

C O N T R I B U T I O N S

from the

RESEARCH CENTER FOR ASTRONOMY AND APPLIED MATHEMATICS

ACADEMY OF ATHENS

SERIES I (ASTRONOMY) No. 32

THE HELIOCENTRIC SYSTEM OF GREEKS

by

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CONTRIBUTIONS

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EVANGELOS S. STAMATIS

1. According to the narration of the Egyptian priest to Solon at the beginning of the sixth century B. C., «in Greece there had been many deluges, which had caused great disasters, on account of which Greeks did not know their own history». However, the Egyptians had entered into their archives all the events which took place in the Greek area. According to the records of the Egyptians, the Athenians had developed a civilization 9.000 years before that period of time. In these same ancient times the great island of Atlantis situated in the Atlantic Ocean beyond the Pillars of Heracles (The Straits of Gibraltar) sank under the water. The Egyptians got their civilization from the Athenians 1.000 years later, that is 8.000 years before the time the discussion between Solon and the priest took place (Plato, *Timeo* 23 - 26).

No information is available since then and up to the protominoic period on any achievements related to the civilization in the Greek area. Later tradition praises with admiration the cultural achievements of Orpheus, born in Libithra of Thrace. Orpheus was a disciple of Linos the Thebian, while he himself taught the Athenian Moseos (Dictionary of Soudas). Orpheus is believed to have flourished about the 15th century B. C. The oldest Greek theory on the creation of the world is attributed to Orpheus and mentioned in *Ornithes* by Aristophanes [1].

There was Chaos at first, and darkness, and Night,
and Tartarus wasty and dismal ;
But the Earth was not there, nor the Sky, nor the Air,
till at length in the bosom abysmal
Of darkness an egg, from the whirlwind conceived,
was laid by the sable - plumed Night
And out of that egg, as the Seasons revolved,
sprang Love, the entrancing, the bright
Love brilliant and bold with his pinions of gold,
like a whirlwind, refulgent and sparkling.

[Loeb, B. B. Rogers]

2. Written records of the teaching of Orpheus and his disciples do not exist. Some indirect information has been compiled and published under the titles :

1) Orphics (Orphica, G. HERMANN, Leipzig 1805).

2) Orphic Fragments (Orphicorum fragmenta, KERN, Berolini 1922). Later scholars, including Willamowitz, date the first collection and edition of those scattered texts to the 2nd century A. D. (PAULY - WIS-SOWA R. E., Orphische Dichtung, sp. 1332, VIII, 49 - 59).

The Orphics consist of the Argonautics, of the Hymns related to the Orphic worship, of the Lithics and of the Extracts and Inscriptions. The contents of the above, as well as of the Orphic Extracts are attributed to Orpheus and his disciples and their initial formulation dates back to the 15th century B. C.

In the Orphic Extracts we find the view that the celestial globe rotates around the axis of the world, which coincides with the axis of the Earth ; the latter rotates around its own axis which is at rest (KERN p. 261, 24).

3. The view mentioned in the Orphics that the Earth rotates around its own axis which is at rest and which coincides with the axis of the world, around which the celestial globe is rotating, is found also in «Timeo» by Plato and in the work of Aristotle on the Heavens, as mentioned below.

4. Since the time of Orpheus and up to the 7th century B. C. all available information regarding the creation of the world is mentioned, according to tradition, chiefly by Homer and Hesiod. It is not until the 7th - 6th century B. C. that scientific reasoning about the creation of the world starts with Thales and the School of Miletus.

Information is given below, concerning the theory of the heliocentric system of Ancient Greeks, as formulated from the 6th century B. C. up to the beginning of the Christian Era. A further part of this study is devoted to the publication of the astronomical book of Copernicus.

A N A X I M A N D E R

5. Eudemus narrates in the Astrologies that Oenopides was the first to find the Zodiacal circle and the duration of the great year while Thales studied the eclipse of the Sun and discovered that the seasons

of the year are not of equal duration. In addition, Anaximander suggested that the Earth is suspended and moves around the center of the world [2].

