Lecture Three

Truth, Beauty, and Heliocentrism

Scope: The geocentric model of the solar system provides adequate predictions of the positions of the Sun, Moon, and planets for human-eye astronomy. In 1543, Copernicus presented an alternative hypothesis of a Sun-centered, or heliocentric, solar system. Being based on the same geometrical constructs as its predecessors, the model was not scientifically more compelling. One could argue that it was philosophically more attractive, especially in that it raised the discussion from a calculational device to a physical model of nature. Still, given the state of science and mathematics in the early 1600s, even Galileo could not prove the correctness of the heliocentric model. The fundamental lesson is that the reference frame of Earth and the reference frame of the Sun provide essentially equivalent vantage points from which to calculate the motions in the solar system.

Outline

I. The geocentric model of the solar system was successful for more than 1000 years.

- **A.** The geometric calculations were based on inventive combinations of circular motions, including off-center circles (eccentric circle, equant) and circles upon circles (epicycle and deferent).
- **B.** The combinations that could predict the position of a celestial body were not unique.
- **C.** During the Middle Ages, Arabic astronomers preserved the knowledge of the geocentric model and developed alternative versions.
- **D.** At the start of the Renaissance, the Aristotelian philosophy of "perfect" heavens still held sway.

II. The heliocentric model is an alternative hypothesis with deep philosophical implications.

- **A.** Nicolaus Copernicus's heliocentric model switched the places of Earth and the Moon with that of the Sun.
  1. His book, *On the Revolutions of Heavenly Spheres*, was published in 1543, the same year he died.
  2. Copernicus worked part-time for more than 30 years developing his heliocentric model, but few details of this development work remain.
- **B.** Many myths about the heliocentric model have arisen in popular culture.
  1. It is a myth that the heliocentric model was more accurate in its predictions than the geocentric model.
  2. It is a myth that the heliocentric model was much simpler than the geocentric model.
  3. It is a myth that the center of the universe is the most important place in the geocentric model.
  4. It is a myth that Copernicus delayed publishing for fear of reprisal from the church.
  5. It is a myth that the heliocentric model was considered a mathematical calculation device and not a representation of reality.
  6. It is a myth that astronomers quickly embraced the heliocentric model.
  7. It is a myth that Galileo proved the heliocentric model was correct.
- **C.** The heliocentric model provides several advantages over the geocentric model.
  1. It makes more sense that the much smaller sphere of Earth moves, rather than the much larger Sun or the sphere of the stars.
  2. The heliocentric model provides a natural explanation for why Mercury and Venus are always found near the Sun.
  3. The heliocentric model explains why Mars, Jupiter, and Saturn are closest to Earth when they are opposite the Sun on the sky.
  4. The heliocentric model provides an explanation of retrograde motion that does not involve any true backward motion.
  5. The heliocentric model is a physical model representing nature, not just a mathematical device.
- **D.** The heliocentric model had several problems.
  1. If Earth rotates, a point on the equator would be moving at an absurd speed of about 1000 kilometers per hour (600 mph).

2. If Earth orbits the Sun, it would be moving at an absurd speed of about 100,000 kilometers per hour (60,000 mph).
3. If Earth orbits the Sun, the stars should shift positions over the course of a year due to the parallax effect.
4. The scriptures state in several places that Earth does not move.

E. Both the advantages and disadvantages of the heliocentric model were essentially philosophical, not scientific, in nature.

III. Given the science of the early 1600s, one could not provide irrefutable proof of the heliocentric hypothesis.

A. Several observations showed that the Aristotelian view of perfect and immutable heavens was wrong.
1. A supernova explosion in 1572 showed that the stars do indeed change.
2. Mountains on the Moon showed that celestial bodies were not all perfect spheres.
3. The moons of Jupiter showed that not everything orbited Earth.
4. The Tychonian model of the solar system reflected this thinking, with the Sun and Moon orbiting Earth while the planets orbited the Sun.

B. In 1615, the Catholic Church reviewed Copernicus's book and decreed that the heliocentric model could only be called a hypothesis.
1. Galileo, whose work had inspired this review, was cautioned not to hold or defend the ideas of heliocentrism.
2. Galileo instead took up the challenge of proving the heliocentric model was correct, and he presented his arguments in his book *Dialogue Concerning the Two Chief World Systems* in 1630.
3. For this work, he was tried by the Inquisition, forced to abjure, and placed under house arrest for the remainder of his life.

C. Galileo proposed that the tides were proof that Earth moved.
1. In physics, the combination of two motions is simply the vector sum of the two separate motions.
2. The combination of Earth's rotational and orbital motion produces a faster motion at the point on Earth farthest from the Sun and a slower motion at the point closest to the Sun.
3. Galileo argued that the acceleration and deceleration in speed produces a sloshing of the oceans that creates the tides.

D. Galileo's argument for the heliocentric model was wrong.
1. The tides are an effect seen from the reference frame of the Earth, while the change of speed in his argument is seen only from the reference frame of the Sun.
2. The high and low tides cycle every 12 hours, while his argument would produce a 24-hour cycle.
3. Galileo was aware of the argument that the Moon produced the tides but dismissed it as "ridiculous."

IV. The shift from geocentric to heliocentric is just a transformation of the heavens.

A. All motion is relative to some defined frame of reference.

B. The various solar system models discussed so far can be viewed as essentially equivalent.
1. The geocentric model compared to the heliocentric model is a change of reference frame from Earth to the Sun.
2. The Tychonian model is a rotational transformation of the heliocentric model.
3. Galileo wrote a note in his copy of his book that could be interpreted as recognition that he had not truly proved that Earth moved.

C. In 1979 the Catholic Church reexamined Galileo's case, and in 1992 Pope John Paul II endorsed its findings that Galileo should not have been condemned.

D. Astronomers would not be convinced to switch to the heliocentric model until it could make better predictions for their observing than other models.

Suggested Readings:

Bennett, Donahue, Schneider, and Voit, *The Cosmic Perspective*, chap. 3.

Copernicus, *On the Revolutions of Heavenly Spheres*.

Crowe, *Theories of the World*.

Galilei, *Dialogue Concerning the Two Chief World Systems*.

———, *Siderius Nuncius*.

Gingerich, *The Book Nobody Read*.

Weintraub, *Is Pluto a Planet?* chap. 3.

Wilson, *Astronomy through the Ages*, chap. 5.