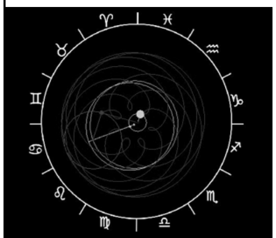
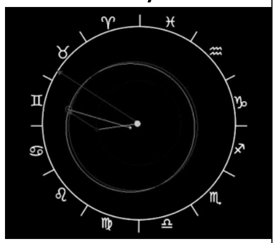
Using Computer Simulations in Introductory Astronomy





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Outline

- Why use computer simulations to teach astronomy?
- Simulating observations: the retrograde motion of Mars
- Simulating theories: Ptolemy vs. Copernicus
- An ode to *Easy Java Simulations* (EJS)
- Free stuff
- If there is time: a look at some other simulations.

Why use computer simulations to teach astronomy?

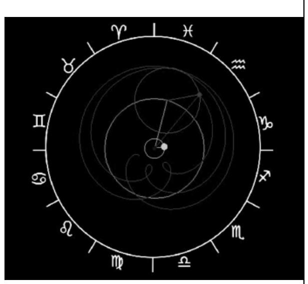
- Any astronomy course:
  - Many students need a visual image in order to understand a concept.
  - Simulations are practical when real observations would be impractical.
  - Students are comfortable with simulations and generally enjoy them (although many still prefer real-world activities, and some even like lectures).
- Historical course focusing on the nature of science:
  - Astronomical theories are abstract. The simulations let students see how the theories connect to observations so they can EVALUTE the theories (and learn about the Nature of Science).
  - Historical theories can be simulated in a virtual world even if they don't work in the real world.

Simulating Observations

- Stellarium
  - Free and open-source planetarium program
  - Available at www.stellarium.org.
- Retrograde motion of Mars
  - Always occurs when Mars is in opposition (opposite the sun in the sky)
  - Mars is always brightest in opposition/retrograde

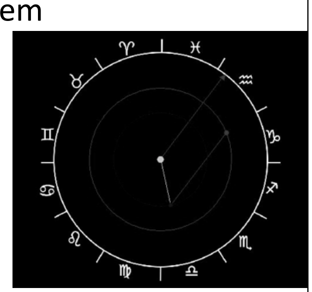
SuperiorPtolemaic

- Simplified Ptolemaic model for the superior planets.
- Evaluating Ptolemy:
  - Retrograde motion?
  - Brightest during retrograde?
  - Retrograde at opposition?



CopernicanSystem

- Simplified Copernican model of planetary motions.
- Evaluating Copernicus:
  - Retrograde motion?
  - Brightest during retrograde?
  - Retrograde at opposition?



Ptolemy vs. Copernicus

- Can both theories reproduce the three basic features of Mars' motion? Yes!
- Which theory is better? That depends on your criteria…
  - Empirical Adequacy: Both fit the data equally well.
  - Internal coherence: Ptolemy's theory requires *ad hoc* synchronization of Mars' epicycle with the sun's orbit. Copernicus' theory requires no such *ad hoc* adjustments.
  - External coherence: Ptolemy's theory of a stationary Earth fit with the physics of the 16^{th} century (essentially Aristotle's physics). Copernicus' moving Earth did not. Copernicus' theory also predicted an unobserved parallax.

Easy Java Simulations (EJS)

- EJS: a tool for building simulations created by Francisco Esquembre.
- Advantages of EJS for simulations authors:
  - Zero to working simulation in minutes!
  - Build sophisticated simulations.
  - Open-source with lots of examples to use as a starting point.
  - Distribution through Open Source Physics collection on comPADRE library: www.compadre.org/osp/.
  - Build once, use anywhere (mostly).
- Advantages of EJS for casual users:
  - FREE!
  - Easy to find in OSP collection.
  - Create your own version of an existing simulation. Minor modifications (changing default options, etc.) can be made without any programming.

Resources

- My stuff: all simulations (including some unfinished ones), activity handouts, and lab handouts are available at
  facultyweb.berry.edu/ttimberlake/copernican
- Book on the Copernican Revolution: Interested instructors can obtain a pre-publication version for review and possible use by emailing me: ttimberlake@berry.edu.
- EJS: wiki (www.um.es/fem/EjsWiki/) and upcoming book by Wolfgang Christian.
- Finished EJS astronomy simulations (including some new ones by Mario Belloni) at www.compadre.org/osp/.

EJS Astronomy Models

EJS Astronomy Models

- 20 Astronomy Models, 18 General Relativity Models

Sidereal and Solar Day	Equinox Precession	Phases of Moon
Kepler System	Copernican System	Exoplanet Detection: Transit
Local Coordinates	Superior Ptolemaic	Exoplanet Detection: Radial Velocity
Equitorial Coordinates	Inferior Ptolemaic	Eclipsing Binary Stars
Solar and Lunar Eclipse	Celestial Globe	Colliding Galaxies
Newton's Mountain	Gnomon	Remarkable Three Body Motions
Earth Orbit	Phases of Venus	Plus 18 General Relativity Models

Thanks To

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