PHILOLAOS

6. Philolaos held the view that in the middle of the world approximately at the center lies the fire which he calls the hearth of the universe, the Jupiter's abode, the mother of Gods, the altar and unity and measure of nature. There is also another fire in the upper part of the world which surrounds it. First comes by nature the center around which ten divine bodies revolve (the heavens, the sphere of fixed stars, the five planets, then the Sun under which the Moon the Earth and the Counter-Earth (Antichthon) come in succession; at the very end comes the fire which is the focus around the centers [3].

7. Philolaos the Pythagorean believed that the center of the world was occupied by the fire (because this is the focus of the universe), then came the Counter-Earth and thirdly the inhabited Earth which lies opposite the Counter-Earth and revolves around the center along with the Counter-Earth; thus, the inhabitants of the Counter-Earth are not visible to those who live on Earth [4].

PLATO

8. The form of the divine class He wrought for the most part out of fire, that this Kind might be as bright as possible to behold and as fair; and likening it to the All He made it truly spherical; and He placed it in the intelligence of the Supreme to follow therewith, distributing in round about over all the Heaven, to be unto it a veritable adornment cunningly traced over the whole.

And each member of this class He endowed with two motions, whereof the one is uniform motion in the same spot, whereby it conceives always identical thoughts about the same objects, and the other is a forward motion due to its being dominated by the revolution of the Same and Similar; but in respect of the other five motions they are at rest and move not, so that each of them may attain the greatest possible perfection. From this cause, then, came into existence all those *unwandering* stars which are living creatures divine and wandering have-

been generated in the fashion previously described. And Earth, our nurse, *which is globed around the pole that stretches through all, He framed to be the wardress and fashioner of night and day*, she being the first and eldest of all the gods which have come into existence within the Heaven [5].

[Loeb, R. Bury]

ARISTOTLE

9. It remains to speak of the earth, where it is, whether it should be classed among things at rest or things in motion and of its shape.

Concerning its position there is some divergence of opinion. Most of those who hold that the whole Universe is finite say that it 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 . . .* These reason that the most honourable body ought to occupy the most honourable place, that fire is more honourable than earth, that a limit is a more honourable place than what lies between limits, and that the centre and outer boundary are the limits. Arguing from these premises, they say it must be not the earth, but rather fire, that is situated at the centre of the sphere . . . This then is the opinion of some about the position of the earth, and on the question of its rest or motion there are conformable views. Here again all do not think alike. Those who deny that it lies at the centre suppose that it moves in a circle about the centre, and not the earth alone, but also the *counter-earth*, as we have already explained . . . Some again say that although the earth lies at the centre, it «winds», i. e. is in motion, *«round the axis which stretches right through»*, as is written in the Timaeus [6].

[Loeb, W. Guthrie]

SIMPLICIUS

10. The Pythagoreans held the view that the Earth is at the center of the universe and that around this center revolves the Counter-Earth, which is also another Earth opposite to this Earth; that is the reason it is called Counter-Earth. Beyond Counter-Earth lies this Earth, which also revolves around the center. The Moon comes next.

Furthermore, they said that the Earth, being one of the stars and revolving around the center, creates night and day, according to its position with reference to the Sun. But the Counter - Earth revolving around the center and following this Earth is not visible, because, it is occulted by the body of the Earth. The Pythagoreans also believed that the Earth is a star and an instrument of time, as it causes day and night, for it makes day to the part illuminated by the Sun but night to the part which is in the cone of the shadow [7].

A R C H I M E D E S

11. You are well acquainted with the fact that most astronomers consider the universe as a sphere, the center of which coincides with the center of the Earth. Its radius is equal to the distance from the center of the Earth to the center of the Sun, as you have been informed by the teaching of astronomers. Aristarchos the Samian has published in outline certain hypotheses from which it follows that the universe is vaster than formerly believed. He assumed that the fixed stars and the Sun are at rest, while the Earth revolves in an orbit the center of which is occupied by the Sun. On the other hand, the sphere of fixed stars, having the same center as the Sun, is so large that the circular orbit of the Earth around the Sun has the same ratio to the distance of the fixed stars, as that existing between the center of the sphere and its surface [8].

