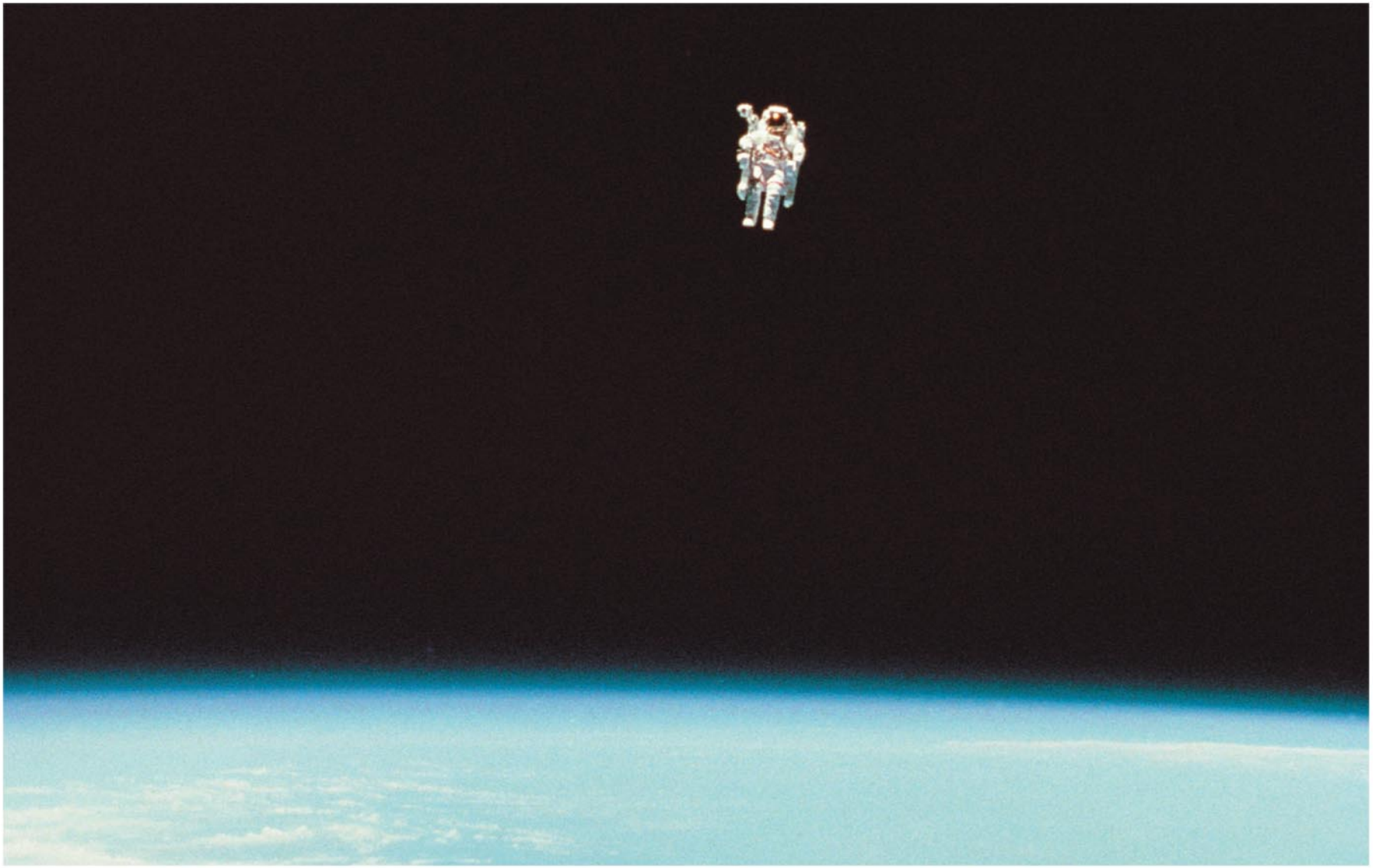
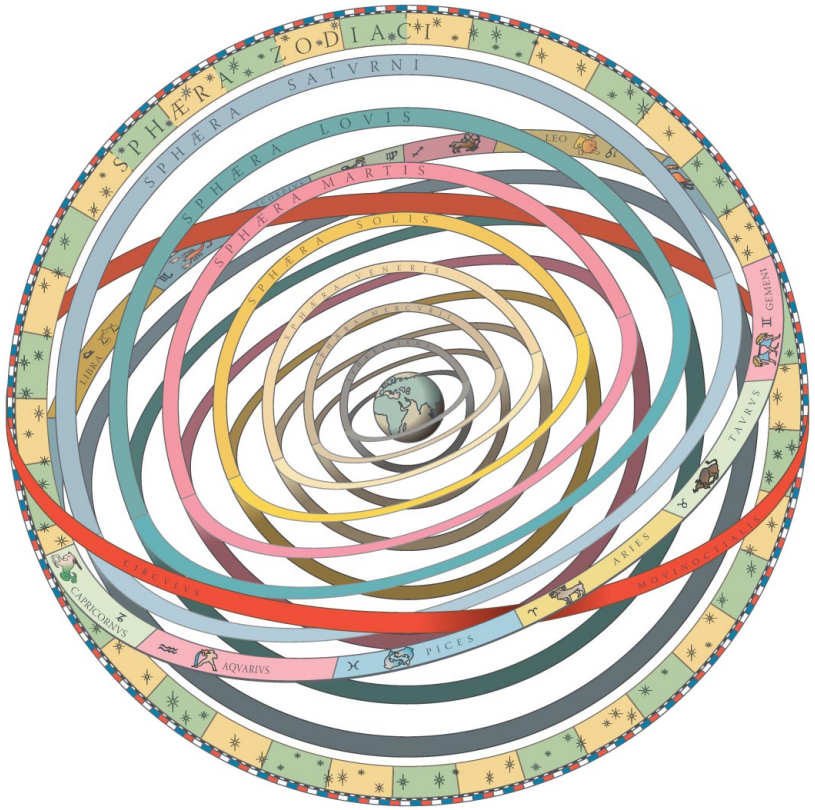
The Science of Astronomy



