The Search for PLANET X

• Recall Neptune was predicted from observed changes in orbit of Uranus
• Lowell & Pickering suggest small changes in Neptune’s orbit are due to “Planet X”
• They predict position and propose a “wide-angle” camera to be built at Lowell observatory for search.
• Actually their calculation were wrong! It wasn’t really changing Neptune’s orbit

1930 Pluto Discovered

• Clyde William Tombaugh (1906-1997)
• At Lowell Observatory with this telescope -
• Part of his ashes are being carried on the “New Horizons” spacecraft which is travelling towards Pluto.

Blink Comparator Used to spot Pluto

It “blinks” between the two photographs so you can see that something moved!

Pluto (Hades): King of the Underworld

• Apparent Magnitude +14
• Need 30 cm aperture scope to see it
• Small size 0.15", can’t resolve into a disk
• Mass and size were vastly overestimated
• Color “light brown” with some yellow.
The orbit of Pluto is very elliptical

Passes inside the orbit of Neptune!

Early ideas were that it was an escaped moon of Neptune.

The orbit of Pluto is inclined 17°

Implies that its captured Kuiper Belt Object, rather than an "original" planet, or escaped moon of Neptune.

1978: Discovery of Pluto’s Moon

• "Charon" looks like a lump on side of planet due to poor resolution

• Orbital Period gives mass of Pluto (smaller than was thought, only 0.21% of earth!)

• Mass of Charon is 1/7 the mass of Pluto

1985-1991 Eclipses every day!

• Pluto’s rotation & Charon’s orbit are tilted 122° to its orbit

• Eclipses in 1980s gave sizes of both Pluto and Charon.

• Pluto is about 18% size of earth (smaller than was previously thought)

• Charon is about half the size of Pluto!

Density was revised

• Albedo:
  • Pluto (0.49 to 0.66) is close to Triton (0.5)
  • Charon is less reflective (0.36 to 0.39)

• Density:
  • Pluto is 1950 km/m³, close to Triton (1638), Ganymede (1936) and Callisto (1851)
  • Charon is only 1250 km/m³ (more ice, less rock, similar to Saturn’s icy moon Rhea)

• Implies that Pluto & Charon could not have formed together.

1990 Hubble views Pluto & Charon
1994-6: Hubble Mapping of Pluto

Possible highly reflective South Pole Ice Caps
Less reflective North Pole Cap.

1998: Hubble Mapping of Charon

Pluto and Charon are tidally locked into “double synchronous” rotation.

Rotation = revolution = 6.4 days.

Model of Pluto

- Inside Pluto is probably 50 to 75% rock, covered with ice
- Surface is 98% Nitrogen ice, with rest methane ice (CH4) and traces of carbon monoxide ice (CO).
- Solid Methane tells us it’s colder than 70 kelvin (around 40 K?)
- Thin Nitrogen atmosphere!

Dichotomy: The face of Pluto oriented toward Charon has more methane ice, while the opposite face has more ices of nitrogen and carbon monoxide.
Model of Charon

• Unlike Pluto, has no Nitrogen ice or methane. Dominated by water ice. Less reflective.
• NO atmosphere!
• Perhaps 55% rock, 45% ice (whereas Pluto is 70% rock)

Formation of Pluto-Charon System

Proposed theory: a large Kuiper belt object struck Pluto at high velocity 4.6 billion years ago, destroying itself and blasting off much of Pluto's outer mantle, and Charon coalesced from the debris. However, such an impact should result in an icier Charon and rockier Pluto than we find. It is now thought that Pluto and Charon may have been two bodies that collided before going into orbit about each other. The collision would have been violent enough to boil off volatile ices like methane but not violent enough to be disrupted

The newly discovered moons of Pluto

Images with the Hubble Space Telescope

The exploration of Pluto is about to begin!

• The New Horizons mission to Pluto was launched in January 2005.

➢ After a fly-by of Jupiter (Feb 2007), the spacecraft will continue on to Pluto, arriving there in 2016.
➢ We will fly close to Pluto and its moon Charon, and then on out into the Kuiper Belt, hoping to encounter one or two other Kuiper Belt objects by about 2025.

New Horizons Mission to Pluto

KBOs 2016–2020
Pluto-Charon July 2015
Jupiter System February–March 2007
Interplanetary Cruise March 2007–June 2015
Launch January 2006

Ten Years and Three Billion Miles...

Mission
New Horizons mission

Location of New Horizons (Dec 6, 2006)

Location of New Horizons (Dec 1, 2009)

New Horizons at Pluto, July 2016

New Horizons fly-by of Pluto and Charon, July 2016

Composite: Pluto & Charon to scale
Note Charon is less reflective

New Horizons fly-by of Pluto, July 13, 2016
**Goals of the New Horizons mission to Pluto**

- Map the surfaces (craters, ice flows, other geological structures) of Pluto and its moons
- Study the atmosphere; search for an atmosphere of the largest moon (Charon)
- Study the surface compositions of Pluto and its moons
- Continue on into the Kuiper Belt to study one or more Kuiper Belt objects beyond Pluto
Pluto’s not a planet anymore?

• The discovery of the many objects in the Kuiper Belt (beyond Neptune) which are even bigger than Pluto, and have their own “moons” have called Pluto’s status as a planet into question.
• International Astronomical Union now calls Pluto, the asteroid Ceres and the SDO (scattered disk object) Eris/Xena “Dwarf Planets”

Why does Pluto matter?

• It is a large body that exists in the region where about half of the comets come from.
• It therefore probably has a composition similar to that of comets.
• It’s history is somewhat different because of its large size, however.
• We want to understand Pluto better because it is a key object in the Kuiper Belt.
• The Kuiper Belt, in turn, tells us much about the origin of our Solar System, as well as planetary systems around other stars.

TNO: Trans-Neptune Objects

More objects have been found further out! Divide into three basic families

• KBO: Kuiper Belt Objects 30 to 50 AU
• SDO: Scattered Disk Objects, out to 100 AU(?)
• OCO: Oort Cloud Objects, out to 100,000 AU

The Kuiper Belt viewed edge-on

Largest KBO
Plutinos: Resonant KBO

- Plutinos are in a 2:3 resonance with Neptune.
- “TwoTinos” are in 1:2 resonance with Neptune.

Kuiper Belt Objects are a subset of the Trans-Neptunian Objects.

Largest known trans-Neptunian objects (TNOs)

- Sedna: the most distant object known in the Solar System.
- Discovered in 2003 by Brown et al.:  
  - Eccentricity: 0.855  
  - Semi-major axis: 525.606 A.U.  
  - Perihelion: 76.156 A.U.  
  - Aphelion: 975.056 A.U.  
  - Orbital period: 12050.32 years!  
  - Might be added as a “dwarf planet”.

Sedna: Even further away!

Oort Cloud
The Oort Cloud might look like this. The Sun and the planets are in the very center.

Things to do

- Updated July 2009
- Updated Dec 1, 2009, added more recent Horizons mission status/location.
- Need to make outline format.
- Add Pluto’s not a planet anymore song
- Find pluto comic