Geocentrism Vs. Heliocentrism: Ancient Disputes

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Overview

During the second century a.d., Greek-Egyptian astronomer and mathematician Ptolemy (100-170) summarized eight centuries of Greek geocentric (earth-centered) thought about the nature of the cosmos. Despite the heliocentric (sun-centered) theories of Aristarchus of Samos (/people/science-and-technology/astronomy-biographies/aristarchus-samos) (320?-250? b.c.) and a few others, Ptolemaic geocentrism dominated Western astronomy until Nicolaus Copernicus (1473-1543) proposed his heliocentric theory in the sixteenth century.

Background

In the sixth century b.c. the philosopher Pythagoras (580?-500 b.c.) founded a school of thought that concentrated on order, harmony, permanence, rationality, and regularity. His ideals were music and mathematics. Music was viewed as the origin and expression of harmony, and mathematics the rational explanation of music. Pythagoras believed that everything could be understood in terms of number, and therefore that everything is accessible to the mind, since the concept of number is intelligible. He posited a geocentric universe in which the Moon, Sun, and the five known planets (Mercury, Venus, Mars, Jupiter, and Saturn) all moved in perfect geometrical order by virtue of their natural and eternal mathematical relationships. He saw the geometry of space as "the music of the spheres," the ultimate harmony. He clearly recognized that the Earth is a sphere.

The most productive periods in the history of science are Pythagorean periods, that is, periods in which number and quantity are given preeminent roles in scientific investigation. Especially in the ancient world, nearly all progress in science was influenced in some way by Pythagoras.

In the fifth century b.c. the Pythagorean astronomer Philolaus departed from the geocentric model. He suggested that the Earth revolved not around the Sun, but around a cosmic central fire, around which the Sun also revolved. To explain why this central fire was never seen from Earth, Philolaus imagined the existence of an "anti-earth" always between the Earth and the fire.

The universe propounded by Plato (427?-347 b.c.) in the early fourth century b.c. was essentially Pythagorean. He emphasized the perfection, divinity, and eternity of spheres and circles, but disdained empirical observations of the heavens. Even though Platonic cosmology was grounded in questionable science, its influence on Western theology, philosophy, and culture persists even into the twenty-first century.

Sophisticated geocentric theory began with Plato's contemporary, Eudoxus of Cnidus (/people/science-and-technology/astronomy-biographies/eudoxus-cnidus) (400?-350? b.c.), who proposed an onion-like arrangement of 27 concentric spheres, with the Earth innermost and the fixed stars outermost. Each planet needed four spheres to explain its observed motion, the Sun and Moon each needed three, but the fixed stars only needed one. Later in the fourth century b.c. this system was made more complicated by Callipus, and even more complicated by Aristotle (384-322 b.c.), who posited 55 spheres, all
"unmoved mover" or *primum mobile* outside the outermost sphere.
Callipus, and Aristotle over Plato consisted in their use of observati
As a result, the influence of Aristotle's cosmology on Western theol
has been even greater than that of Plato, especially through the leg

One reason that the ancients, especially the Greeks, favored a geocentric model of the universe is that the Earth obviously had great weight, whereas the Moon, planets, and stars were believed to be light and airy or fiery. Weight would naturally determine the center of the celestial spheres, i.e., whichever body weighed the most would be central.

In Alexandria, Egypt, in the third century b.c., Aristarchus of Samos (/people/science-and-technology/astronomy-biographies/aristarchus-samos), a student of the Aristotelian Strato of Lampsacus (/people/philosophy-and-religion/philosophy-biographies/strato-lampsacus) (?-270? b.c.), calculated the relative distances of the Sun, Earth, and Moon from one another by measuring the Moon-Earth-Sun angle as it changed through the various phases of the Moon. His observations and calculations showed that that Sun was about 20 times the moon's distance from the Earth, and that the Sun was much larger than the Earth or Moon. His method was sound, but his primitive instruments impaired his results. In fact, the Sun is about 390 times the Moon's distance from the Earth. He further reasoned that since the sun is so large and so far away, it must also be proportionately greater in weight.

Aristarchus's correct conclusions that the Sun is larger and more massive than the Earth, and so distant, led him to suppose that the universe is heliocentric. He was the first major thinker to suggest such a theory and to support it with empirical data. His book *On the Sizes and Distances of the Sun and Moon,* survives, but all his writings on hel
his heliocentric theory is not known in detail, and is only known at a
Archimedes (287?-212 b.c.) in the third century b.c. and Plutarch in

The Greeks generally rejected Aristarchus's heliocentric theory, but he had a few supporters. Seleucus, for example, as reported by Plutarch, defended heliocentrism in the second century b.c. The observations of Timocharis and Aristyllus, contemporaries of Aristarchus, may have been intended to support his heliocentrism.

