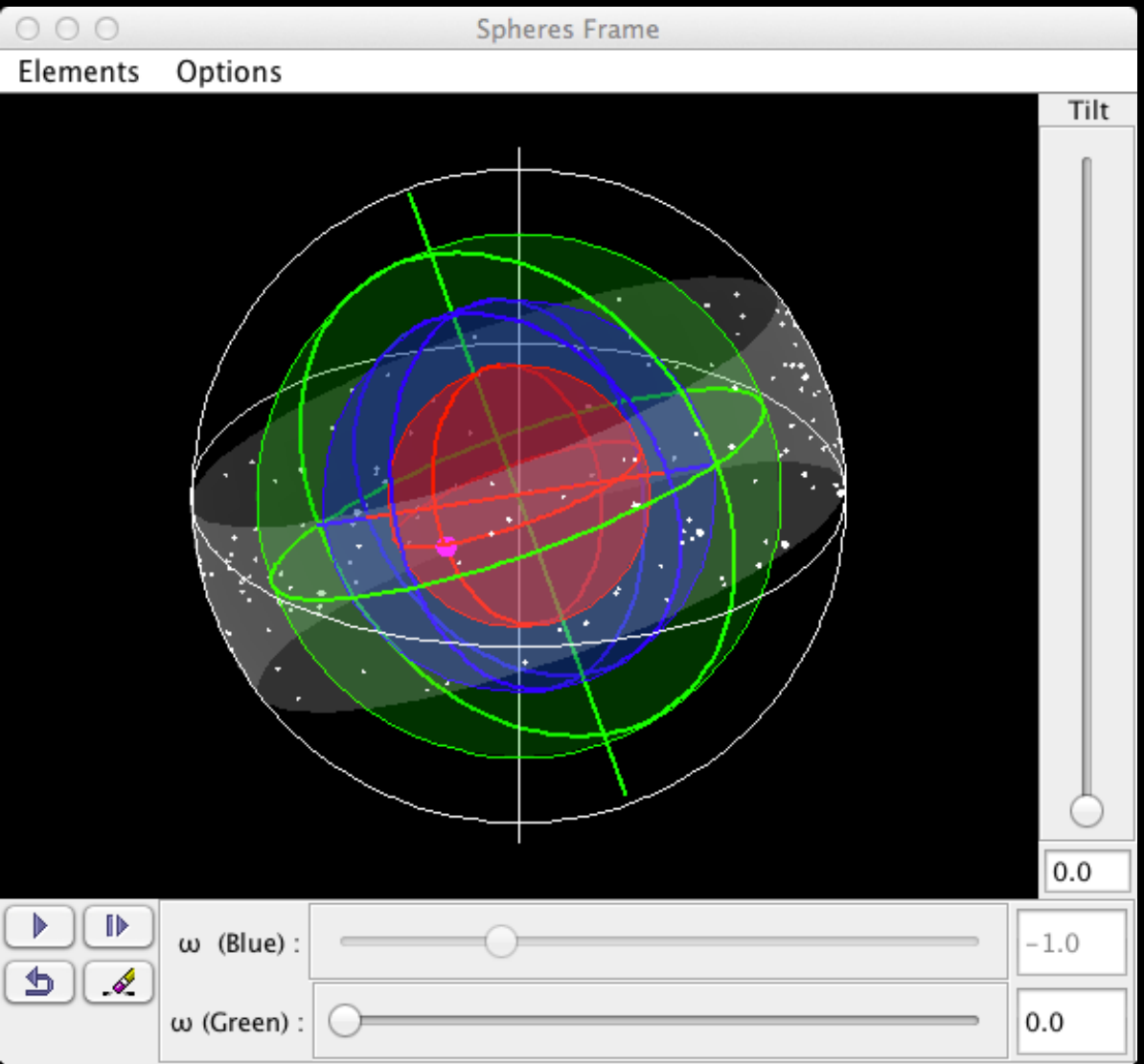
The Spheres of Eudoxus



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Resources

- Spheres of Eudoxus EJS model on ComPADRE:

http://www.compadre.org/osp/items/detail.cfm?ID=11198

- Copernican Revolution page:

http://facultyweb.berry.edu/ttimberlake/copernican/

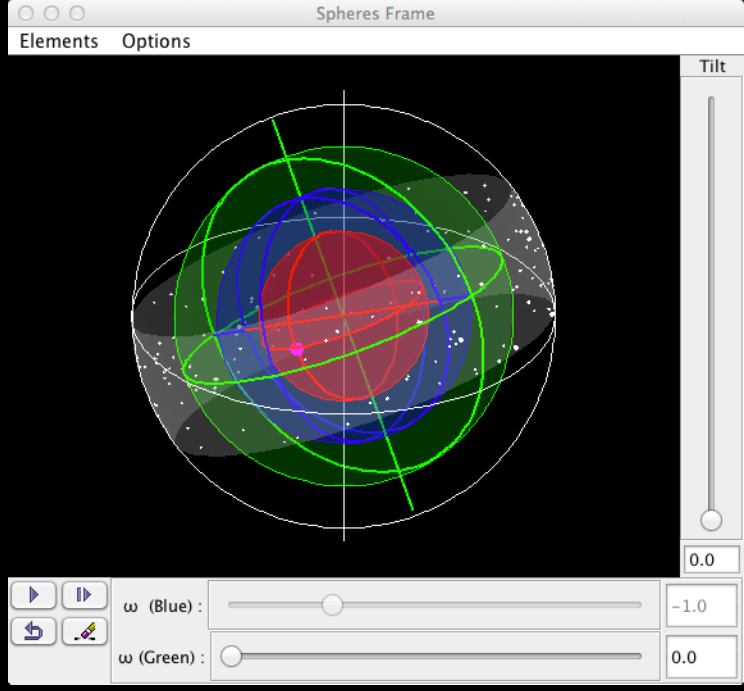
- Scale of the Universe page:

http://facultyweb.berry.edu/ttimberlake/galaxies/

Model of Eudoxus (408-355 BCE)

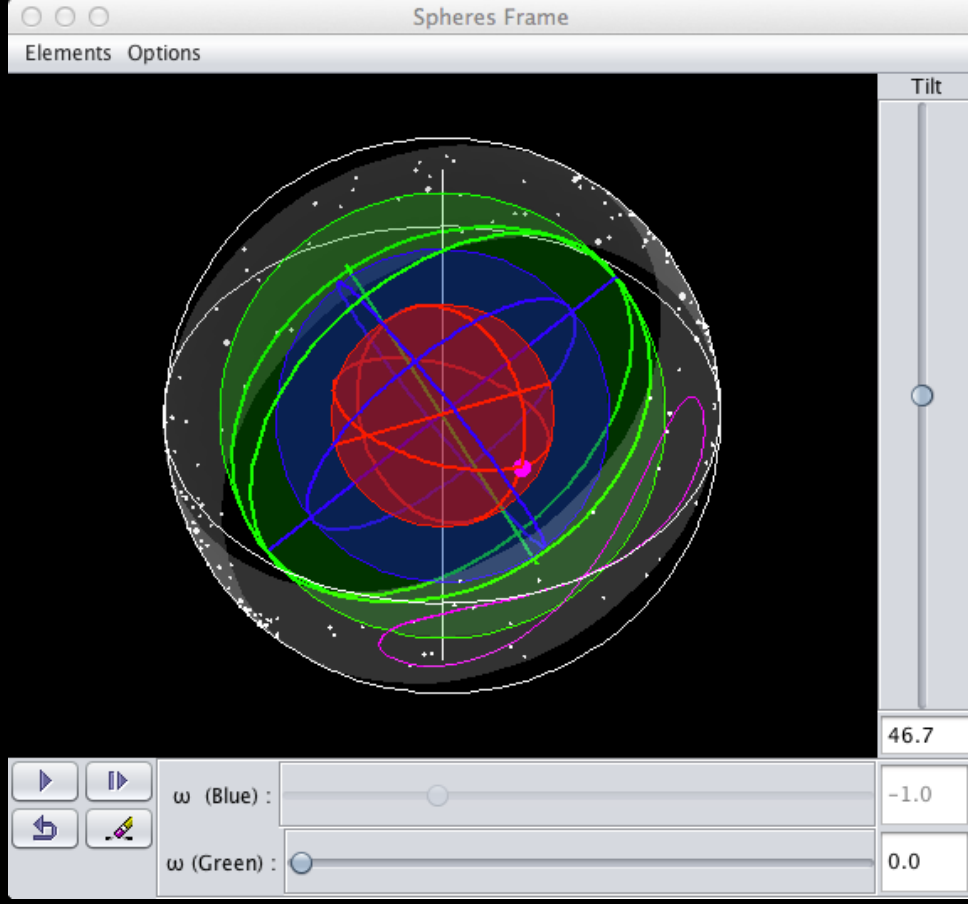
- First geometrical model for motion of heavenly bodies.
- All of Eudoxus' works have been lost.
- Descriptions from Aristotle and Simplicius, reconstruction by Schiaparelli (others possible).
- We will focus on model of planetary motion.

