Biographical Encyclopedia of Astronomers

Aristarchus of Samos

Born Samos, (Greece), circa 310 BCE

Died circa 230 BCE

Aristarchus as astronomer and mathematician has not always been given the credit he deserves by historians of science, even though he made two remarkable contributions to astronomy: a heliocentric solar system and estimates of the relative sizes and distances of the Sun and the Moon

Aristarchus was a native of the island of Samos and a contemporary of Euclid and Archimedes. Not very much is known of his early life or his work except for comments by later writers or his contemporaries. Only one of his works is extant, *Aristarchus on the Sizes and Distances of the Sun and Moon*, which is the oldest surviving mathematical work on determining the sizes of the Sun and the Moon in terms of the dimensions of the Earth and the relative distance to the Sun in terms of the distance to the Moon. He reportedly also wrote on vision, light, and colors. Aetius tells us that Aristarchus was a pupil of Strato of Lampsacus, either in Athens or in Alexandria. A comment by

Ptolemy in Almagest III states that Aristarchus observed the solstice of 281/280 BCE (the only date for Aristarchus we know for certain), and Archimedes' comments in the Sand Reckoner concerning Aristarchus' heliocentric theory of the Earth's motion help to place his floruit. Vitruvius in his De architectura tells us that Aristarchus invented the "hemisphaerium" or "scaphe," a sundial with a hemispherical surface, and he is also identified as having invented the "discus in planitia," a dial with a horizontal shadow-receiving surface.

Among the ancient astronomers, Philolaus and Aristarchus stand alone in believing that the Earth moved in an orbit. Aristarchus proposed that it rotated about its axis and revolved around the Sun. Our most secure evidence for attributing the heliocentric hypothesis to Aristarchus comes from Archimedes' Sand Reckoner, where he explains to Gelon, son of Hieron II, King of Syracuse, how one might express very large numbers, and mentions Aristarchus: "Aristarchus of Samos... supposes that the fixed stars and the sun do not move, but that the earth revolves in the circumference of a circle about the sun, which lies in the middle of the orbit, and that the sphere of the fixed stars, situated about the same center as the sun, is so great that the circle in which the earth is supposed to revolve has the same ratio to the distance of the fixed stars as the center of a sphere to its surface."

In Aristarchus on the Sizes and Distances of the Sun and Moon, Aristarchus applied geometry to the problem of determining the distances to the Sun and the Moon and their sizes relative to that of the Earth. Aristarchus made the following hypotheses (Heath, 1913):

(1) The Moon receives its light from the Sun.

(2) The Earth is like a point and is center to the sphere in which the Moon moves.

(3) When the Moon appears to us halved, the great circle that divides the dark and the bright portions of the Moon is in the direction of our eye.

(4) When the Moon appears to us halved, its distance from the Sun is less than one quadrant by one-thirtieth of a quadrant.

(5) The breadth of the Earth's shadow is that of two moons.

(6) The Moon subtends one-fifteenth part of a sign of the zodiac

Hypotheses (1) and (2) are straightforward in their meaning. The implication of hypothesis (3) is that the angle formed at the Moon between the Earth and the Sun is a right angle when the Moon's terminator appears to be a straight line to an observer on Earth, and of hypothesis (4) that the angle between the Moon and the Sun viewed from the Earth is 87°. Hypothesis 4, of course, requires an extremely difficult measurement, the actual value being about 89° 51'. As Otto Neugebauer and others point out, it is extremely difficult to determine the exact time of a straight terminator within a day or two, which makes this approach observationally improbable. Hypothesis (5) claims the diameter of the Earth's shadow at the orbit of the Moon is 2 diameters of the Moon; the actual value is closer to Ptolemy's estimate of 2 and 3/5ths of the Moon's diameters Finally, hypothesis (6) claims that the angular diameter of the Moon is 2°, a value four times too large. From the first three hypotheses, Aristarchus determined that the distance of the Sun from the Earth is greater than 18 times, but less than 20 times, the distance of the Moon from the Earth. During a total solar eclipse, it is observed that the Moon just covers the Sun; with this fact and the preceding conclusion, simple geometry gives the relative diameter of the Sun to be between 18 and 20 times the diameter of the Moon. Finally, from the hypothesis about the size of the Earth's shadow at the orbit of the Moon compared with the size of the Moon, he obtained that the Sun is between 19.3 and 43.6 (between 6.3 and 7.2) times the diameter of the Earth

How do these numbers compare with current calculations? The actual distance to the Sun, in terms of the distance to the Moon, is 389, compared with the 18 to 20 times determined by Aristarchus. The actual size of the Sun compared to that of the Moon is 400, compared to 18 to 20 times the diameter of the Moon for Aristarchus. Both calculations are in error by roughly a factor of about 20. His determination of the size of the Sun ranges between 6.33 and 7.2 times the diameter of the Earth, with the actual value about 109 times. Using Aristarchus's numbers, the size of the Moon is between 0.389 and 0.317 Earth diameters, with the actual value being 0.272, a value that is surprisingly comparable

Although the values determined for the sizes and distances do not compare well with modern determinations, the methods set forth by Aristarchus were employed and modified by succeeding generations of astronomers and marked a move to sophisticated methods of mathematical astronomy. Although he is credited with numerous other contributions, his hypotheses concerning the motion of the Earth and his theoretical approach to mathematical astronomy are truly remarkable.

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Selected References

Dijksterhuis, E. J. (1987). Archimedes, translated by C. Dikshoorn, with a new bibliographic essay by Wilbur R. Knorr. Princeton, New Jersey: Princeton University Press.

Dreyer, J. L. E. (1906). History of the Planetary Systems from Thales to Kepler.

(Revised, with a foreword by W. H. Stahl, as A History of Astronomy from Thales to Kepler. New York: Dover, 1953.)

Evans, James (1998). The History and Practice of Ancient Astronomy. New York: Oxford University Press.

Gibbs, Sharon L. (1976). Greek and Roman Sundials. New Haven: Yale University Press.

Heath, Sir Thomas L. (1913). Aristarchus of Samos, the Ancient Copernicus. Oxford: Clarendon Press. (Reprint, New York: Dover, 1981.)

Neugebauer, Otto (1975). A History of Ancient Mathematical Astronomy. 3 pts. New York: Springer-Verlag.