



The Scientific Revolution: Its Classical and Christian History with Dr. Ted Davis

Lecture 7: Measuring the World: Eratosthenes, Aristarchus, and the Size of the Cosmos in Antiquity

Outline:

Measuring the World: Eratosthenes, Aristarchus, and the Size of the Cosmos in Antiquity

- Geographer and mathematician Eratosthenes (fl. 235 BC) was the librarian at Alexandria, the greatest library in the ancient world. He knew that, on a certain day of the year (the summer solstice), the sun was directly overhead in Syene, south of Alexandria.
- Eratosthenes' assumptions:
 - The Earth is round.
 - The sun is very far away, so that its rays may be considered parallel to one another.
 - The sun is directly overhead at noon on a particular day of the year in Syene.
 - Syene is due south of Alexandria.
 - He uses this information to calculate the circumference of the Earth.
- When the numbers were run, his result (as reported by Pliny) was a circumference of 250,000 stades (later altered to 252,000). Depending on the actual value of this unit (the stade), his result differed from the modern value by as little as 1% to as much as 20%.
- Aristarchus Measures the Cosmos
 - Aristarchus of Samos (c. 310 – 230), *On the Sizes and Distances of the Sun and Moon*
 - A very clever computation of the dimensions of the earth-sun-moon system.
 - Although Aristarchus believed that the Earth revolves around the sun, his calculation did not depend on that assumption at all. It depended only on making 3 specific measurements involving the sun & moon.
 - First, he estimated the angle between the moon and the sun, when the moon is exactly half full.
 - Then, he noticed that the sun and moon have exactly the same apparent size (angular size) in the sky. If this were not so, a total eclipse of the sun would not be possible.
 - The third observation involved a lunar (not solar) eclipse. He timed the moon as it passed through the earth's shadow, from



start to finish. The earth's shadow is about twice as large as the moon.

- Putting it all together, he got the following result: The moon is about $\frac{1}{3}$ the size of the earth in diameter. The sun is 19 times as far away as the moon – and 19 times larger in diameter.
- Ptolemy measures the Cosmos.
 - Claudius Ptolemy (c. 90-c. 165 AD), *The Planetary Hypotheses*, calculated the distance to the stellar sphere, by first figuring out the distances to each planet, one at a time.
 - Ptolemy's big assumption: There are no empty spaces between spheres of the planets. Therefore, the maximum distance to one planet = minimum distance to the next one.
 - The distance to the sphere of the stars, just beyond the outer edge of Saturn's sphere, is 19,865 earth radii. Roughly 80 million miles in radius. Minute compared with the modern universe, but enormous compared with the Earth.
 - Ptolemy had already said, in *Almagest*, that the earth is just a tiny speck in the universe: "the earth has sensibly the ratio of a point to its distance from the sphere of the so-called fixed stars..."
 - University students were still learning Ptolemy's conception of the universe as late as the 17th century. This, when John Calvin interpreted Genesis 1:16, he gave nod to Ptolemy over the literal sense of Scripture, which speaks of the Sun as "the greater light" and the Moon as "the lesser light."
 - "Moses makes two great luminaries, but astronomers prove by conclusive reasons that the star of Saturn, which on account of its great distance, appears the least of all, is greater than the moon." Where "Moses wrote in a popular style" for "ordinary persons, endued with common sense," the astronomers investigate with great labor whatever the sagacity of the human mind can comprehend.