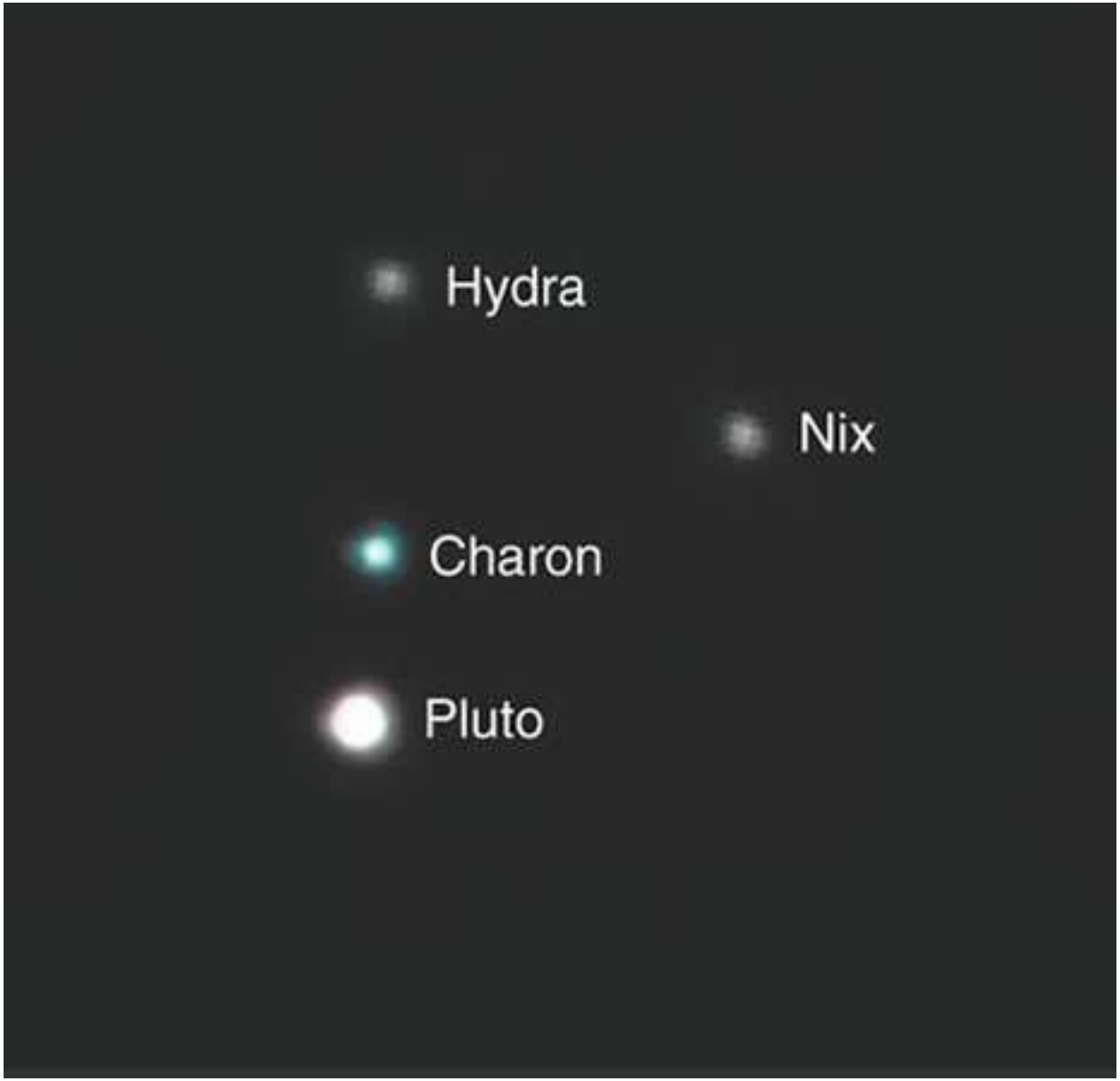

“Pluto, The Dwarf Planet”

What We Will Learn Today

- How long have we known about the Kuiper Belt?
- What are the major objects in the Kuiper Belt?
- What do we know about the KBOs?
- Why is Pluto not a planet?
- How do we plan to explore Pluto and the Kuiper Belt?