Why does modern science trace its roots to the Greeks?



- Greeks were known to make ***models*** of nature.
- They tried to explain patterns in nature without resorting to myth or the supernatural.

Greek geocentric model (c. 400 B.C.)

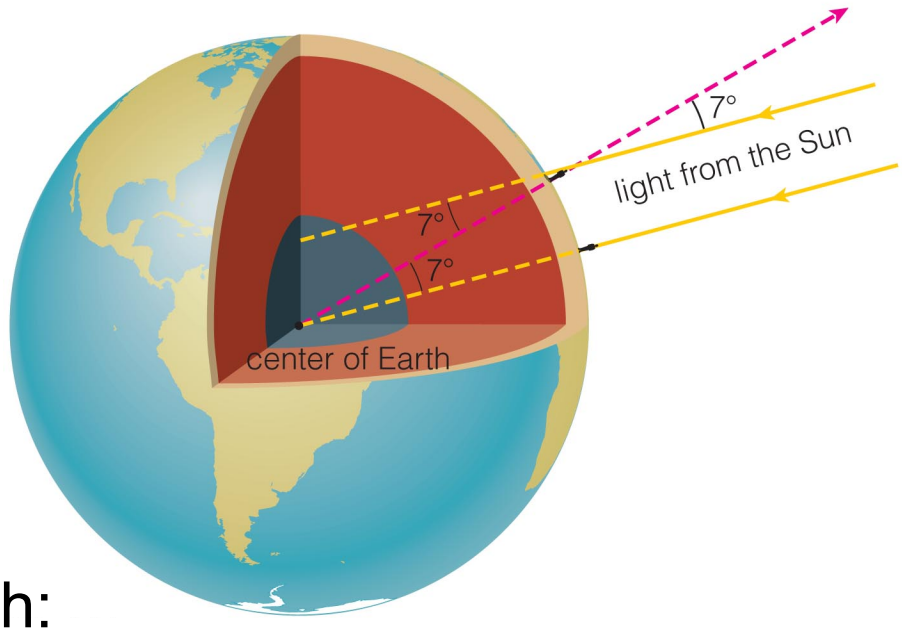
Eratosthenes Measures Earth (c. 240 B.C.)

