



SPACE PHYSICS

Lecture 9

J. Sahraei

*Physics Department,
Razi University*

<http://www.razi.ac.ir/sahraei>

Neptune

Mass = 17 Earths,

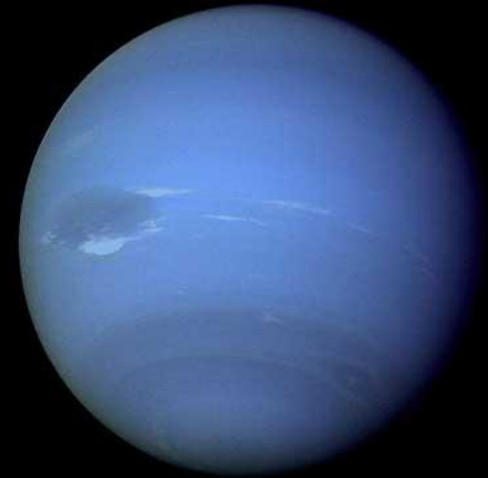
Radius = 3.9 Earths,

density = 1.76 x water

Distance: 30 AU;

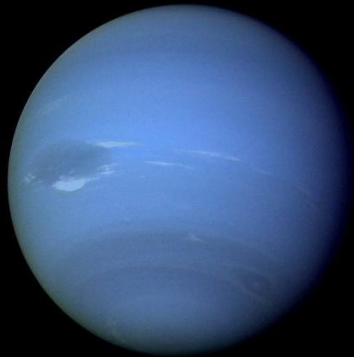
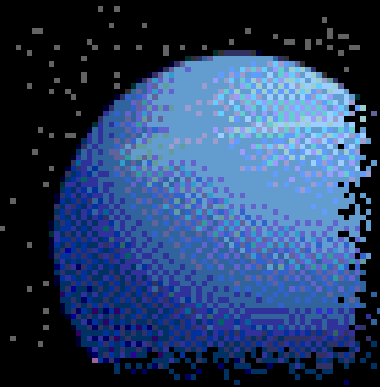
Orbital Period: 163 years;

Rotation period: 16.1 hours.



Voyager showed it is more like Jupiter than Uranus in appearance. Recently, we have developed the ability to see its storms from Earth, using “adaptive optics” in infrared.

NEPTUNE



*4,495,000,000 km from the sun
taking 165 Earth years to
complete an orbit.*

*A day on this planet lasts 16
hours.*

*Record winds of 2400 Km/h
have been recorded.*

*The Great Dark Spot is about
the size of Earth.*

*Methane gives this world a
bluish color.*

Neptune Statistics

Discovered by	Johann Gotfried Galle
Date of discovery	September 23, 1846
Mass (kg)	1.024e+26
Mass (Earth = 1)	1.7135e+01
Equatorial radius (km)	24,746
Equatorial radius (Earth = 1)	3.8799e+00
Mean density (gm/cm³)	1.64
Mean distance from the Sun (km)	4,504,300,000
Mean distance from the Sun (Earth = 1)	30.0611
Rotational period (hours)	16.11
Orbital period (years)	164.79
Tilt of axis (degrees)	28.31
Equatorial escape velocity (km/sec)	23.50
Mean cloud temperature	-193 to -153°C
Atmospheric pressure (bars)	1-3
Atmospheric composition	
Hydrogen	85%
Helium	13%
Methane	2%

SELECT:

OUR SOLAR SYSTEM

BEYOND



Our Solar System

Clouds and Storms on Neptune

High clouds are made of methane ice crystals. The heat flow is greater than expected, giving more storms. The Great Dark spot was an upwelling, but has already disappeared.