Dwarf Planet Pluto Details

Property	Value	
Semi-major axis	39.5 AU	
Size (radius)	0.18 R_{Earth}	Smaller than 7 moons!
Mass	0.0022 M_{Earth}	
Average density	2.0 g/cc	
Composition	Ices, Rocks	
Average surface temperature	40 K	
Moons	3	Surprising?
Orbital period	248 years	3:2 resonance with Neptune
Rotation period (sidereal)	6.4 days	Synchronous with Charon
Axis tilt	122.5^{o}	Retrograde
Orbital inclination	17.2^{o}	Higher than all planets
Orbital eccentricity	0.25	Higher than all planets

Pluto's Inclined and Eccentric Orbit

- Pluto's orbit is more eccentric and inclined than all the planets
- Pluto is sometimes closer to the Sun than Neptune
- Pluto has a 3:2 resonance with Neptune: *Plutinos*
- ¼ of the known KBOs are Plutinos

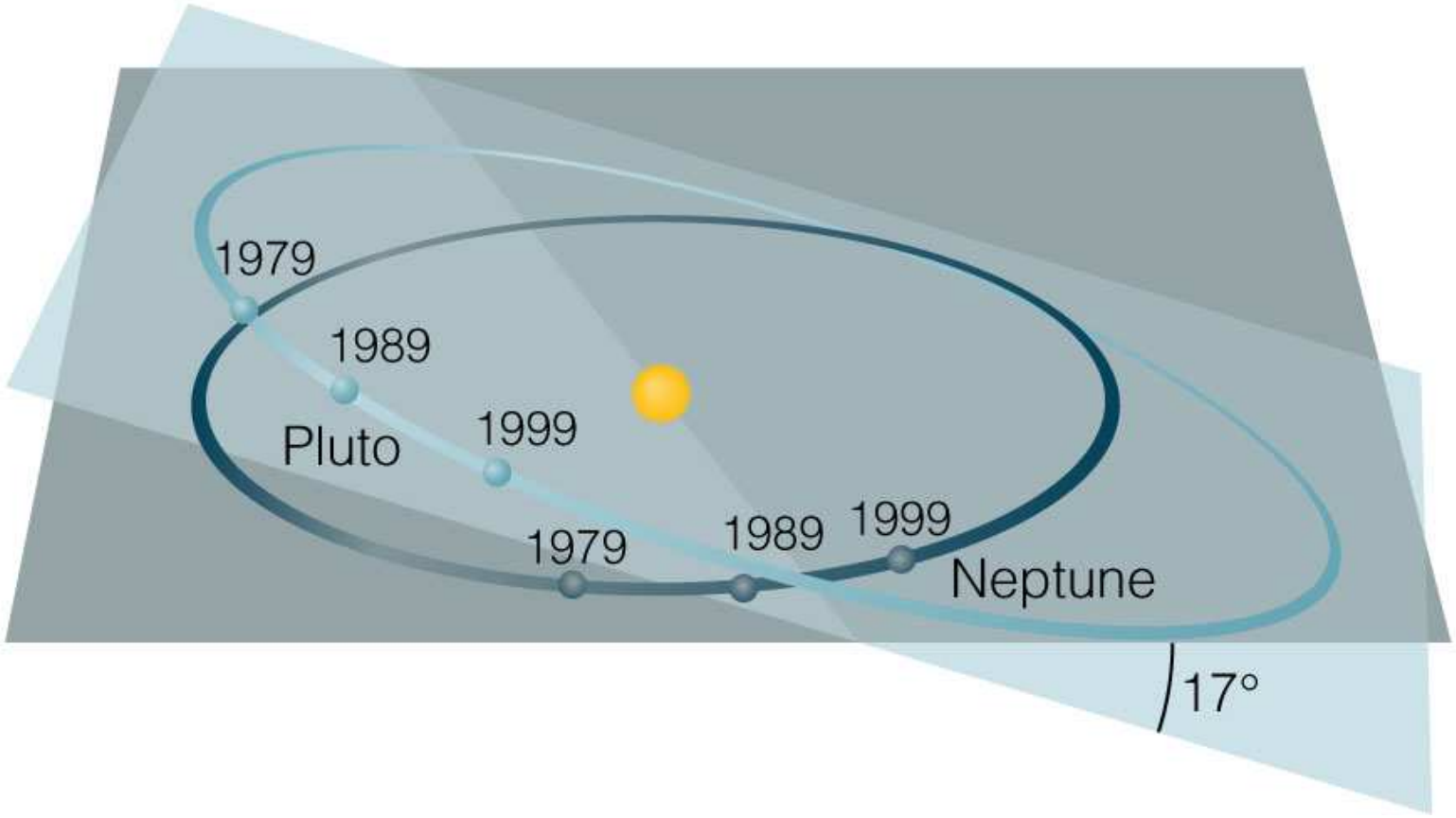

Fig 12.15

The Kuiper Belt

- Gerard Kuiper proposed a belt of Trans Neptunian Objects in 1951
- First object in the KB, other that Pluto, was discovered by Jewitt & Luu in 1992
- Quaoar discovered in 2002
  - More than half of Pluto's size
- Sedna and 2004DW discovered in 2004
  - 2/3 – ¾ Pluto's size
- Kuiper belt likely has at least 100,000 objects larger than 100 km across

- Michael Brown discovered Eris in July 2005
  - 5% larger than Pluto
  - a = 68 AU, e = 0.44, i = 44º, P = 557 years
  - Does this ever come closer to the Sun than Pluto?