C I C E R O

12. The Syracusan Hicetas, as Theophrastus 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 as would be produced if the earth were stationary and the heaven in motion; and this is also in same people's opinion the doctrine stated by Plato in Timaeus (40 B), but a little more obscurely [9].

[Loeb, H. Rackham]

P L U T A R C H

13. It is doubtful whether Plato considered the Earth as being at rest or revolving in the same way as he said that the Sun, the Moon and the five planets (which he called instruments of time because of their turnings) did. He was wrong in considering the Earth, which revolves around the axis of the world, as being connected with the axis and at rest instead of considering, it as revolving and in motion. Later Aristarchos and Seleucos embraced the theory mentioned last, the former just assuming it, the latter also affirming it as true. Theophrastos narrates that Plato in his old age regretted that he had wrongly attributed to the Earth the position of the center of the universe [10].

P L U T A R C H

14. Oh, sir, just don't bring suit against us for impiety as Cleanthes thought that the Greeks ought to lay an action for impiety against Aristarchus the Samian on the ground that he was disturbing the hearth of the universe because he sought to save the phenomena by assuming that the heaven is at rest while the earth is revolving along the ecliptic and at the same time *is rotating about its own axis* [11].

[Loeb, H. Cherniss - W. Helmbold]

P L U T A R C H

15. Furthermore, it is said that Numa built the temple of Vesta, where the perpetual fire was kept, of a circular form, not in imitation of the shape of the earth, believing Vesta to be the earth, but of the entire universe, at the centre of which the Pythagoreans place the element of fire, and call it *Vesta and Unit*. And they hold that the earth is neither motionsless nor situated in the centre of surrounding space, but that it revolves in a circle about the central fire, not being one of the most important, nor even one of the primary elements of the universe. This is the conception, we are told, which Plato also, in his old age, had of the earth, namely that it is established in a secondary space, and that the central and sovereign space is reserved for some other and nobler body [12].

[Loeb, B. Perrin]

P L U T A R C H

16. «Some think that the Earth is at rest ; but Philolaus the Pythagorean says that it moves around the fire with an *obliquely circular motion*, like the Sun and Moon. Heracleides of Pontus and Ekphantus Pythagorean do not give the Earth any movement of locomotion, but rather a limited movement of rising and setting around its centre, like a wheel» [13].

17. Aristarchos held the view that the Sun and the fixed stars are at rest while Earth is revolving around the solar circle ; also that during the Earth's obliquely circular motion the Sun's disc is shadowed (causing a solar eclipse) [14].

18. Some mathematicians have the same conception of the Earth as Plato did, namely that it is situated in the center of the Universe, while others believe that the Sun is in the center [15].

19. Seleucos the mathematician, who also formulated the doctrine that the Earth is in motion believed that the Earth's rotation and revolution hinder the Moon's motion [16].

S E X T U S E M P I R I C U S

20. Therefore the motion of the Universe is one thing and time another. And in fact those who, like Aristarchus the mathematician, have rejected the motion of the Universe, but have held that the earth moves, are not precluded from conceiving time [17].

[Loeb, R. Bury].

C O P E R N I C U S

21. Accordingly, when I had meditated upon this lack of certitude in the traditional mathematics concerning the composition of movements of the spheres of the world, I began to be annoyed that the philosophers, who in other respects had made a very careful scrutiny of the least details of the world, had discovered no sure scheme for the movements of the machinery of the world which has been built for us by the best and Most Orderly Workman of all. Wherefore I took the trouble to reread all the books by philosophers which I could get hold of, to see if any of them even supposed that the movements of the spheres of the world

were different from those laid down by those who taught mathematics in the schools. As a matter of fact, I found first in Cicero that Nicetas thought that the Earth moved. And afterwards I found in Plutarch that there were some others of the same opinion : I shall copy out his words here, so that they may be known to all: «Some think that the Earth is at rest ; but Philolaus the Pythagorean says that it moves around the fire with an obliquely circular motion, like the sun and moon. Herakleides of Pontus and Ekphantus the Pythagorean do not give the Earth any movement of locomotion, but rather a limited movement of rising and setting around its centre, like a wheel».

