Kuiper Belt—21 Feb

- Orbit of Pluto
- Discovery of objects beyond Neptune
- Orbits of trans Neptune objects
- Kuiper Belt and Oort Cloud
- Answer to preclass question for today is wrong.
- No preclass questions for Fri.
- Read about Kepler’s Laws for Friday.
  - Textbook §4.4 & Carroll & Ostlie §2.1-2.3
- Midterm exam next week
  - Mon. Missouri (Ask Me State) Club
  - No late Homework 5 after Mon.
  - Answers will be on angel.
  - Send me equations to put on cheat sheet before 8:00am, Fri, 4 March
  - Test on Fri, 4 March
- After Spring Break
  - Formation of the Kuiper Belt

Pluto’s orbit

- 3:2 resonance with Neptune
  - \( P_{\text{pluto}} / P_{\text{neptune}} = 248\text{yr} / 165\text{yr} = \frac{3}{2} \)
- At perihelion, Pluto is inside Neptune’s orbit.
- Neptune affects Pluto’s orbit.
  - Why does Pluto survive in resonance when the asteroids in the 3:2 resonance with Jupiter did not.
  - What happened to create this arrangement?
3-d positions

1. When Pluto is closest to Neptune, it is in danger of colliding with Neptune.
   A. True
   B. False

2. When Pluto is closest to Neptune, they are not really close because
   1. The distances to the sun are not close.
   2. Pluto is high above the ecliptic.

3-d positions

- When Pluto is closest to Neptune, they are not really close because
  - Pluto is high above the ecliptic.

- At perihelion, where Pluto is inside Neptune’s orbit,
  - Pluto is above the ecliptic
  - Neptune is 50° behind Pluto

- One Pluto year later,
  - Neptune has moved 1.5 periods. 180°-50°=130° ahead of Pluto
Are there other objects beyond Neptune?

• Are other objects locked with Neptune or are their orbits independent of Neptune?
• Searches in 1992

Discovery of second object beyond Neptune

• 1992 QB1
  – P=289.225 yr
  – a=43.7AU
  – a_{Pluto}=39.5
  – D=160km
  – D_{Pluto}=2330km

Discovery images. Note the streak, an asteroid
Determining semi-major axis

- Determining the semi-major axis, $a$.

\[
\frac{d\theta}{dt} = 148 \text{arcs/hr}(1 - a^{\frac{1}{2}})/(1 - a)
\]

Earth and asteroid at two times. The dashed lines show the directions of the asteroid as viewed from earth at two times. (Hwk 4)

More Kuiper Belt objects keep being discovered.

CNN Oct. 7, 2002

The spherical planetoid, half the size of Pluto, is the biggest found in the solar system since astronomers detected it at the New Horizons probe in 1980.

Thousands of primordial icy, rocky chunks beyond the planets that date back to the origins of the solar system.

The object, dubbed Quaoar, further strengthens the theory that Pluto is not a conventional planet but rather a Kuiper Belt object.

CNN -- A newly discovered body in the outer reaches of the solar system is larger than all the objects in the asteroid belt combined, astronomers announced Monday.

Artist's concept of Quaoar

Object Tools

More

Quaoar

REACT

-- At web site
100,000
-- In the last 2 years
-- For 8 hours
Population of objects beyond Neptune

- Kuiper belt
  - a>30 AU
  - Inclination is not high
- Largest
  - Eris 2700km
  - Pluto 2300km

Kuiper Belt objects
Black: Resonant objects
Green: Unstable. Colliding with Neptune
Red: Stable, non resonant
Line shows constant perihelion q
Levinson et al 2008, Icarus, 196, 258
Kuiper Belt & Oort Cloud Comets

- Short period comets
  - small inclinations
  - prograde orbits.
  - belong to Kuiper Belt
- Long period orbits
  - large inclinations
  - retrograde and prograde orbits
- Oort 1950, BAN, 11, 910.
  - Distribution of semimajor axis peaks at 20,000AU
  - Comets last a short time relative to age of the solar system.
Oort Cloud

- $10^{11} - 10^{12}$ comets in loosely bound solar orbits at 50,000AU
- Ejected by Jupiter into random directions
- Gravitational perturbations occasionally deflect one in.
- Guesstimate: 1 trillion ($10^{12}$) comets total
  \[ \times 10^{-10} \text{ earth-mass/comet} = 10^{2} \text{ earth masses total.} \]