Reminders

1. No Online Quiz this Week
2. Midterm 1: Friday Sept 25 (this Friday)
   - Bring OU ID
   - Pencil
   - Eraser
3. Practice Midterm on course web page (also under Supplementary Material –> Midterm 1)
4. All lectures are posted on Course Webpage
Lecture 13 – Kepler and Newton’s Laws
Aristotle
Aristotle’s Teaching

Earth is center of the universe. Gravity is due to the fact that things want to move towards the center of the universe. Heavy things move faster than light things. Earth is corruptible, things change on it. Heavens are perfect and unchanging. Knew Earth was round.
End of Classical Greece

- Ptolemy’s system and textbook *Almagest* (the greatest, renamed by the Arabs) remained virtually unchanged until the 13th century.

- With the end of classical Greece, pursuit of knowledge passed to the Arab world. (The Romans did little to further scientific knowledge)
  Arabs updated the tables several times, remember precession causes them to become out of date.
Ptolemy
Fly in the ointment:
Retrograde Motion of Mars
Astronomy in the Dark Ages

- in 13th Century Arabs were driven out of Spain by Christians, Ptolemy’s book became more widely available in Latin.

- Last great adjustment of Ptolemy’s system financed by Alfonso X of Castille: *Alfonsine Tables*

- The Renaissance was beginning in Europe
Critics of Aristotle and Ptolemy

- Heraclides: A Pythagorean who explained the diurnal motion of the stars by positing an eastward axial rotation of the central earth.

- Nicole Oresme (14th Century A.D.) member of the Parisian nominalist school. Formulated what we now call Galilean Relativity

- Critics rejected due to lack of parallax

- How does this illustrate the workings of the scientific method?
Copernicus 1473-1543

- Wrote *De Revoluionibus Orbium Coelestium* (De Reb) around 1530, not published until year of his death.
- Established *heliocentric* system
- Still used uniform circular motion and epicycles
- Prutenic Tables (1551) based on Copernican system, but not particularly more accurate than Alfonsine Tables
- Triumph: Could explain retrograde motion of Mars
Copernicus
Copernicus’ System from *De Reb*
Copernicus’ System
Planets nearer the sun move faster
Triumph of Copernican System

- Copernicus’ ideas were disseminated throughout Europe even before he published.
- Even though Copernican system wasn’t necessarily accepted, it was used by astronomers for pragmatic reasons. Remember how inelegant Ptolemy’s system was!
Copernicus’ Explanation for Retrograde Motion
Tycho (1546-1601)

- Keen observer
- Recognized that the Alfonsine and Prutenic tables were in error by as much as a month
- Discovered a “new star” (Tycho’s supernova) in 1572
- Published his results in *De Stella Nova*
- Since the Heavens changed this challenged Aristotle’s system
- Did careful measurements, devising measuring instruments for 20 years
Rejected Copernicus again because he detected no parallax. Why didn’t he?
Developed his own (rather weird) system
Patron (Frederik II) died and he moved to Prague to produce Rudolphine Tables. Died (how?) before he could complete them and the observations passed to Kepler
Tycho at Hveen
Tycho’s System
Kepler (1571-1630)

- Dedicated Copernican
- Published ideas in *Mysterium Cosmographicum* in 1596
- Joined Tycho in Prague in 1600
- After Tycho’s death got full access to Tycho’s observations
- Abandoned uniform circular motion, published Rudolphine Tables in 1627.
Kepler
Kepler’s Laws

Kepler’s Three Laws of Planetary Motion

1. The orbits of the planets are ellipses with the sun at one focus

\[ e = \frac{c}{a} \]

\[ 1 - e^2 = \left(\frac{b}{a}\right)^2 \]

2. A line from the sun to the planet sweeps out equal areas in equal times

\[ P_{\text{year}}^2 = a^3_{\text{AU}} \]
Ellipse
Ellipse Axes
Kepler’s Second Law
Galileo (1564-1642)

- True Scientist, made observations and then tried to interpret them
- Did not discover Telescope, but built one and pointed it at the Heavens
- Observed the moon, Jupiter, Saturn, and Venus