Therefore I also, having found occasion, began to meditate upon the mobility of the Earth. And although the opinion seemed absurd, nevertheless because I knew that others before me had been granted the liberty of constructing whatever circles they pleased in order to demonstrate astral phenomena, I thought that I too would be readily permitted to test whether or not, by the laying down that the Earth had some movement, demonstrations less shaky than those of my predecessors could be found for the revolutions of the celestial spheres [18].

22. It seems credible to say that for similar reasons Philolaos held that the Earth is in motion. Also, Aristarch the Samian is said to have admitted the same conception. (*De Revol. Orb. Celest.* 1873). (*Credibile est hisce similibusque causis Philolaum mobilitatem terrae sensisse quod etiam nonnulli Aristarchum Samium ferunt in eadem fuisse sententia*).

23. Copernicus (1473 - 1543 A.D.), who had a sound knowledge of Greek and Latin, was acquainted with the geocentric and heliocentric system of Ancient Greeks. He personally admitted in his book that he got informed about the heliocentric system by Aristarchos the Samian, Cicero and Plutarch. His book entitled *de Revolutionibus Orbium Coelestium, Libri VI* was published in 1543, after the approval of the Pope of Rome. Later on, the same book was banned by the Catholic Church and its circulation among the Catholics was forbidden. In the edition of 1873 A.D., on page 34, there is still a paragraph where Copernicus mentioned that Aristarchos the Samian was the one who first stated the theory of the heliocentric system (COUDER P. *Les Etapes de l'Astronomie*, Paris 1948, p. 79). In all the other editions,

both before and after 1873 A.D. this paragraph is omitted for unknown reasons. The view supported by some later commentators that Copernicus was not acquainted with the theory of Aristarchos the Samian on the heliocentric system, as mentioned by Archimedes (Psammites, I. L. HEIBERG, Leipsig 1913, p. 218, 7) is completely groundless and wrong. These commentators base their view on the false argument that the work of Archimedes were printed in 1544 while the book of Copernicus was published in 1543. The truth is that the works of Archimedes in Latin translation started circulating in Europe in the 12th century A.D. or even earlier in the 5th century A.D. according to another evidence. (Boëthius). However, there is no reason to dwell upon that subject any longer, since Copernicus himself mentioned in his book, that he knew the heliocentric system of Aristarchos the Samian which is also mentioned by Plutarch. Besides, Copernicus assured that he had studied the related works of Plutarch, where the heliocentric system of Aristarchos the Samian, is mentioned [13].

A comparison between the Greek Mathematical Syntaxis of Ptolemy and Copernicus work *De Revolutionibus Orbium Coelestium* proves the great influence of Ptolemy's work on Copernicus. (The great books on the Western World, 16, Ptolemy, Copernicus, Kepler, University of Chicago, by Encyclopedia Britannica Ink., 1952).

Copernicus not only adopted the theory of Aristarchos the Samian about the heliocentric system, but also presented in the above mentioned book some other astronomical and meteorological theories of the Ancient Greeks

Therefore, the great contribution of Copernicus to the progress of Astronomy is due to the fact that he was the first one who dared adopt and declare the heliocentric system of Aristarchos the Samian and who, through the support of his uncle, who was a Catholic bishop, got the Pope's approval for the publishing of his views.

24. Some astronomical and meteorological theories included in the work of Copernicus, *de Revolutionibus Orbium Celestium*, are listed below. There is no mentioning of the greek sources.

GREEK SOURCES

COPERNICUS,

De revol. orb. celest.