The Spheres

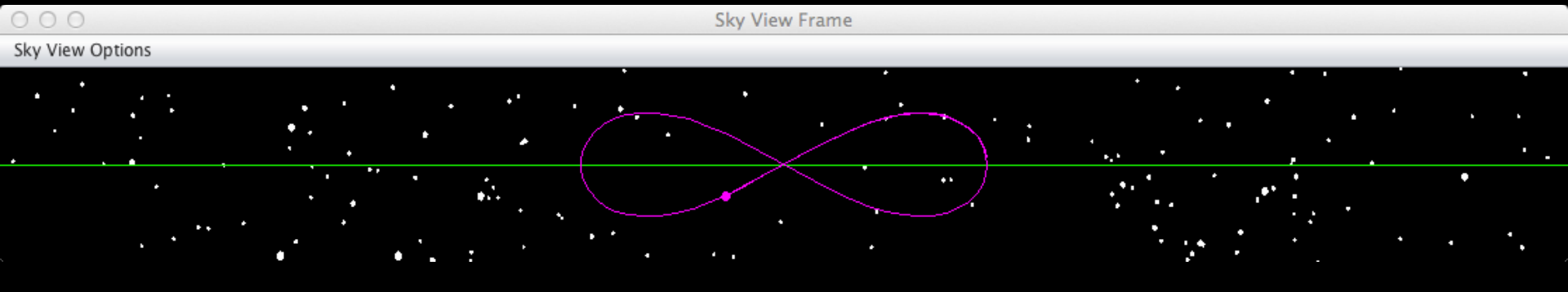


- Nested spheres concentric with Earth. Axis of each sphere attaches to next sphere out.
- Sphere 1 (outer): rotates about celestial axis in one sidereal day.
- Sphere 2: rotates about ecliptic axis in planet's zodiacal (or ecliptic) period.
- Sphere 3: rotates about axis through equator of Sphere 2 in planet's synodic period.
- Sphere 4: rotates about axis tilted relative to Sphere 3's axis with same period but in opposite sense from Sphere 3.