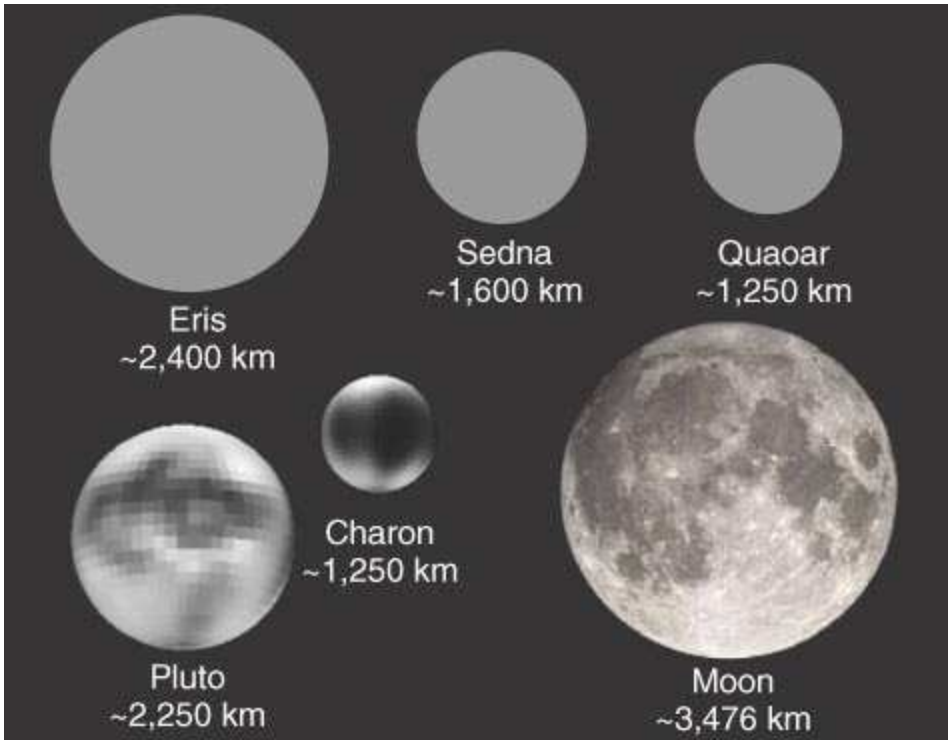

Fig 12.16

The Kuiper Belt

- Gerard Kuiper proposed a belt of Trans Neptunian Objects in 1951
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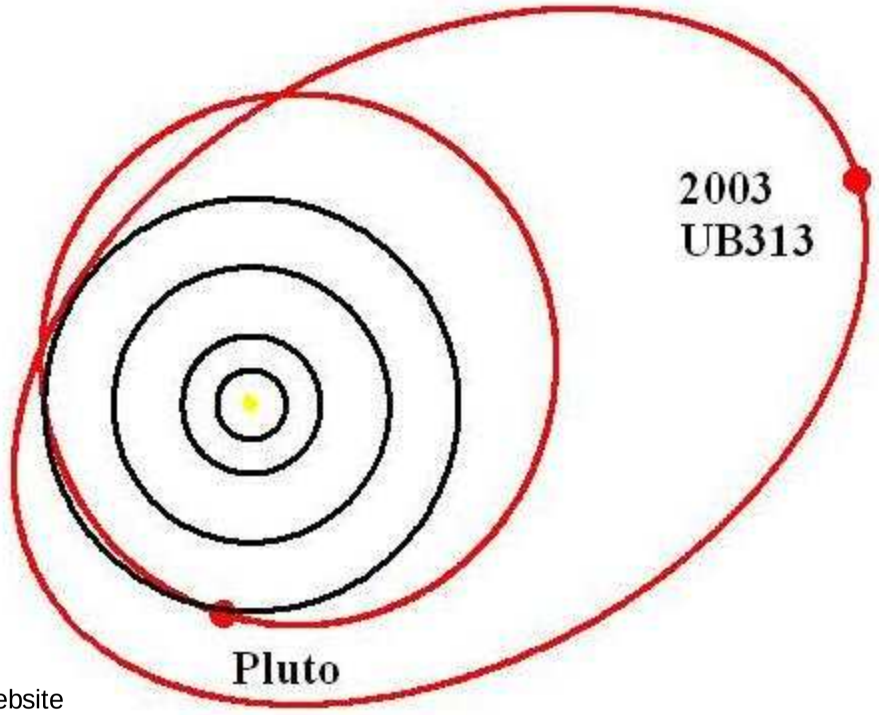