Neptune

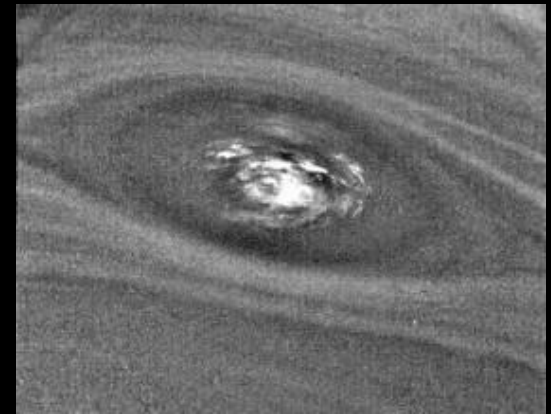
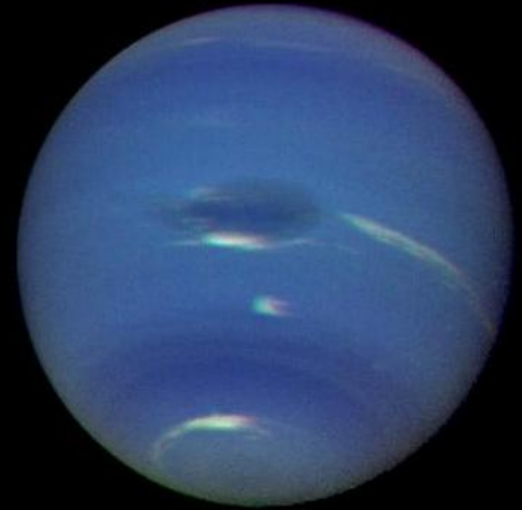
- Neptune is the fourth largest planet and the eighth from the sun.
- Because of the orbits, from 1979 to 1999, Neptune was the ninth planet.
- Like Uranus, the methane gives Neptune its color.



- *The blue coloration of Neptune is probably due to the presence of methane*

Neptune

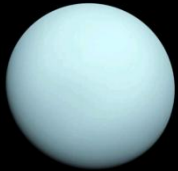
- Ices and rock - 15% H and little He
- H, He, methane atmosphere (blue!)
- Uniform through out; small rocky core?
- Had storm "Great Dark Spot" MIA since Voyager 2
- Pretty Good White Spot (Scooter) zipped around every 16 hours....
- 4 Rings - unknown composition
- 13 moons
- Voyager (1989)





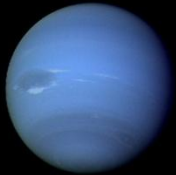
The Romans named the Greek god of the sea and earthquakes Neptune. Neptune had a violent temper and caused storms and earthquakes to occur on Earth. Because its appearance is similar to that of the sea, the planet Neptune is named after the god of the sea. Its extremely stormy atmosphere also reminds us of the god's violent temper!

What does the density tell us about the interior of Uranus and Neptune?



Uranus

density = 1.3 gm/cm³



Neptune

density = 1.6 gm/cm³

Like Jupiter and Saturn these planets have low densities which suggest they are primarily made of gas.

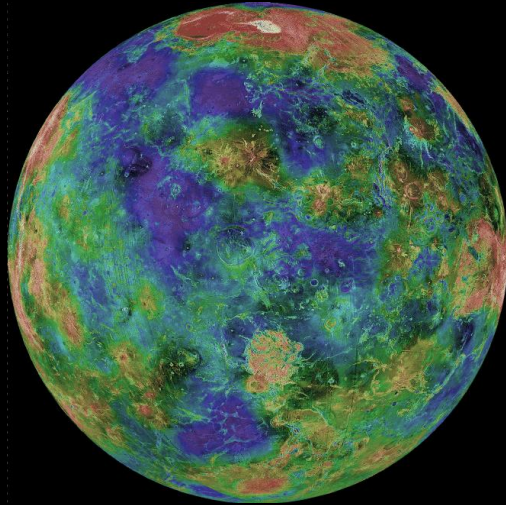
(in this case methane)

