ASTR 2310: Chapter 2

- 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

ASTR 2310: Chapter 2

- Early Greek Astronomy
  - Smart, but limited experimentation
  - Limited tools (e.g. no telescopes)
  - Our knowledge is fragmentary
  - Still, lots of stuff right, from thousands of years ago
  - E.g., lunar phases and eclipses understood, and more as well

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- 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!

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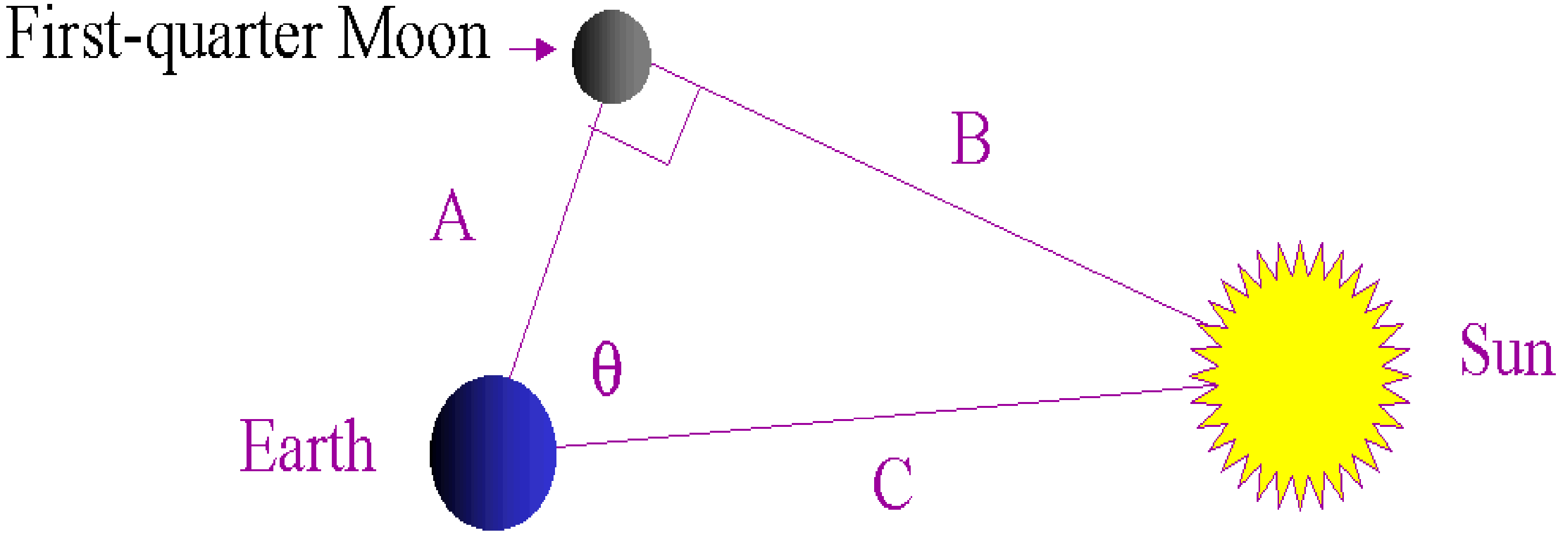
- Aristarchus: Relative Distances to Sun and Moon
  - Wikipedia: http://en.wikipedia.org/wiki/Aristarchus_On_the_Sizes_and_Distances



