Emergence of Modern Astronomy
- Early Greek Astronomy
- Ptolemaic Astronomy
- Copernican Astronomy
- Galileo: The First Modern Scientist
- Kepler's Laws of Planetary Motion
- Proof of the Earth's Motion
Early Greek Astronomy

- Smart, but limited experimentation
- Limited tools (e.g. no telescopes)
- Our knowledge is fragmentary
- Still lots of stuff right way back then
- E.g., Lunar phases and eclipses
- more as well
Aristotle's Explanations for Spherical Earth

- Gravity pulls everything together, strongly, and a sphere is the most compact form.
- Partial lunar eclipses always show an arc of a circle and only spheres ALWAYS show such shadows from any angle.
- Different stars visible as you move south, suggesting a curved Earth.
- African and Indian elephants similar and on “opposite sides of the world” so they must be close to each other...well, not quite!
Aristarchus: Relative Distances to Sun and Moon

Aristarchus: Relative Distances to Sun and Moon

- \( \frac{A}{C} = \cos \theta \). \( \theta = 87^\circ \) means \( C = 19A \)
- If \( \theta = 89.853^\circ \) (modern value) then \( C = 390A \)
Aristarchus: Relative Sizes of Moon, Earth, Sun

- Geometry involving eclipses
- Came up with 1:3:19 (modern values 1:4:390) for ratios of diameters.
Eratosthenes: Size of the Earth

- Geometry involving the sun
- Figured out what fraction (1/50) of the Earth's circumference corresponded to the distance between Alexandria and Syene
- Figure from Wired Magazine
- Theta is about 7 degrees
- Answer is the circumference is 46,000 km
- Modern value closer to 40,000 km
ASTR 2310: Chapter 2

- Hipparchus: Extraordinary Observer
  - Star Catalog
  - Led to detection of precession of equinoxes
  - Magnitude system (ASTR 2320 horror show!)
  - Accurate distance to the Moon
    (not too far off the modern value of 60.5 Earth radii)
  - Length of tropical year (good to 7 minutes)
ASTR 2310: Chapter 2

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ASTR 2310: Chapter 2

- Ptolemaic Astronomy
  - Ptolemy developed detailed mathematical model to predict positions of objects in the sky
  - Used for 14 centuries
  - Accurate but conceptually flawed
ASTR 2310: Chapter 2

- Ptolemaic Astronomy
  - Observed elements:
    - Stars, with fixed relative positions, rotate around celestial pole
    - Sun moves east along ecliptic, tilted at 23.5 degrees, about 1 degree per day
    - Moon moves east also, not quite on ecliptic, about 13 degrees per day
    - Planets usually move eastward (prograde), but sometimes west (retrograde). And only some planets.
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- Ptolemaic Astronomy
  - Earth doesn't move (no sense of motion, parallax)
  - Not quite at center
  - Everything “circles”
  - Lots of weird terms
  - Predicts positions ok!
ASTR 2310: Chapter 2

- Ptolemaic Astronomy
  - Not all planets equal!
  - Placements look odd
  - Tested by Galileo
ASTR 2310: Chapter 2

- Copernican Astronomy
  - Sun at center -- heliocentric
  - Still circles
  - Simpler
  - Not more predictive
ASTR 2310: Chapter 2

- Copernican Astronomy
  - Explanation for retrograde motion
ASTR 2310: Chapter 2

- Copernican Astronomy
  - Inferior Planets
    - no retrograde motion
    - always close to the sun
    - orbits smaller than Earth's
    - Venus, Mercury
  - Superior Planets
    - (Mars, Jupiter, Saturn known by Greeks)
      - Retrograde motion, orbits larger than Earth's
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- Copernican Astronomy
  - More Terminology – draw Figure on board
    - Opposition
    - Conjunction
    - Quadratures
    - Elongation (angle between planet and sun)
    - Synodic period (e.g., time between conjunctions)
    - Sidereal period (period relative to background stars)
ASTR 2310: Chapter 2

- Copernican Astronomy – Inferior Planets
  - Orbital Periods and Relative Planetary Distances
  - Angular Velocities ($\omega$)
  - Inferior Planets: $\omega_P = \omega_E + \omega_{\text{syn}}$ ($\omega_P > \omega_E$)
  - Inferior Planets: $1/P_P = 1/P_E + 1/P_{\text{syn}}$
  - Period of Venus: $(1/365.256 \text{ days} + 1/583.92 \text{ days})^{-1}$
  - So we get the orbital period of 224.70 days
Copernican Astronomy – Superior Planets

- Orbital Periods and Relative Planetary Distances
- Angular Velocities ($\omega$)
- Superior Planets: $\omega_P = \omega_E - \omega_{\text{syn}}$ ($\omega_P < \omega_E$)
- Superior Planets: $1/P_P = 1/P_E - 1/P_{\text{syn}}$
- Period of Mars: $(1/365.256 \text{ days} - 1/779.95 \text{ days})^{-1}$
- So we get the orbital period of 686.98 days
Copernican Astronomy – Planetary Distances

Relative to Earth-Sun Distance (Astronomical Unit)

See nice webpage at:

http://astro.unl.edu/naap/ssm/ssm_advanced.html
Copernican Astronomy

- Inferior Planet Orbital Distances (assume circular)
- $D = 1$ Astronomical Unit (1 AU):
- So $d = \sin \theta$ in AU
Copernican Astronomy

- Superior Planet Orbital Distances
- Time $t$ from position 1 to 2
- Angle $\alpha = t \left( \frac{360}{P_E} \right)$
- Angle $\beta = t \left( \frac{360}{P_P} \right)$
- So $d = \frac{1}{\cos(\alpha - \beta)}$
- Again in AU