Geocentric Model of the Universe

Andreas Cellarius, *Harmonia Macocosmia*, AD 1660

Geocentric Model Key Concepts

1) The most famous advocate of the geocentric model was Ptolemy (2nd century AD).
2) Observed motion of the Sun can be explained by either a geocentric or heliocentric model.
3) Explaining the observed motion of planets in a geocentric model required epicycles.

For 2000 years, a geocentric (earth-centered) model for the universe was widely assumed.

Moon, Sun, planets, between Earth & stars

Spherical Earth at center of universe

Stars affixed to celestial sphere

Most famous advocate of geocentric model: the astronomer Ptolemy, who lived in Alexandria during the 2nd century AD.

He developed an elaborate model to describe motion of stars, Sun, Moon, & planets.

Ptolemy’s book describing his geocentric model was called the Almagest (from the Arabic word “greatest”).

manuscript of the Almagest (9th cent. AD)

Stars:

Circular motion around the north celestial pole (near the North Star, Polaris)

Time to complete circle = 23 hours, 56 min. = 1 sidereal day
Stars look as if they were glued to a rigid spherical shell rotating once every 23 hr, 56 min.

(You can’t tell, without a telescope, that some stars are closer than others.)

Sun:
Circular motion around the celestial pole: part of the circle is below the horizon, so we say the Sun “rises” and “sets”.

Time to complete circle = 24 hours.

Observed motions of the Sun = the first clock.

1 solar day = time from one noon to the next = 24 hours

IF the Sun orbited the Earth once per day (geocentric):

Q: Why did ancient astronomers believe the Earth is not moving?

A: Well, do you feel any motion?

Rotation speed at Earth’s equator = circumference / rotation period = 40,000 kilometers / 24 hours = 1667 kilometers/hour
Describing motions of the stars and Sun (and also the Moon) was fairly simple in the geocentric model.

Describing the motion of planets was difficult.

To the naked eye, a planet looks like a star - a tiny blob of light.

Planet = “Wanderer” in Greek

Planets are distinguished by their motion relative to stars.

Planets usually move west to east, but sometimes east to west (retrograde), relative to stars.

Retrograde Motion

- In general, the planets move eastward relative to the "fixed" stars.
  - Called “Direct Motion”.
  - Motion is non-uniform (changing speed)
- Sometimes, however, the planets appear to
  - Slow down & stop!
  - Start moving westward, or RETROGRADE.
  - Slow down, stop, & resume moving eastward.

Ptolemy’s explanation of retrograde motion:

Planet (P) moves in a small circle called the epicycle.

Center of the epicycle (A) moves in a larger circle called the deferent.
The combination of small and large circles creates “loop-the-loop” retrograde motion.

Detailed structure of Ptolemy’s geocentric model:

Earth

Complicated!

OCCAM’S RAZOR: (William of Occam, medieval philosopher)

The simplest theory that fits all the data is the preferable one.

Is Ptolemy’s geocentric theory the simplest one that explains planetary motions?

In the geocentric model of Ptolemy, Mars undergoes retrograde motion when:

1. Mars is closest to the Sun
2. Mars is farthest from the Sun
3. Mars is closest to the Earth
4. Mars is farthest from the Earth