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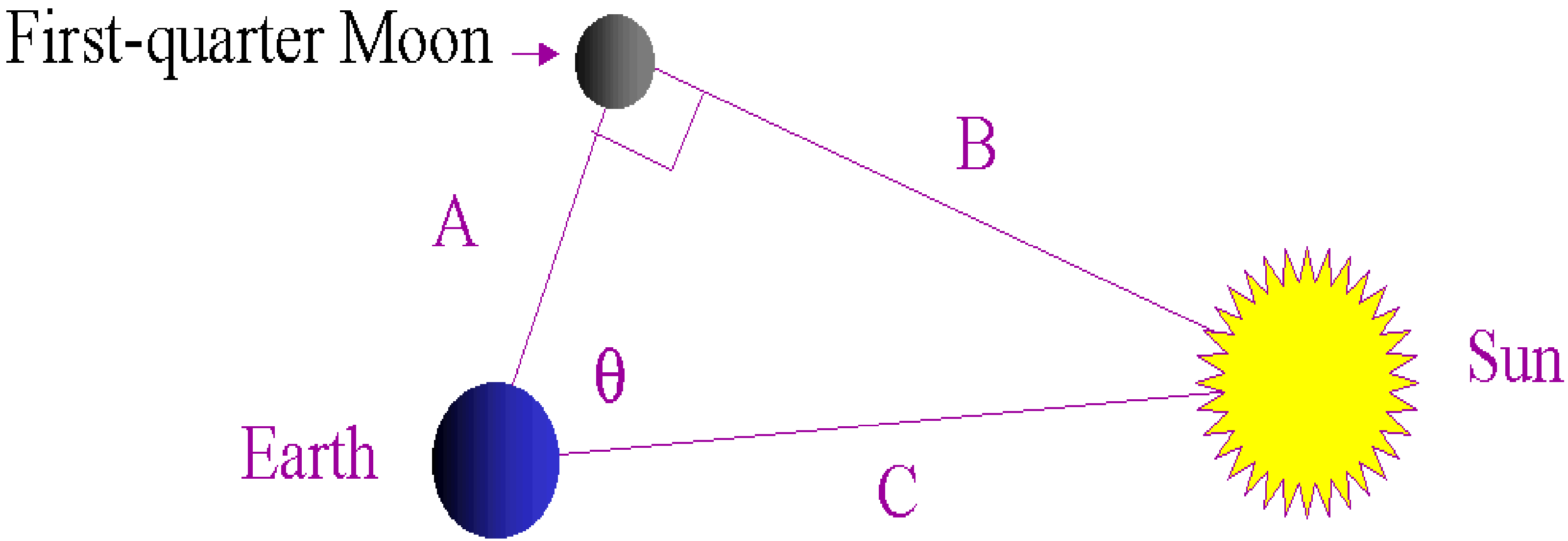
- Aristarchus: Relative Distances to Sun and Moon
  - A/C=cosine theta. Theta=87degrees means C=19A
  - If theta =89.853 degrees (modern value) then C=390A



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- Aristarchus: Relative Sizes of Moon, Earth, Sun
  - Geometry involving eclipses
  - Wiki: http://en.wikipedia.org/wiki/Aristarchus_On_the_Sizes_and_Distances
  - Came up with 1:3:19 (modern values 1:4:390) for ratios of diameters.

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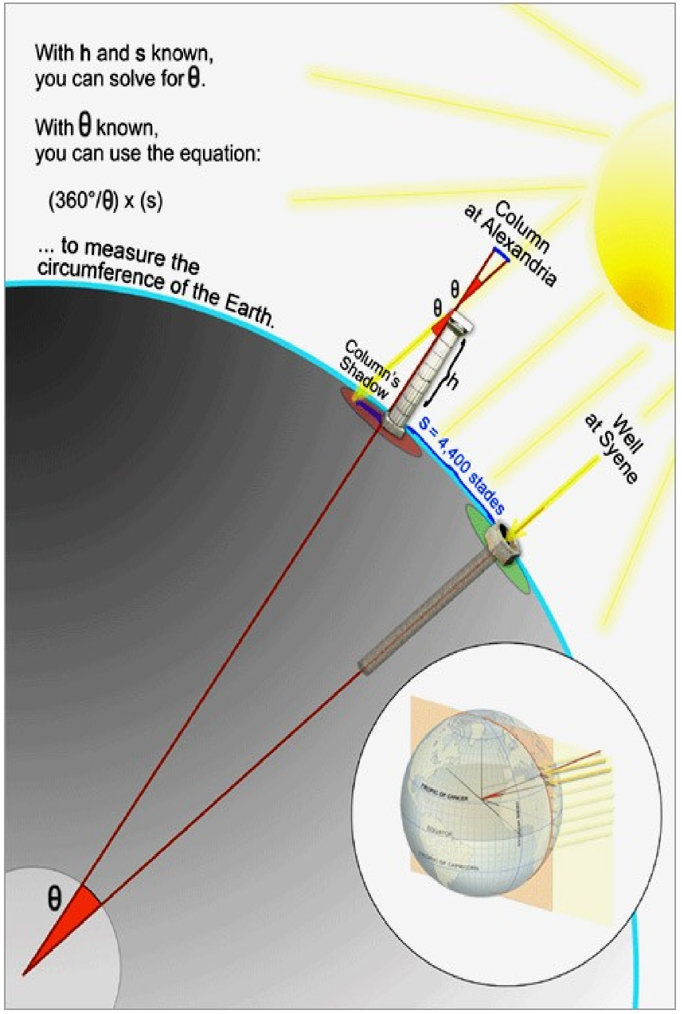
- Eratosthenes: Size of the Earth
  - Geometry involving the sun
  - Wiki: http://en.wikipedia.org/wiki/Eratosthenes
  - Figured out what fraction (1/50) of the Earth's circumference corresponded to the distance between Alexandria and Syene
  - Figure from Wired Magazine
  - Theta is about 7 degrees
  - Answer is the circumference is 46,000 km
  - Modern value closer to 40,000 km