Measurements:

Syene to Alexandria

distance ≈ 5000 stadia

angle = 7°



<u>Calculate circumference of Earth:</u>

7/360 × (circum. Earth) = 5000 stadia

⇒ circum. Earth = 5000 × 360/7 stadia ≈ 250,000 stadia

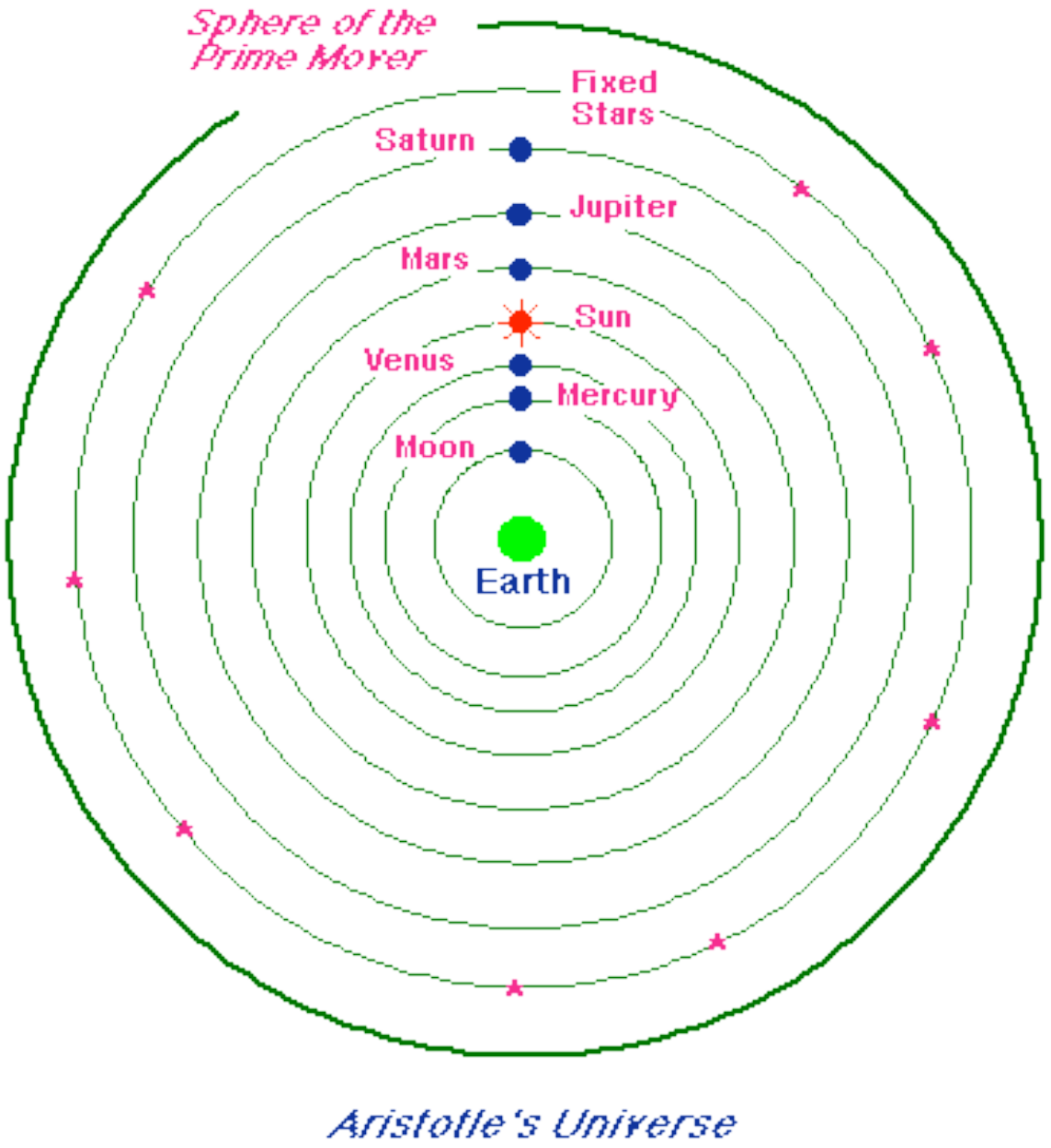
<u>Compare to modern value (≈ 40,100 km):</u>