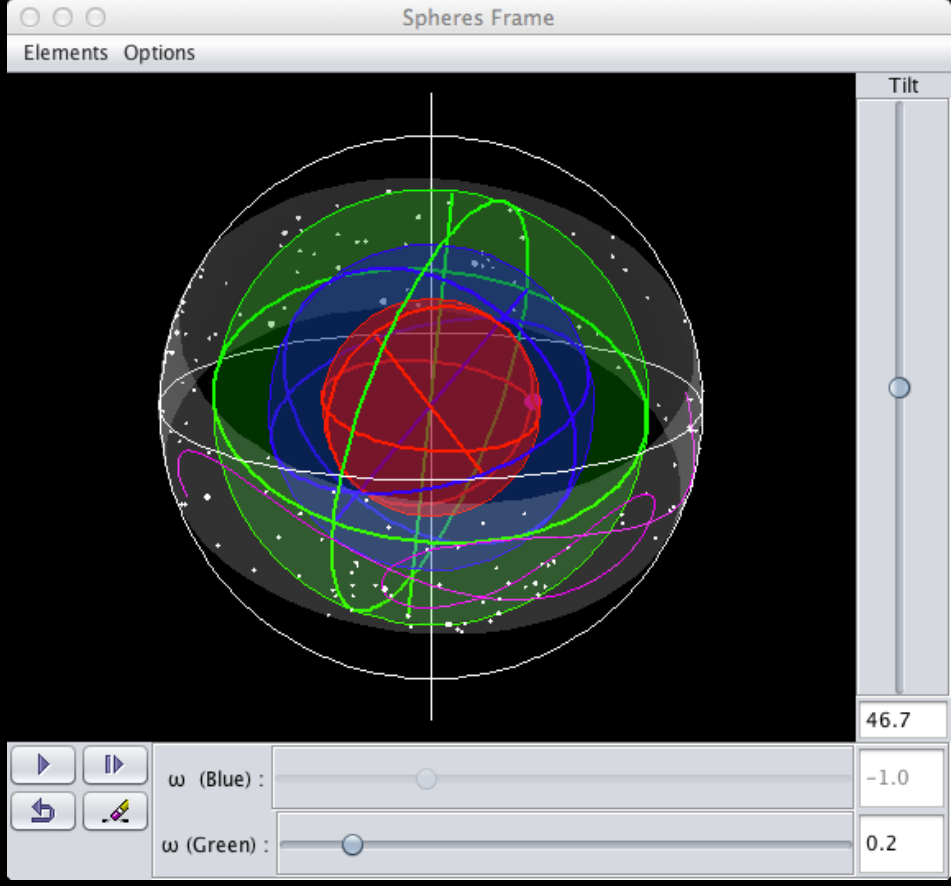
The Hippopede



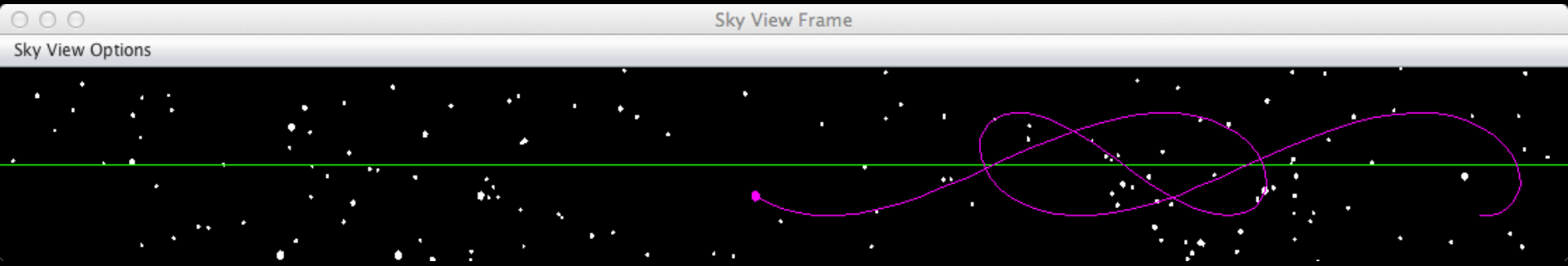
- The function of Spheres 3 and 4 is to produce a figure-8 motion known as the “hippopede” (horse fetter).