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- Hipparchus: Extraordinary Observer
  - Star Catalog (leading to detection of precession of the 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)

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- 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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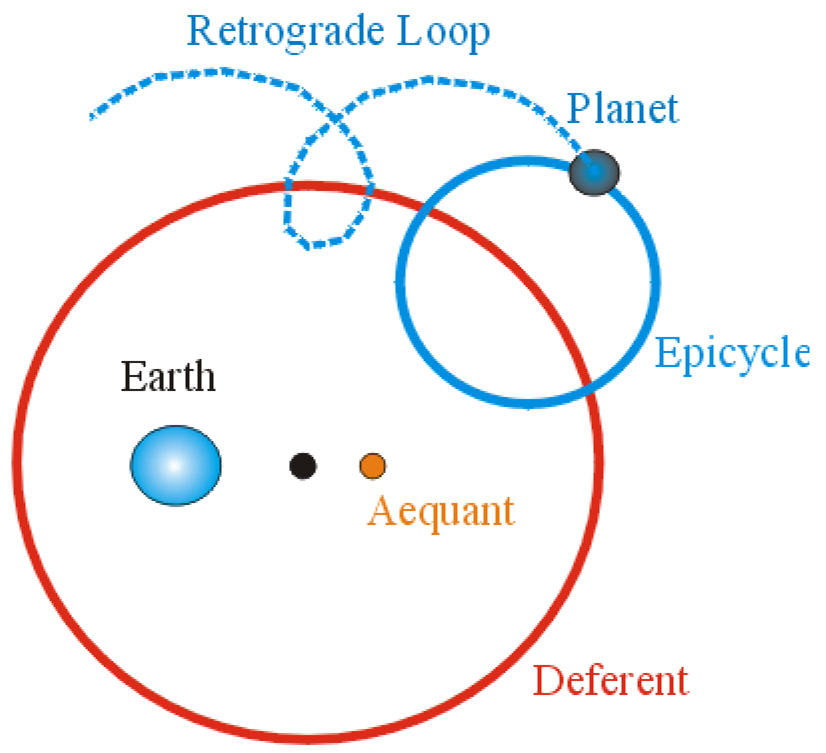
- Ptolemaic Astronomy
  - Earth doesn't move (no sense of motion, parallax)
  - Not quite at center
  - Everything “circles”
  - Lots of weird terms
  - Predicts positions ok!



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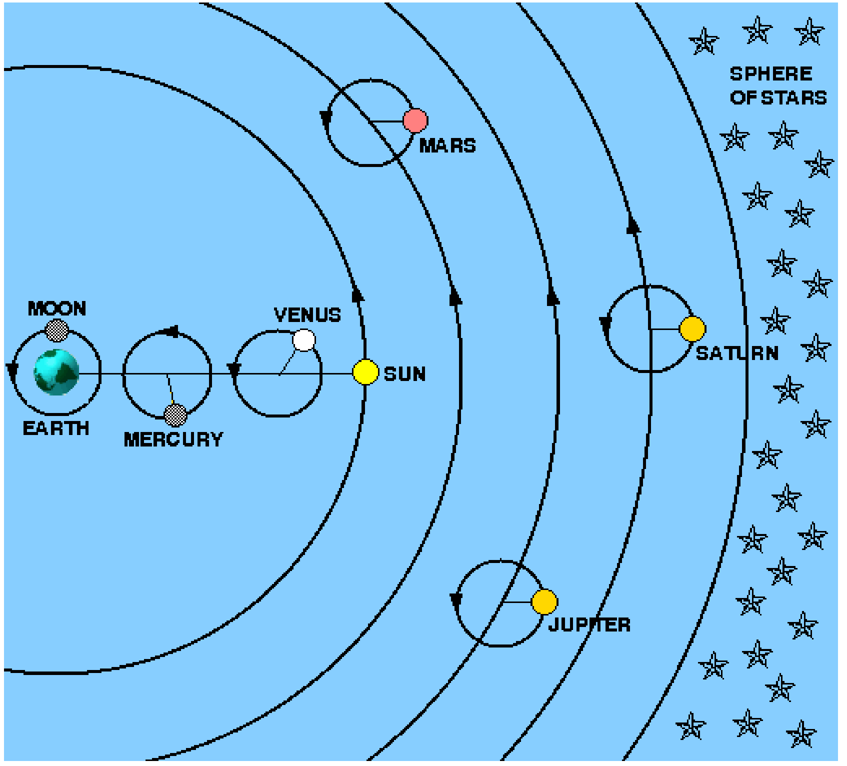
- Ptolemaic Astronomy
  - Not all planets equal!
  - Placements look odd
  - Tested by Galileo