Pythagoras held the view that the Earth is spherical, having life and reasoning. He also held that the universe is a sphere [19]	»	»	A ₁
The sphere has the greatest volume of all the solids of equal surface. Consequently, it is bigger compared with bodies of equal surface [20]	»	»	A ₁
All the stars are spherical. The Sun and Moon are spherical [21]	»	»	A ₁
The Earth must have a spherical shape [22]	»	»	A ₂
When we move southwards or northwards . . . the stars above our head undergo great change and they appear to be different, when we move northwards or southwards [23]	»	»	A ₂
The star Kanovos, being not visible to those living north of Knidos, becomes visible to those living south [24]	»	»	A ₂
When we move northwards some stars visible when we were south, are hidden, while others appear which were invisible before. The opposite happens when one moves southwards. But if the Earth was flat, nothing of the above could happen [25]	»	»	A ₂
The eclipses which take place simultaneously become visible later to those living east, than to those living west [26]	»	»	A ₂
When a ship sails away from shore, its main body is hidden first, the masts being visible. However, when the ship approaches the land the masts appear first, the main body being hidden because of the curvature of the water's surface [27]	»	»	A ₂

During the lunar eclipses, the limit of Earth's shadow on the Moon is always convex which proves that the Earth's periphery is spherical in shape [28] » » A₃

The horizons bisect always the sphere of the heavens. That would be impossible if the size of the Earth was significant as compared to that of the heavens [29] » » A₆

Aristarchos the Samian held that the Earth revolves around the Sun in a circular orbit [31]

There are also other gods, generated within the universe like the Sun made of the same immaculate substance as the Deity. These gods, though numerus form a whole with the Sun.

It is obvious that the planets which revolve around the Sun follow some laws in their motion [32] » » E₁

B I B L I O G R A P H Y

1. Aristophanes, Birds, 693.
2. Theon of Smyrna (Theonis Smyrnaei Philos. Platonici. Lipsiae 1878 p. 198, 14-19, Hiller).
3. Stobaei Ecl. I 22 p. 196, 18. Wachsmuth. Dox. 336 B 20 - 337 B 10.
4. Plutarch, De placitis Philosophorum IA' E.
5. Plato, Timaeus 40 A - C.
6. Aristotle, On the heavens B 13. 293 a 15 - b 32.
7. Simplicius, Comm. in On the heaven of Aristotle (CAG. Heiberg) p. 511, 26-512, 17.
8. Archimedes, The Sand-reckoner (or Arenarius). Heiberg, Lipsiae 1913, p. 217, 7.
9. Cicero, Academia priora II 39 (Loeb p. 626).
10. Plutarch, Platonicae Quaestiones H 1.
11. Plutarch, De facie in orbe lunae 922 F.
12. Plutarch, Lives, Numa XI.

13. P l u t a r c h, De placitis Philosophorum III IF'. Dox. 378.
 14. " " " II KΔ'. Dox. 355, 1.
 15. " " " II IE'. Dox. 345, 5.
 16. " " " III IZ'. Dox. 383.
 17. S e x t u s E m p i r i c u s, Adv. math. X 173 - 174.
 18. C o p e r n i c u s, De revol. orb. celes. Praefatio.
 19. D i o g e n e s L a e r t i u s VIII, 25. Copernicus, De revol. orb. celes. A₁
 20. P l a t o, Timaeus 33 b. Pappus E', 350, 24.
 F. Hultsch. " " A₁
 21. A r i s t o t l e, On the heavens B' 11. 291 b 11. " " A₁
 22. " " B' 14. 297 a 8. " " A₂
 23. " " B' 14. 297 b 33 - 298 b 3 " " A₂
 24. T h e o n o f S m y r n a, Phil. Platonic, p. 121, 19. Hiller " " A₂
 25. C l e o m e d e s, De motu circulari Corporum Celestium, Lipsiae 1891, p. 76, 23. H. Ziegler " " A₂
 26. P t o l e m y, Great Collection, A 4. 152, 2. Heiberg. " " A₂
 27. C l e o m e d e s, De motu circ. Corp. Cel. p. 84, 9 " " A₂
 28. A r i s t o t l e, On the heavens, B' 14. 297 b 19 " " A₂
 29. P t o l e m y, Great Collection A' 6. Heiberg " " A₂
 30. A r i s t o t l e, On the heavens A' 7. 274 b 29 " " A₂
 31. See [8].
 32. I u l i a n i I m p e r a t o r i s, vol. I, oratio IV, 143 B, 146 D, Lipsiae 1875 " " E₁