Greek stadium ≈ 1/6 km ⇒ 250,000 stadia ≈ 42,000 km

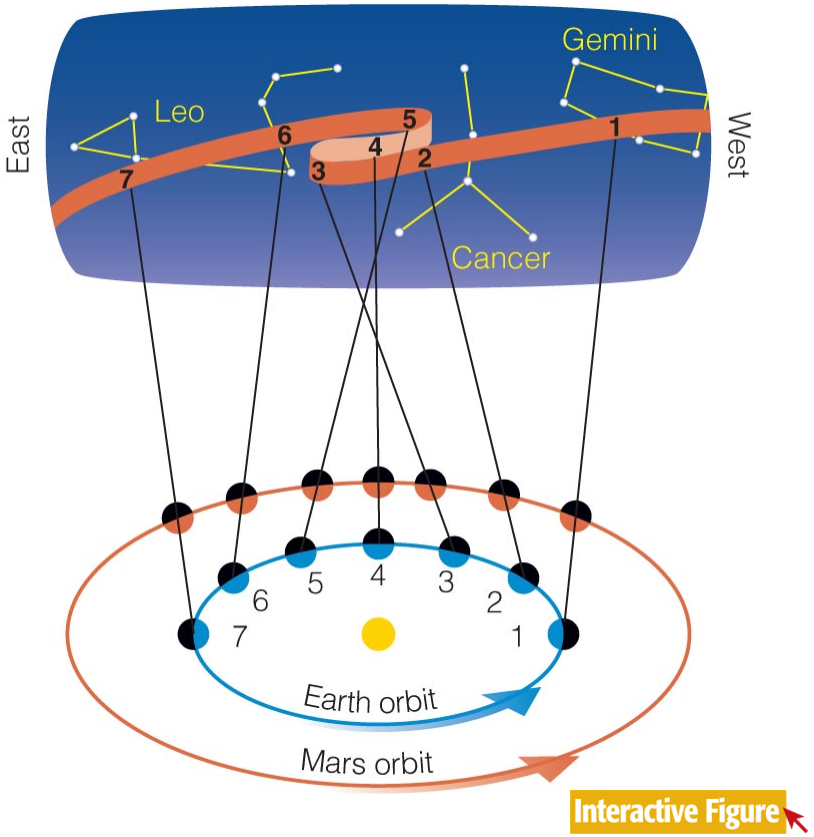
How did the Greeks explain planetary motion?

- Underpinnings of the Greek geocentric model:
  - Earth at the center of the universe
  - Heavens must be "perfect": Objects moving on perfect spheres or in perfect circles.

How did the Greeks explain planetary motion?



But this made it difficult to explain apparent retrograde motion of planets…



- Review: Over a period of 10 weeks, Mars appears to stop, back up, then go forward again.

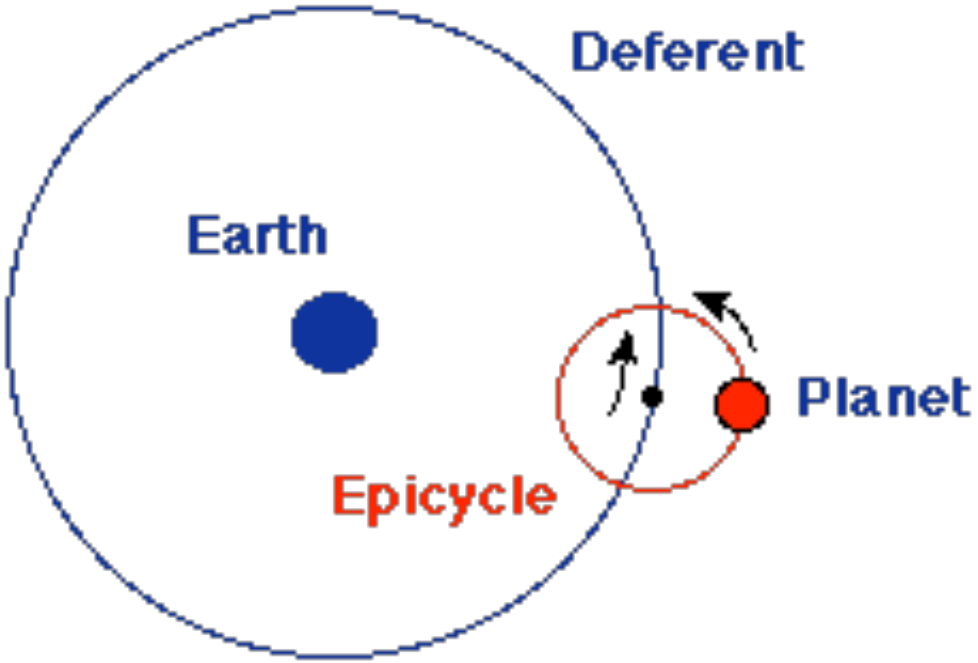
But this made it difficult to explain apparent retrograde motion of planets…