The Terrestrial (inner) Planets

- *Small, dense and rocky*
- *Few moons, no rings*



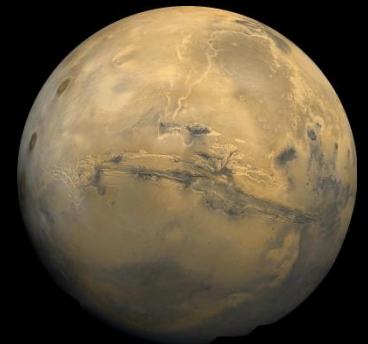
Mercury



Venus

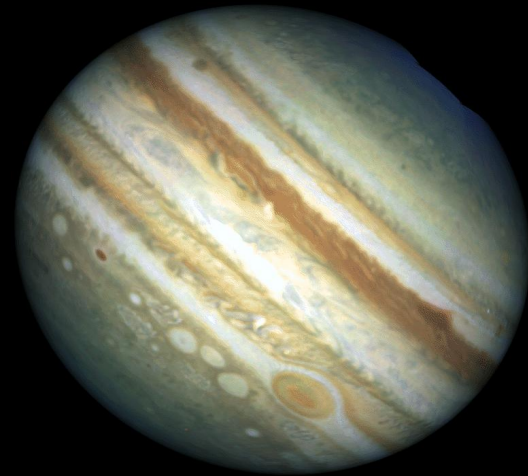


Earth



Mars

The Jovian (Outer) Planets



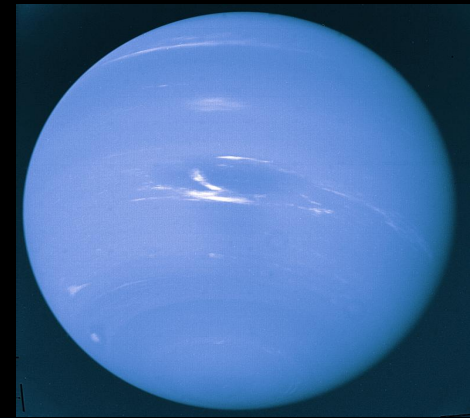
Saturn



Jupiter



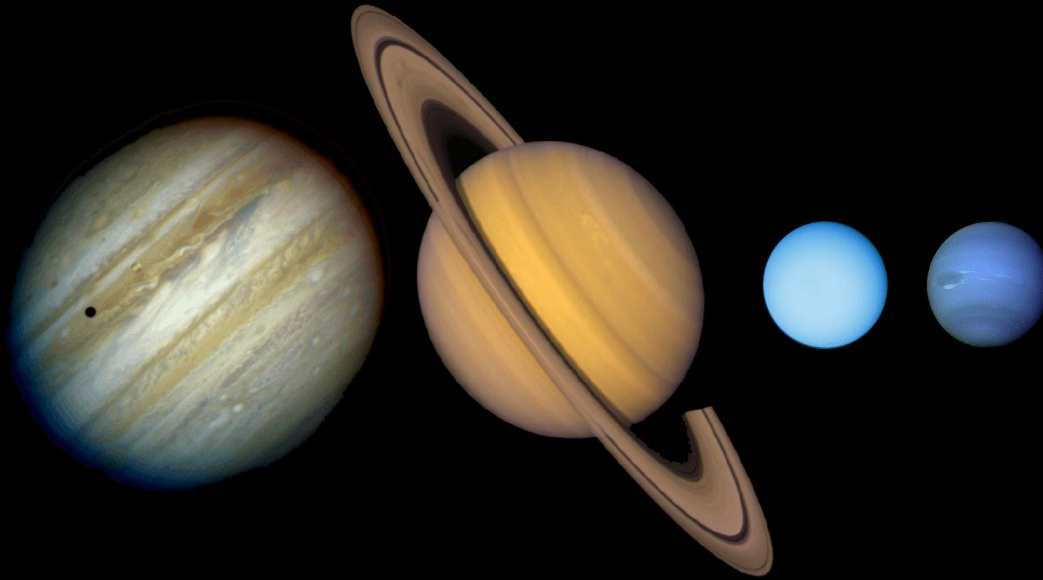
Uranus



Neptune

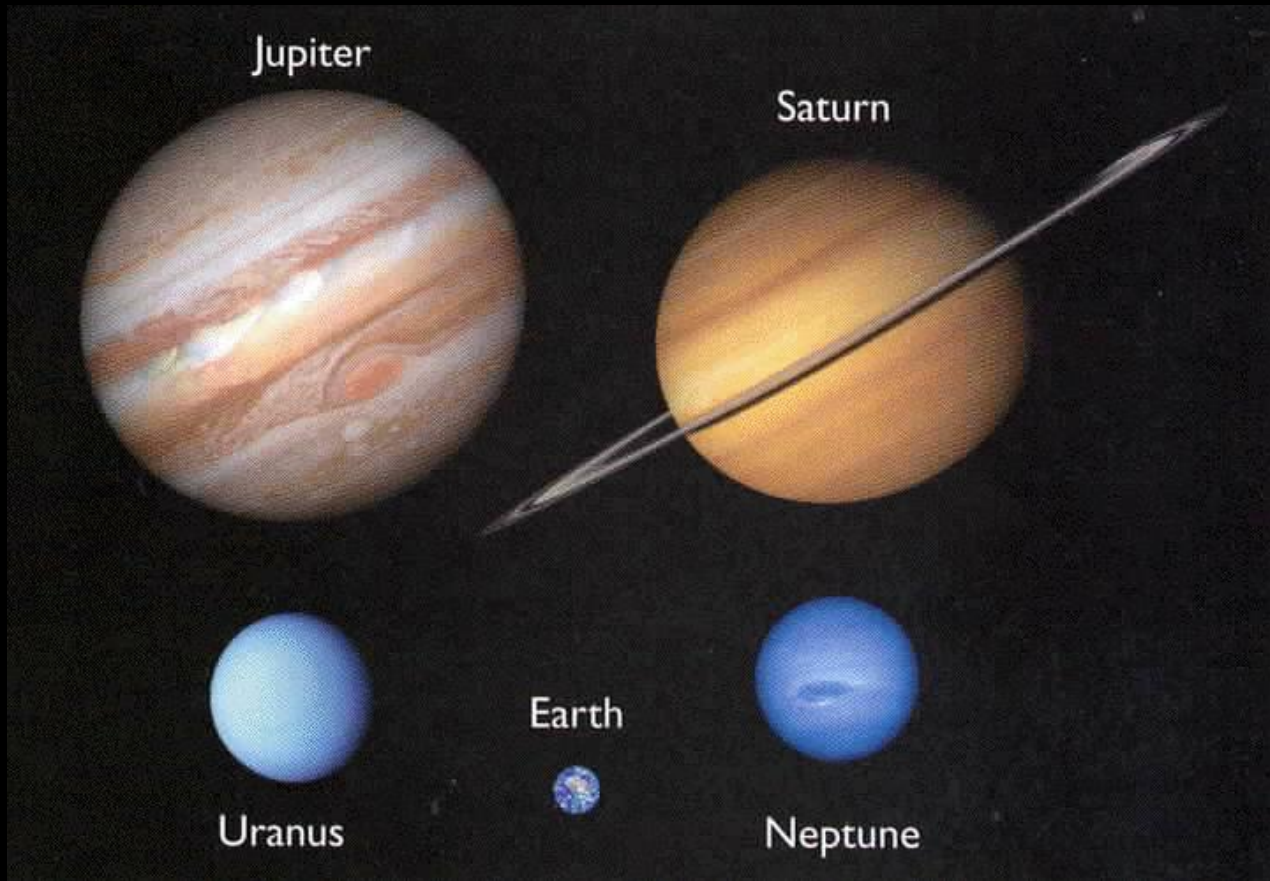
Large, gaseous, lots of moons, rings

Giant Planets



Jupiter, Saturn, Uranus, Neptune

Size Comparison



Jupiter: 318 Earth-masses, Saturn: 95, Uranus: 14.5, Neptune: 17.2

Two subclasses: Jupiter-Saturn and Uranus-Neptune

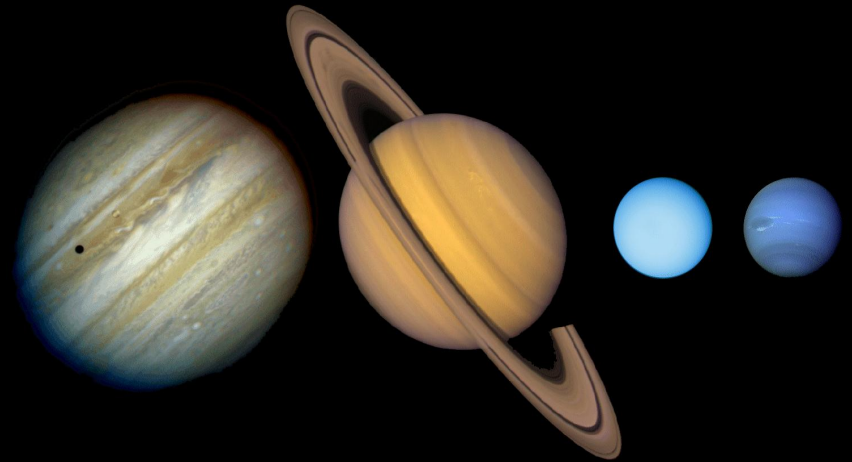
• *Terrestrial planets*

- low mass
- high density
- slow rotators (≤ 24 hours)
- few satellites
- close to Sun (≤ 1.6 AU)
- Thin atmospheres
- Weak or no magnetic field
-



• *Giant planets*

- high mass
- low density
