Historical Overview of Planetary Motions

• Planets as “wandering stars”: Mercury, Venus, Mars, and Jupiter appear to move at a different rate than the “fixed” stars. Also, all 5 planets moved near the ecliptic.

• Most of the time, the planets drift eastward, but sometimes they appear to go backwards: retrograde
Aristotle (350 BC)

- Earth at center of universe.
- Planets and sun revolve around 55 celestial spheres.
- Outermost sphere is the fixed stars.
- Beyond that is the prime mover, which causes the general rotation of spheres.
- Below the moon sphere are the basic elements: earth, air, fire, and water.
- The fifth element is “quintessence”, a perfect, unchanging element of which the celestial spheres are formed.
The Scientific Method

- **Science** is the study of the natural world and the underlying laws of nature.

- The process:
  1. Observe a phenomenon.
  2. Develop a hypothesis (model or theory).
  3. Use the theory to predict a phenomenon not yet observed.
  4. Test the prediction.
     - If prediction ok, then theory is supported (NOT “proved”!)
     - Make other predictions and try to generalize
     - If experiments disprove prediction, then find alternative theory.
Why Study Astronomy?

- Astronomers try to answer the BIG questions:
  - How did the universe begin?
  - How did the universe evolve?
  - What is the fate of the universe?

- Along the way, we need to answer:
  - How did the solar system form and evolve?
  - How did our Galaxy form and evolve?
  - How and where were the elements formed?
  …
• Why did Aristotle’s theory need to be revised?
  – Continued observations indicated that even 55 spheres were not sufficient to predict accurately the motions of the planets.

• Ptolemy (AD 140) introduced the idea of epicycles: small circles superposed on larger circles.
What were the Preconceived Notions?

(Today, we would call these the “standard model,” i.e., the common assumptions by most practitioners in the field.)

- Earth fixed
- Earth at center
- Spheres as “perfect” shapes

However, even epicycles were not enough to explain observations.

So, according to the scientific method, what should happen now?
Copernicus (1543 AD)

• **Rethink** our implicit assumptions.
  – Despite apparent evidence to the contrary, think about the Earth rotating…
    • Arguments against rotation of Earth included: why aren’t birds, clouds, long jumpers, etc left behind by the moving earth?
    • But, an object at rest will stay at rest AND an object in motion will stay in motion unless it experiences a net external force (Newton’s first law).
  – In addition, Ptolemy introduced the idea of “deferents” which moved Earth away from the center of the system.
Heliocentric Models

- First proposed by Aristarchos (3rd cent. B.C.)

A natural explanation for retrograde motion. But not accepted because it predicted that stars should move (parallax).
Copernican Revolution

NOTE: Copernicus’ heliocentric model still needed epicycles, since spheres were still considered “perfect” shape.
Galileo (1564-1642)

• Advances in observational techniques (invention of the telescope) showed that Earth was not “special”:
  – Moons around Jupiter
  – Craters on the Moon
  – Could see many more stars with a telescope
    • Milky Way contained individual stars
  – Saturn is not a sphere
  – Sunspots
  – Venus goes through phases, just like the moon.
Galileo (1564-1642)

- Change from geocentric to heliocentric model required a cognitive shift, not only for astronomy, but also for how we saw ourselves with respect to the universe as a whole.
- Conflict between science and religion (take a history of science class!)
Kepler (1571-1630)

• Using data of Tycho Brahe (1546-1601), generalized the Copernican heliocentric model to a model of elliptical orbits.

NOTE: Tycho Brahe’s data were crucial to this effort because all previous astronomers were trying to fit incorrect data…Ptolemy fudged his data to fit his model! BAD SCIENCE!!!