* dedicated to Sallust, he writes: *For that the planets dance about him as their king, at certain intervals, fired in relation to him, and revolve in a circle in perfect accord, making certain halts, and pursuing their orbit to and fro, as those who are learned in the study of the spheres call their visible motions; and that the light of the moon waxes and wanes varying in proportion to its distance from the Sun is, I think, clear to all* ([19] 135b, 1-6). Therefore, Julian believed that all planets revolved around the Sun in circular orbits at constant distances. Obviously, even during the 4th century AD, the theory of Aristarchus hadn't been forgotten.

7. CONCLUSION

Besides the seeds of heliocentric theory found in the Orphic Hymns, such "heretical" views evolved in the thoughts of Anaximander, Pythagorean philosophers Philolaus, Ictas, Ecphantus, Heraclides, until the father of the heliocentric theory Aristarchus of Samos, who placed the Sun in its right position in the Pythagorean "central fire".

The heliocentric theory was not accepted due to the influence of the great astronomer Claudius Ptolemy and his geocentric model, supported by the authority of Aristotle, but from time to time, philosophers like Seleucus from Seleucia and Emperor Julian supported heliocentrism.

It was only in the 16th century when the great Polish astronomer Mikolaj Kopernik (Nicolaus Copernicus 1473-1543 AD), placed again the Sun in the center of the Solar system. The predecessor of the so called “Copernican revolution” was the heliocentric theory of Aristarchus of Samos and the evolution of such views from the seeds in Orphic hymns to the Pythagoreans and their followers.

References

- [1] Chassapis Constantinos, *The Greek Astronomy of the 2nd millennium BC according the Orphic Hymns*. PhD. Thesis, University of Athens [self-edited], Athens 1967 [in Greek].
- [2] Papathanassiou Maria, Cosmological and cosmogonical aspects in Greece during the 2nd millennium BC, PhD. Thesis, University of Athens [self-edited], Athens 1978 [in Greek].
- [3] Papathanassiou Maria, Aristarchus the Samian, *Mathematical Review* 20, Editions of the Hellenic Mathematical Society, 1980, p. 91-120 [in Greek].
- [4] *Orphic Hymns*, Ed. Ideotheatro, Athens [in Greek, sine anno].
- [5] *Orphicorum Fragmenta*. Ed. O. Kern, Weidmann 1922.
- [6] Papathanassiou Maria, Primordial astronomical learning, *Eleftherotypia-Historica*, Athens, January 2, 2003, p. 6-12 [in Greek].
- [7] Theon of Smyrna, *Mathematics useful for understanding Plato* or Pythagorean Arithmetic, Music, Astronomy, Spiritual Disciplines. Trans. by Christos Toulis, Wizards Bookshelf, 1979.
- [8] Aetius, *Placitorum Compositione (De Vetustis Placitis)*. Vol. IV 9, 8. in Diels Hermann: *Doxographi Graeci*. Berolini. Apud Walter De Gruyter et Socios, Editio Quarta, 1879 (re-printed 1965).
- [9] Cotsakis Demetrios, *The pioneers of Science and the creation of the World*. Ed. Zoe, Athens 1976.
- [10] Iamblichus, *De vita Pythagorica (V.P.) Life of Pythagoras*, with the English translation by Thomas Taylor in 1881, J. M. Watkins, 1965, p. 248-249ff.
- [11] Plakides Stavros, The Geocentric and the Heliocentric Theory. *Parnassos* 16, Athens 1974 [in Greek].
- [12] Diogenes Laertius, 1925. *Lives of Eminent Philosophers*, vol. II, IX 34-35, pp. 3, 441-445. Heinemann, London. The Loeb Classical Library; English translation by R.D. Hicks, revised and reprint 1959.
- [13] Plutarch Chaeronensis: 1841, *Platonicae Quaestiones, Scripta Moralia*, Graece et Latine, Tomus Secundus, Parisiis, Editore Ambrosio Firmin Didot MDCCCXXI, H1 915, vol. XIII, 76-78.
- [14] E. Theodossiou, A. Dacanalis, M. S. Dimitrijević, P. Mantarakis, 2009, Heliocentric system from the Orphic hymns and the Pythagoreans to Emperor Julian. *Bulgarian Astronomical Journal*, 11, 123-138.
- [15] Cicero, *Academica Priora*, with an English Translation by H. Rackham, M.A. The Loeb Classical Library. London. William Heinemann Ltd. Cambridge, Massachussetes, Harvard

- University Press. MCMLXI (First printed 1933, reprinted 1951, 1956 καὶ 1961). πρ. 11, 12, 3.
- [16] Hippolytus, *A Refutation of All Heresies: Refutationis Omnium Haeresium (Filosofoumena)*. Patrologia Graeca (P.G.) 16, In Origenes, Liber VII, 404-405, 339. Typographi Brepols Editores Pontificii, Parisiis 1857-1866.
- [17] Archimedes, *Arenarius in Opera Omnia*, Bibliotheca Scriptorum Graecorum et Romanorum Teubneriana. Ed. I. L. Heiberg, vol. II corrigenda Adiecit E. S. Stamatis. Stutgardiae in Aedibus MCMLXXII.
- [18] Plutarch Chaeronsis, *Scripta Moralia*. Graece et Latine. Tomus Secundus. De placitis Philosophorum Libri quinque. Parisiis. Editore Ambrosio Firmin Didot MDCCCXLI.
- [19] *The works of Emperor Julian. The Orations of Julian, IV. Hymn to king Helios dedicated to Sallust*. The Loeb Classical Library. Trans. By Wilmer Cave Wright, Ph.D., William Heinemann Ltd. Cambridge, Massachusetts, Harvard University Press MCMLIV (First printed 19123, reprinted 1930, 1954).