Formation of the Oort Cloud—25 Mar

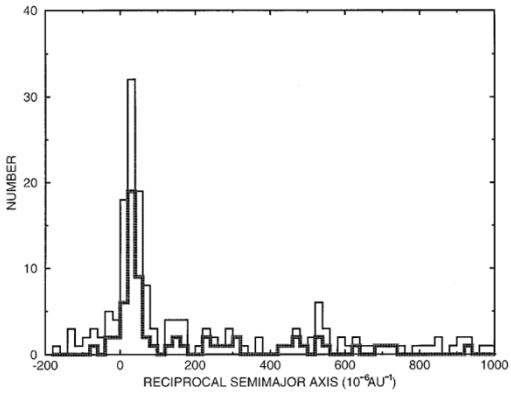
- Homework 7 will be assigned on Mon.
- Next topics
  - Formation of the Kuiper Belt
    - Levinson, H. F., et al. 2008, "Origin of the structure of the Kuiper belt during a dynamical instability in the orbits of Uranus and Neptune," Icarus, 196, 258.
  - Extra-solar planets
- Outline
  - Finding position vs time for an elliptical orbit.
  - Fernandez, J. A. 1997, "The Formation of the Oort Cloud and the Primitive Galactic Environment," Icarus, 129, 106.

What is the Oort Cloud?

- Fig. 1 from Fernandez. Where are the comets in the Oort Cloud?

1. Where would Pluto be on this plot? a=40AU
   A. In the peak
   B. Near the middle
   C. At the right edge
   D. Off the plot on the right.
2. What is the semi-major axis of most of these comets? 25,000AU.
3. What is the period of the majority of these comets? (25000)^3/2=4Myr.

- The distance to the nearest star is 250,000AU.



Collisions with Jovian planets

1. Three-minute Question: A comet passes near Jupiter, and the planet changes its path. Draw possible paths for the comet before and after the encounter with Jupiter. The paths must connect. Assume Jupiter's effect is instantaneous. Turn in your paper.

1. A comet passes near a Jovian planet. What quantity does not change much?
   A. The energy compared with the initial amount.
   B. The semi-major axis compared with the initial value.
   C. The perihelion distance compared with the semi-major axis.

Fernandez's question

- The perihelion distance is approximately constant compared with the semi-major axis. Therefore each orbit will go into the region of planets.
- The energy change in each passage is randomly positive or negative.

1. Three-minute question: What happens to the comets in the Oort cloud after many orbits? Turn in your answer.

Slide

We have solved the position $r(\theta)$ as a function of angle θ, the true anomaly. We want to know where the planet is at a given time.

There is no solution to this problem in closed form.

Define the mean anomaly

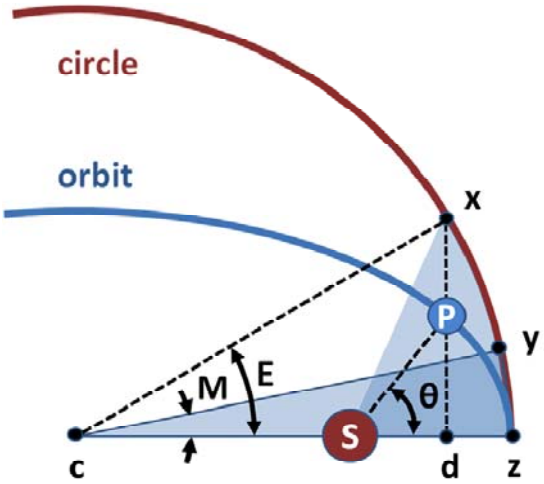
$$M = \frac{2\pi}{T}(t - \tau),$$

which has units of angle and changes linearly with time. τ is the time where the planet is at perihelion.

The eccentric anomaly E

Kepler's equation

$$M = E - e \sin E$$



http://en.wikipedia.org/wiki/Kepler's_laws_of_planetary_motion

How to find the position of a planet:

1. Compute the mean anomaly M. This is easy, since M increases linearly with time.
2. Solve Kepler's equation to get the eccentric anomaly E. You can use a solver on the web.
3. Project from the enclosing circle to the ellipse to find the position.