Ptolemy

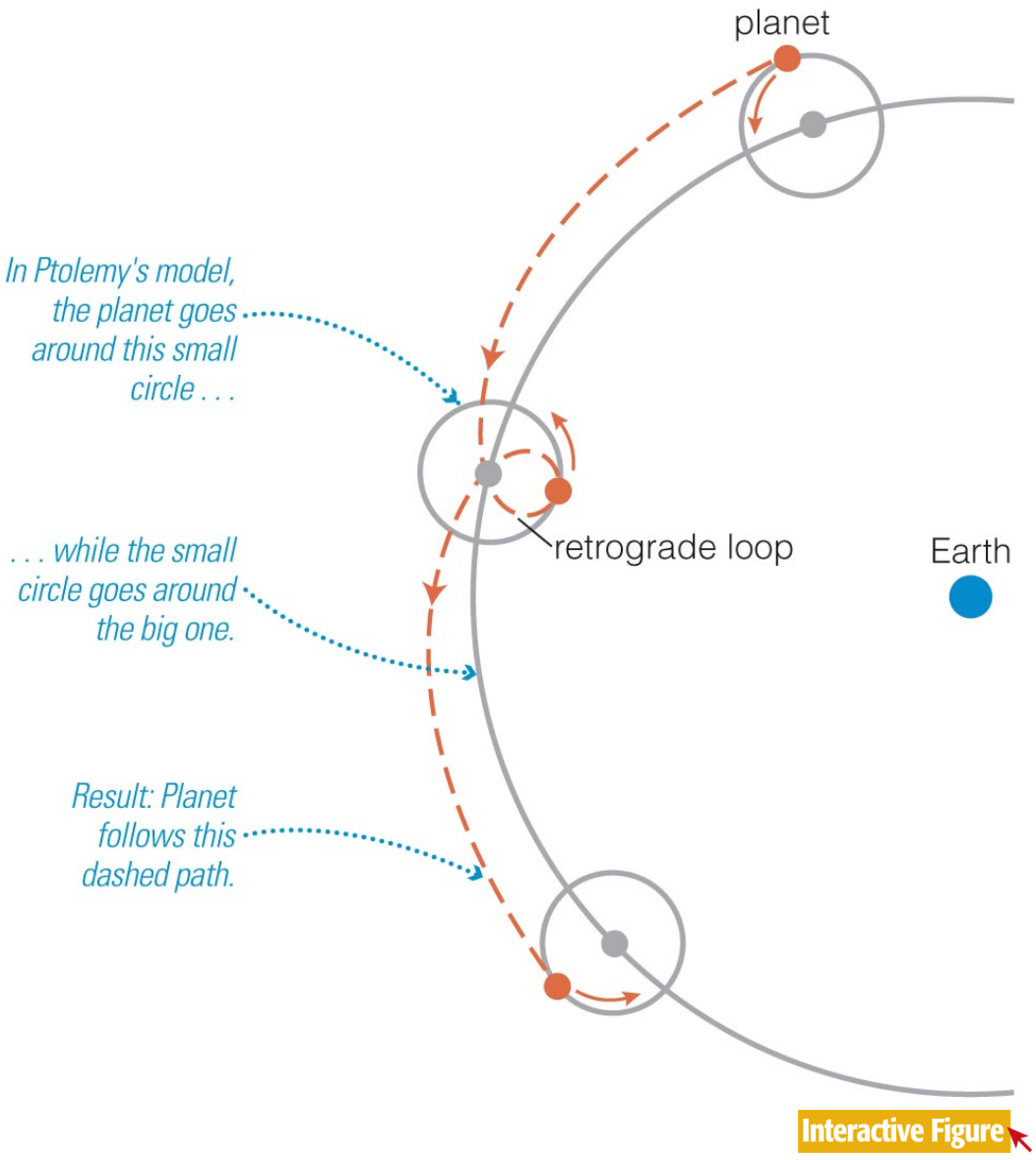
- The most sophisticated geocentric model was that of Ptolemy (A.D. 100-170) — the **Ptolemaic model:**
  - Sufficiently accurate to remain in use for 1,500 years.
  - Arabic translation of Ptolemy's work named *Almagest* ("the greatest compilation")