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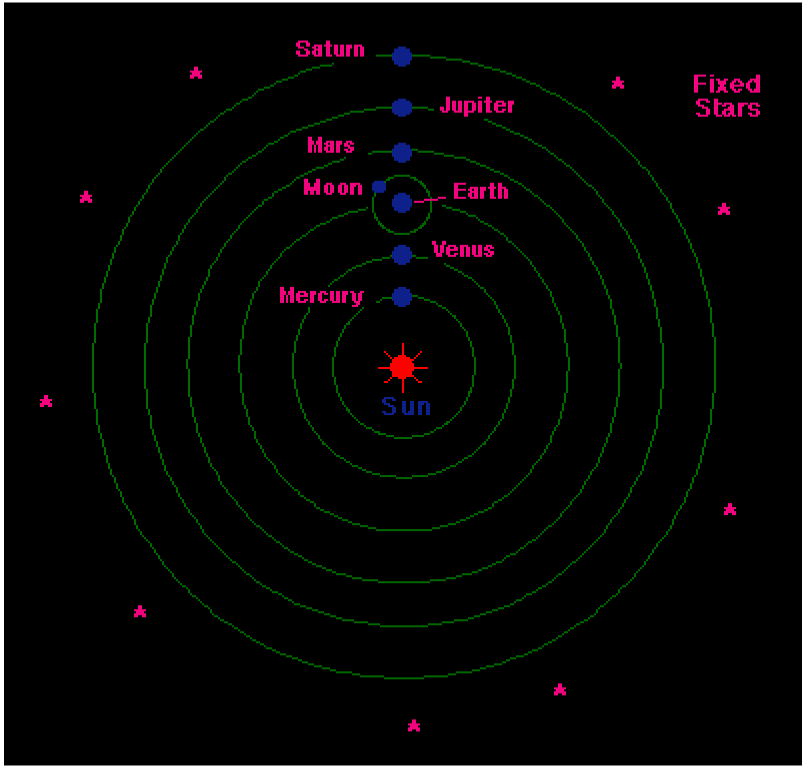
- Copernican Astronomy
  - Sun at center -- heliocentric
  - Still circles
  - Simpler
  - Not more predictive



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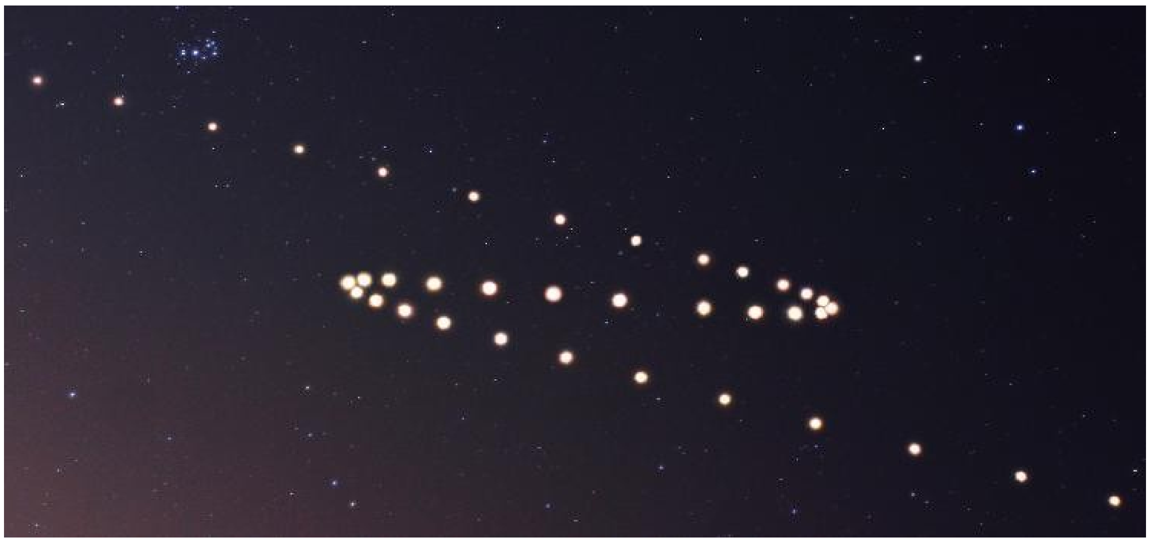
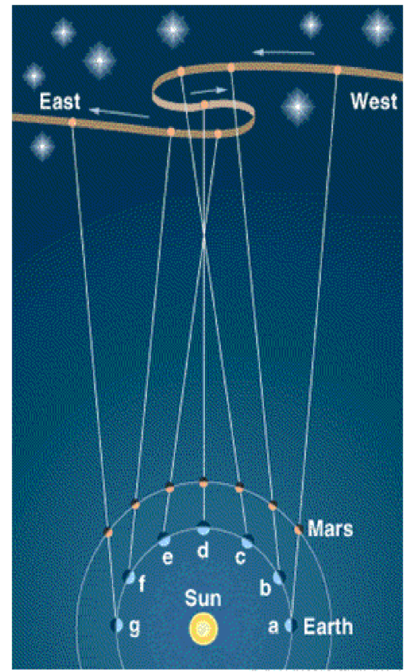
- Copernican Astronomy
  - Explanation for retrograde motion