Around the beginning of the second century a.d., Menelaus of Alexandria (/people/science-and-technology/mathematics-biographies/menelaus-alexandria), a Hellenistic Egyptian mathematician and astronomer, invented spherical geometry. This innovation was of tremendous importance for astronomy, because the treatment of concentric arcs in the geometry of spheres is analogous to the treatment of lines in the Euclidian geometry of planes. Although Menelaus's original Greek book on spherical geometry, *Sphaerica,* is lost, its content survives in Arabic translation.

About a generation later, Ptolemy, another Hellenistic Egyptian mathematician and astronomer, achieved a mathematically complete geocentric system and published it in a large book best known as the *Almagest.* Ptolemy's mathematics was able to explain, albeit in a very complicated way, all the apparent retrograde motions of the planets. He relied heavily upon the mathematics of epicycles developed by Apollonius of Perga (/people/science-and-technology/mathematics-biographies/apollonius-perga) (262?-190? b.c.) in the third century b.c. and upon the trigonometry developed by Hipparchus of Nicaea in the second century b.c. Ptolemy's work soon became the definitive geocentric system.

Impact

Perhaps the clearest example of the extent to which Ptolemaic geocentrism determined Christian cosmology throughout the Middle Ages (/history/modern-europe/ancient-history-middle-ages-and-feudalism/middle-ages) is Dante Alighieri (/people/literature-and-arts/italian-literature-biographies/dante-alighieri)'s *Divine Comedy,* written in about 1310. Dante depicted the Earth as a sphere, with Jerusalem or Zion diametrically opposite the mountain of Purgatory. Hell was inside the Earth, and the Garden of Eden (/philosophy-and-religion/bible/biblical-proper-names/garden-eden) was atop Mount Purgatory. The Earth was surrounded by a sphere of fire, beyond which was Heaven or Paradise, consisting of 10 concentric spheres: 1) the sphere of the Moon; 2) the sphere of Mercury; 3) the sphere of Venus; 4) the sphere of the Sun; 5) the sphere of Mars; 6) the sphere of Jupiter; 7) the sphere of Saturn; 8) the fixed stars and the zodiac; 9) the Aristotelian *primum mobile;* and 10) the Empyrean sphere, i.e., the sphere of pure light, beyond which was only God. Ten is a perfect number in Pythagorean numerology. As Dante, on his journey through the Christian theological universe, emerged from the Garden of Eden (/philosophy-and-religion/bible/biblical-proper-names/garden-eden) and first perceived Paradise, he heard the Pythagorean music of the spheres.

No serious thinker since the time of Ptolemy has believed that the world was flat. Contrary to popular mythology, Christopher Columbus (/people/history/explorers-travelers-and-conquerors-biographies/christopher-columbus) (1451-1506) did not sail west to prove to Europeans that the world was round. All educated people of his time already knew it was round. Columbus sailed to prove that he could navigate safely to Asia westward across open ocean, out of sight of land, thus avoiding the two disadvantageous eastward routes, either the perilous trek overland or the long voyage around Africa, keeping land in sight all the way.

Geocentric cosmology dominated Western thought until the early m
developed a plausible heliocentric theory in about 1512, but circula
because he was afraid of the possible reaction against him. The Rc
(/philosophy-and-religion/christianity/roman-catholic-and-orthodox-c
schisms-and-8) vigorously opposed heliocentric cosmology and pe
believed in it. Copernicus finally published his heliocentric conclusions in *De revolutionibus*

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Heliocentrism is much simpler than geocentrism because it has no need for elaborate mathematical stratagems to account for retrograde motions. This fact was very attractive to Copernicus and his successors.

During the 1633 Inquisition, the fearful Galileo (1564-1642), recalling that another defender of Copernicus, Giordano Bruno (/people/philosophy-and-religion/philosophy-biographies/giordano-bruno) (1548-1600), had been burned at the stake by the Church in 1600, publicly recanted his own findings and affirmed the Church's official view that the Sun orbited a stationary Earth. But in an aside, in accordance with his 1632 book, *Dialogo dei due massimi sistemi del mondo* (Dialogue on the two main world systems), which argued that the Earth orbited the Sun, he is supposed to have muttered under his breath, "And yet it moves." The Inquisition convicted Galileo, and he spent the rest of his life under house arrest and close scrutiny.

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