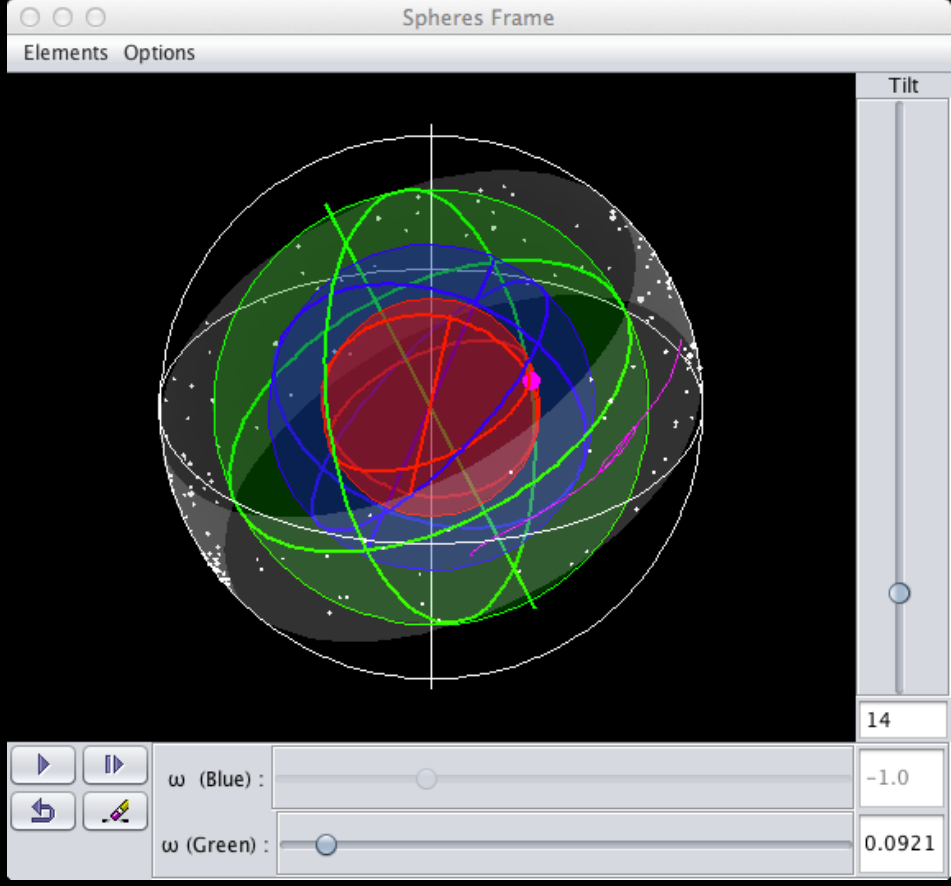
Retrograde



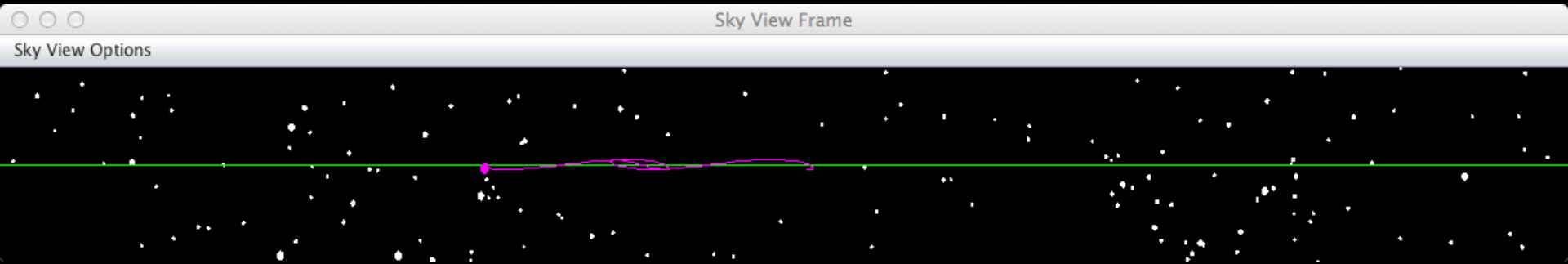
- Combined with the motion along the ecliptic from Sphere 2, the hippopede can produce periodic retrograde motion.



Planetary Motions



- This model can produce qualitatively accurate depictions of the motion of Jupiter and Saturn.
- Ex: Jupiter's Sphere 2 has ω=0.091.