Retrograde Motion in the Copernican Model



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- 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 (ω)
  - Inferior Planets: $\omega_P = \omega_E + \omega_{syn}$ ($\omega_P > \omega_E$)
  - Inferior Planets: $1/P_P = 1/P_E + 1/P_{syn}$
  - Period of Venus: $(1/365.256 \text{ days} + 1/583.92 \text{ days})^{-1}$
  - So we get the orbital period of 224.70 days

ASTR 2310: Chapter 2

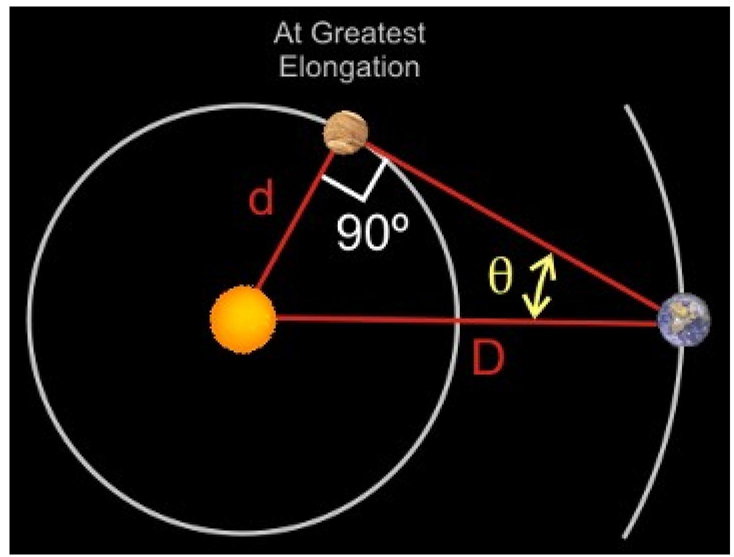
- Copernican Astronomy – Superior Planets
  - Orbital Periods and Relative Planetary Distances
  - Angular Velocities (ω)
  - Inferior Planets: $\omega_P = \omega_E - \omega_{syn}$ ($\omega_P < \omega_E$)
  - Inferior Planets: $1/P_P = 1/P_E - 1/P_{syn}$
  - Period of Mars: $(1/365.256 \text{ days} -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

ASTR 2310: Chapter 2

- Copernican Astronomy – Planetary Distances
  - Relative to Earth-Sun Distance (Astronomical Unit)
  - See nice webpage at:
    - http://astro.unl.edu/naap/ssm/ssm_advanced.html

ASTR 2310: Chapter 2

- Copernican Astronomy
  - Inferior Planet Orbital Distances (assume circular)
  - D = 1 Astronomical Unit (1 AU):
  - So d = cos θ in AU



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- Copernican Astronomy
  - Superior Planet Orbital Distances
  - Time t from position 1 to 2
  - Angle $\alpha = t\ (360/P_E)$
  - Angle $\beta = t\ (360/P_P)$
  - So $d = 1/(\cos(\alpha - \beta))$
  - Again in AU