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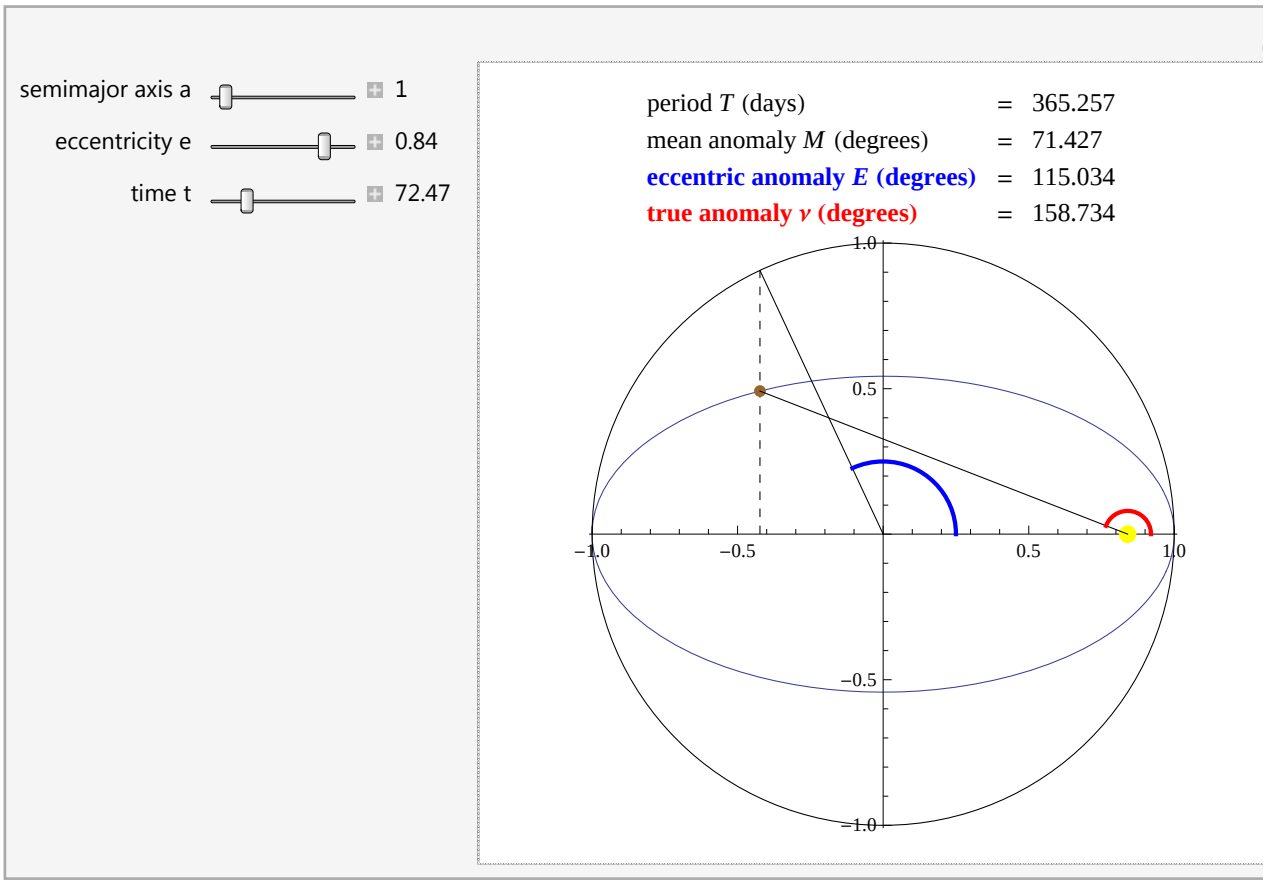

"Anomalies for Planetary Motion" from the Wolfram Demonstrations Project
http://demonstrations.wolfram.com/AnomaliesForPlanetaryMotion/
Contributed by: Thomas Müller