From Michael Brown's Eris website

First Proposal at the IAU GA 2006

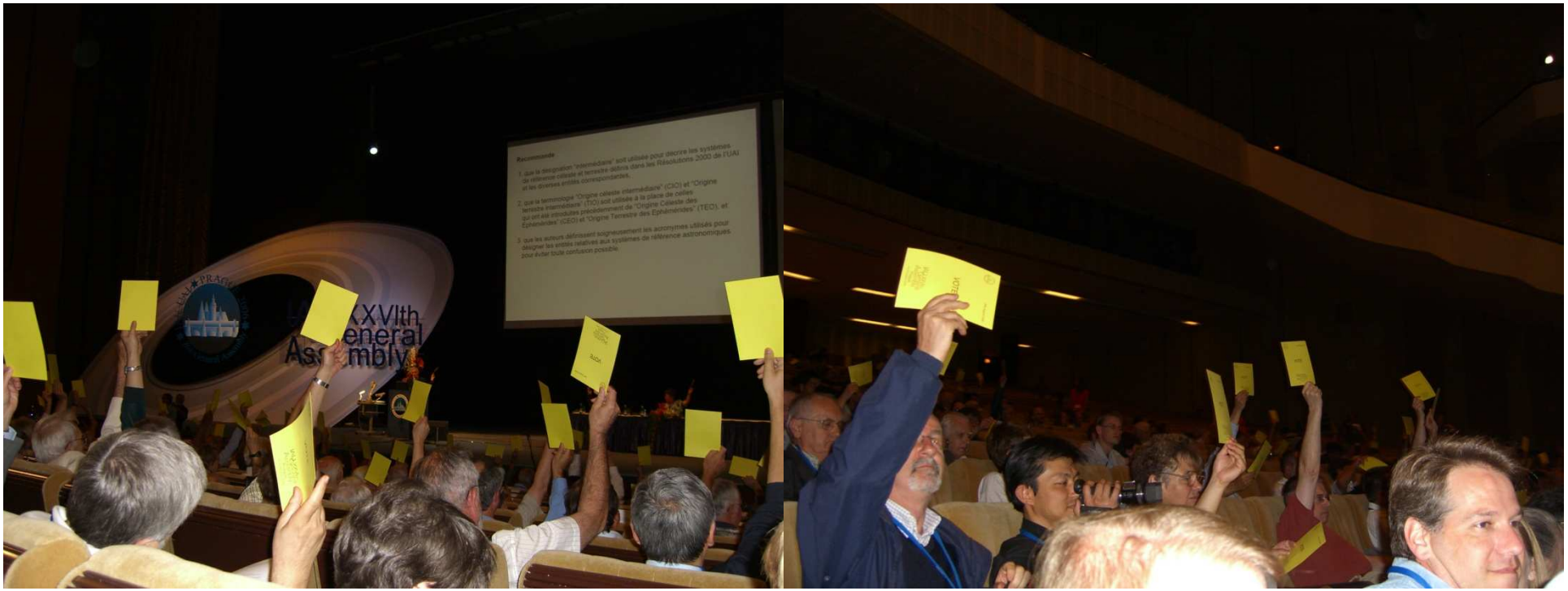
- "A planet is a celestial body that (a) has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape, and (b) is in orbit around a star, and is neither a star nor a satellite of a planet."
- Would have recognized Pluto an Charon as binary planets
- Would have added Eris (Xena) as a planet
- Would have added Ceres as a planet

Why is Pluto Not a Planet?

- Does not fit the pattern
  - Terrestrial, then Jovian, then… ice-ball!
  - Tiny: the “ever-shrinking planet!”
    - Originally thought to be as large as the Earth
  - Most eccentric and inclined orbit
  - Composition is very different from terrestrial and Jovian
- One of many!
  - Kuiper Belt Object
  - No longer the largest known KBO
- If discovered today, would not be classified a planet
  - Discovered in 1930 by Clyde Tombaugh
  - The hunt for “Planet X” funded by Percival Lovell
    - Based on presumed perturbation in Neptune’s orbit
    - Turned out to be a calculation error and a fortuitous discovery

IAU 2006 Definition of a Planet

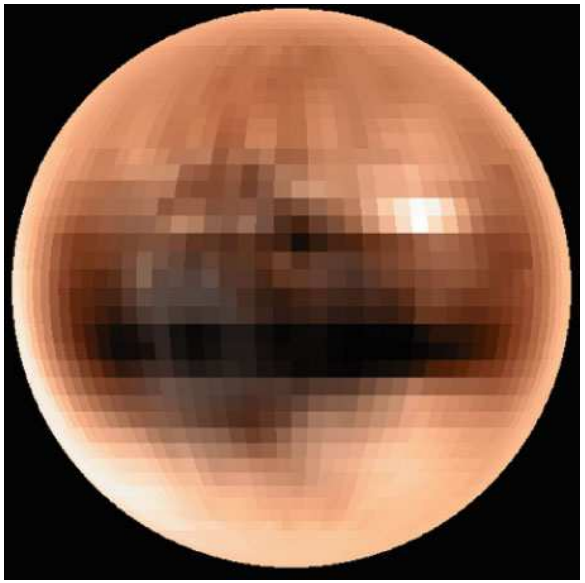
- A Solar System Planet (Resolution 5A, Part 1)
  - Is in orbit around the Sun
  - Has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape
  - Has cleared the neighborhood around its orbit