Epicycles and Epicyclic Motion

So how does the Ptolemaic model explain retrograde motion? *In this model, planets really do go backward, on epicycles...*

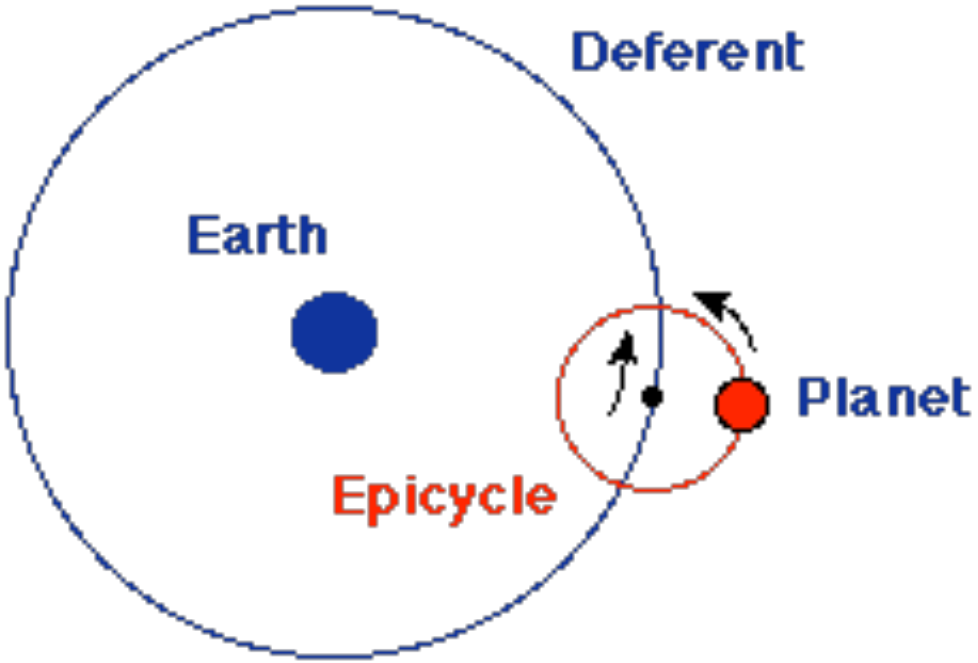


Epicycles and Epicyclic Motion



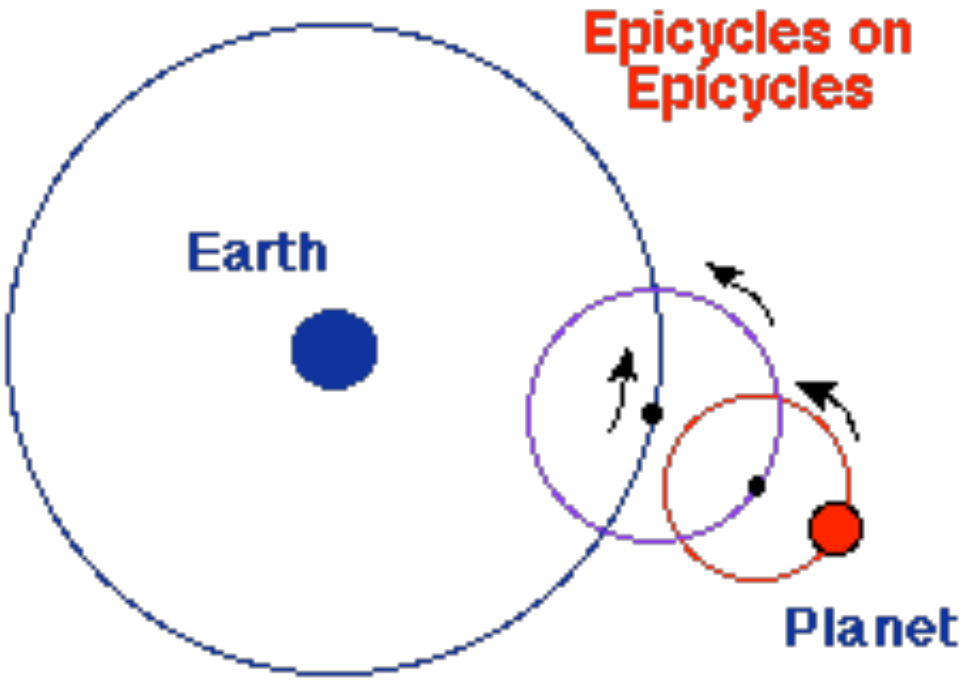
Epicycles and Epicyclic Motion

Problem: Simple epicycles didn't do a very accurate job in explaining planetary motion.

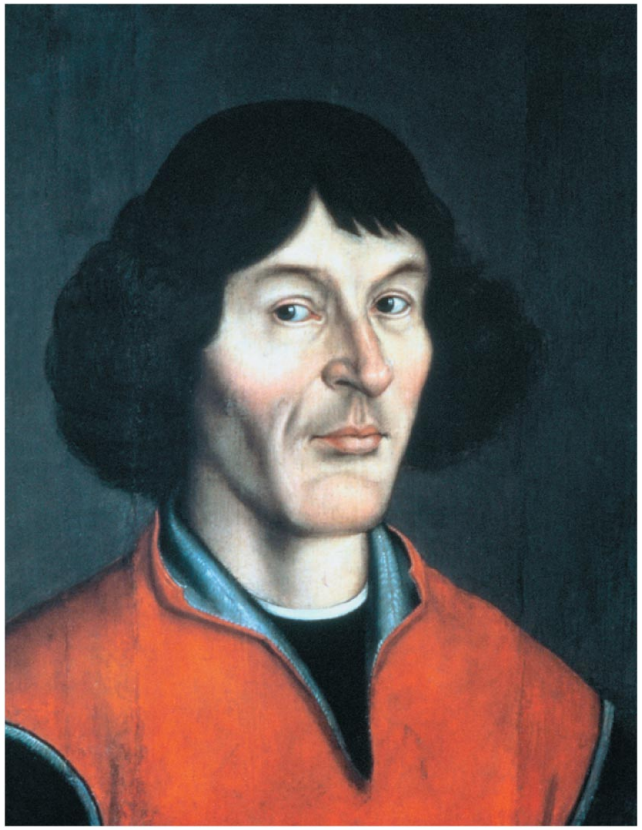


Epicycles and Epicyclic Motion

Solution: More epicycles!



How did Copernicus, Tycho, and Kepler challenge the Earth-centered model?



Copernicus (1473-1543)

- Proposed a Sun-centered model (published 1543)
- Used model to determine layout of solar system (planetary distances in AU) But . . .
- The model was no more accurate than the Ptolemaic model in predicting planetary positions, because it still used perfect circles.
- So Copernicus added epicycles.

How did Copernicus, Tycho, and Kepler challenge the Earth-centered model?

Tycho Brahe (1546-1601)

- Compiled the most accurate (one arcminute) naked eye measurements ever made of planetary positions.
- Still could not detect stellar parallax, and thus still thought Earth must be at center of solar system (but recognized that other planets go around Sun).
- Hired Kepler, who used Tycho's observations to discover the truth about planetary motion.

How did Copernicus, Tycho, and Kepler challenge the Earth-centered model?

Johannes Kepler
(1571-1630)

- Kepler first tried to match Tycho's observations with circular orbits
- But an 8-arcminute discrepancy led him eventually to ellipses.
- *"If I had believed that we could ignore these eight minutes [of arc], I would have patched up my hypothesis accordingly. But, since it was not permissible to ignore, those eight minutes pointed the road to a complete reformation in astronomy."*