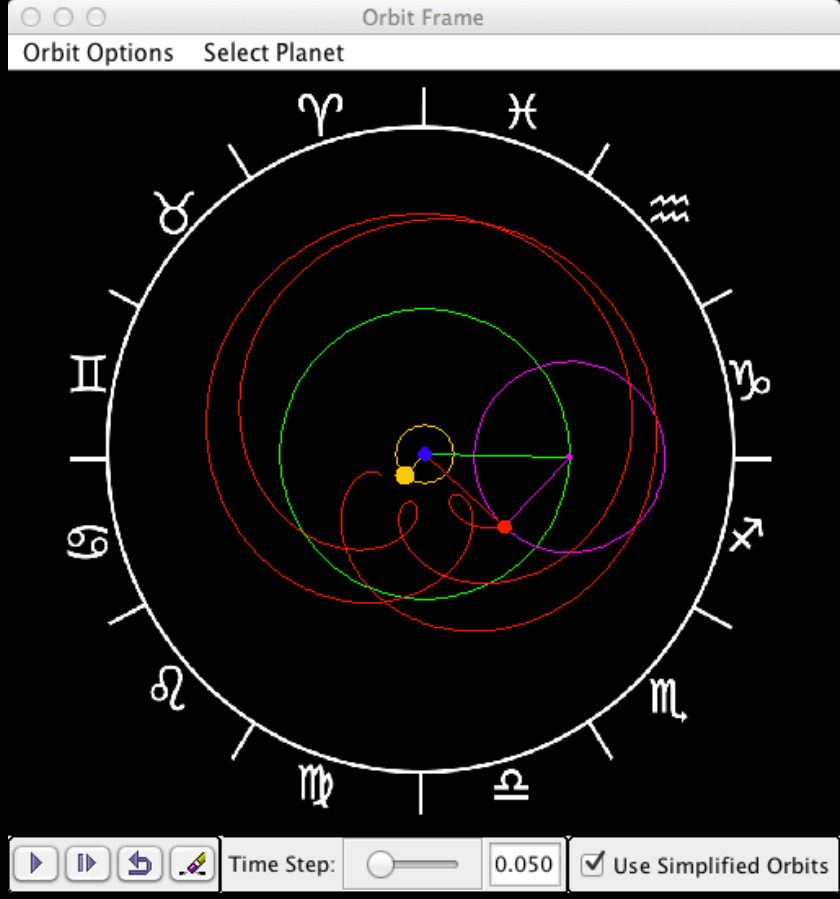
Judging Eudoxus

- Pros
  - Motion of planet along ecliptic
  - Periodic retrogrades
- Cons
  - Retrogrades are always symmetric about ecliptic (not observed).
  - Can't even qualitatively reproduce motions of Venus and Mars (Ex: Venus' Sphere 2 has $\omega=1.6$).
  - No changes in brightness!

Future of Eudoxus

- Adopted by Aristotle (384-322 BCE) for his Earth-centered cosmology.
- Improved by Callipus (c. 370-300 BCE).
- Homocentric models different from that of Eudoxus were revived by al-Bitruji (12th cen), Fracastoro (16th Cen) and others.
- Set the standard by which the astronomical models of Apollonius (3rd cen BCE), Hipparchus (2nd cen BCE), and Ptolemy (2nd cen CE) were judged.

Beauty of Ptolemy



- Pros:
  - Gives qualitatively (and quantitatively) accurate depiction of motion of *all* planets.
  - Retrogrades are not symmetric about the ecliptic (not shown in 2D model).
  - Accounts for variations in brightness, with superior planets brightest at opposition.
- Cons:
  - Motions not all centered on Earth – violates Aristotle's cosmology.
  - Doesn't specify order of planets (neither did Eudoxus).
  - Mysterious connection between planets and Sun (also true for Eudoxus).
  - Only accurate to about a degree (much better than Eudoxus).

Value of Teaching Historical Theories

- Studying historical models gives students the opportunity to *evaluate* a scientific theory.
- Students learn that scientific theories are generally judged in comparison to other theories.
- Students learn that theories are judged not only on predictive accuracy, but also on fit with other accepted theories and explanatory power (solving mysteries).