Composition of KBOs

- Mostly made of ice & rock (similar to comets)
- Pluto + Charon mass known based on their orbit
- Eclipse observed in 1985 – 1990 gave us their radii, masses, and densities, surface markings
- Pluto + Charon is actually a binary dwarf planet system rather than planet + moon
  - Charon is over half Pluto's size
  - Over 1/8 Pluto's mass
  - Orbits 20,000 km away
  - Orbit is two-way synchronized
    - Only one side of Charon seen from Pluto
    - Only one half of Pluto sees Charon

Fig 12.18

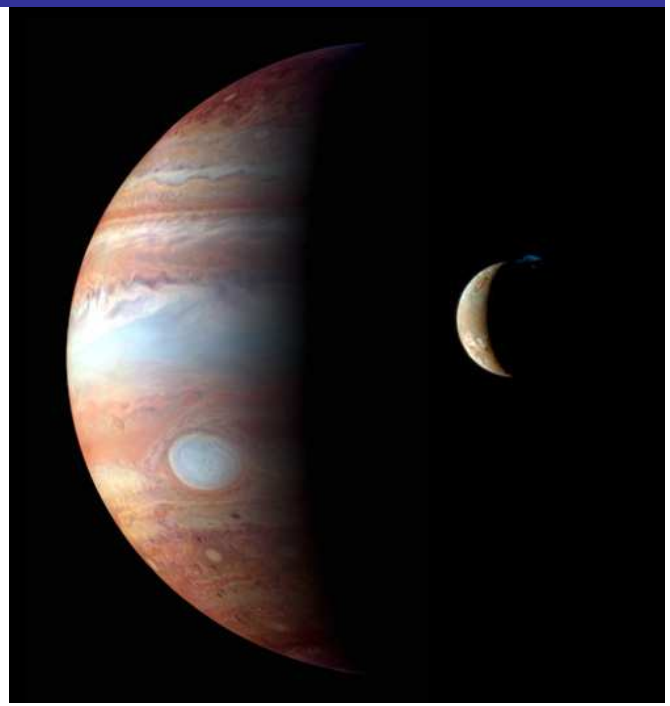


If You Visited Pluto…

- It would be very cold!
  - 40 K, -243 ^{o}C, -387 ^{o}F
- There would be a thin atmosphere of N_2 & CH_4
  - Sublimation from the surface when close to the Sun
- The Sun would be over a 1,000 times fainter than it is as viewed from Earth
  - Not much more than a much brighter Jupiter as seen from Earth (a very bright star in the sky)
- Charon would dominate the sky, if you were on the half that could see it
  - 10 times the angular size of the full moon from Earth!
- Charon would be stationary in the sky but go through phases
- One day would be 6.4 Earth days long
- Seasons would be extreme

Exploration of Pluto

- Pluto and the Kuiper Belt have yet been unexplored by a spacecraft
  - Voyager 1 visited Jupiter & Saturn
  - Voyager 2 visited all four gas giants
- The New Horizons spacecraft is on its way to Pluto
  - Launched January 19, 2006
  - 4 **billion** mile journey to Pluto
  - Jupiter gravity assist in February 2007
  - Pluto Charon encounter in July 2015
  - KBO encounter 2016 – 2020
  - Nuclear energy powered spacecraft is the fastest yet, at 20 km/s (45,000 mph!)
    - Reached Moon's orbit in less than 9 hours
    - Reached Jupiter in just over 1 year
    - Will take 9 years to get to Pluto



New Horizons Image of Jupiter & Io, February 28, 2007