- rapid rotators (≥ 18 hours)
- many satellites
- far from Sun (≥ 5 AU)
- Thick atmospheres
- Strong magnetic field



Jupiter, Saturn, Uranus, and Neptune have all been visited by the Voyager space probes.

- Galileo was crashed into Jupiter
- Cassini is now at Saturn

Jupiter, Saturn, Uranus, and Neptune are all massive bodies

- formed in outer part of pre-solar nebula where ices condense
- growth by accretion and coalescence

Giant planets are gaseous/fluid bodies

- supported by balance between pressure and gravity: Hydrostatic equilibrium

Pluto

*Discovered in 1930 by Clyde Tombaugh.
Charon discovered at **USNO** in 1978.*

Pluto: radius = 1145km,
mass = 0.002 Earths,
density = 2.1x water
Charon: radius = 600 km,
mass = 0.1-0.2 Plutos



Pluto is the only planet that has not been visited by a spacecraft.

Pluto Data

Mean distance from Sun:	39.53 AU = 5.914×10^9 km
Maximum distance from Sun:	49.34 AU = 7.381×10^9 km
Minimum distance from Sun:	29.72 AU = 4.446×10^9 km
Mean orbital velocity:	4.7 km/s
Sidereal period:	248.5 years
Rotation period:	6.387 days
Inclination of equator to orbit:	122°
Inclination of orbit to ecliptic:	17.1°
Diameter:	2300 km
Diameter (Earth = 1):	0.18
Mass:	1.29×10^{22} kg
Mass (Earth = 1):	0.002
Mean density:	2030 kg/m ³
Surface gravity (Earth = 1):	0.04
Escape speed:	1.1 km/s
Mean surface temperature:	-223°C = -369°F = 50 K

Pluto

- Diameter :2274 km
- **2/3 size of Earth's Moon**
- Rotation: 6 1/3 days
- Orbit: 248 years highly elliptical
- Light from Sun takes 5.5 hours to reach it
- **Surface of water and methane ice, frozen nitrogen**
- When closer to the Sun, heat produces an atmosphere



Hubble Space Telescope View of Pluto and Charon



New Satellites of Pluto Discovered by HST



May 15, 2005



May 18, 2005

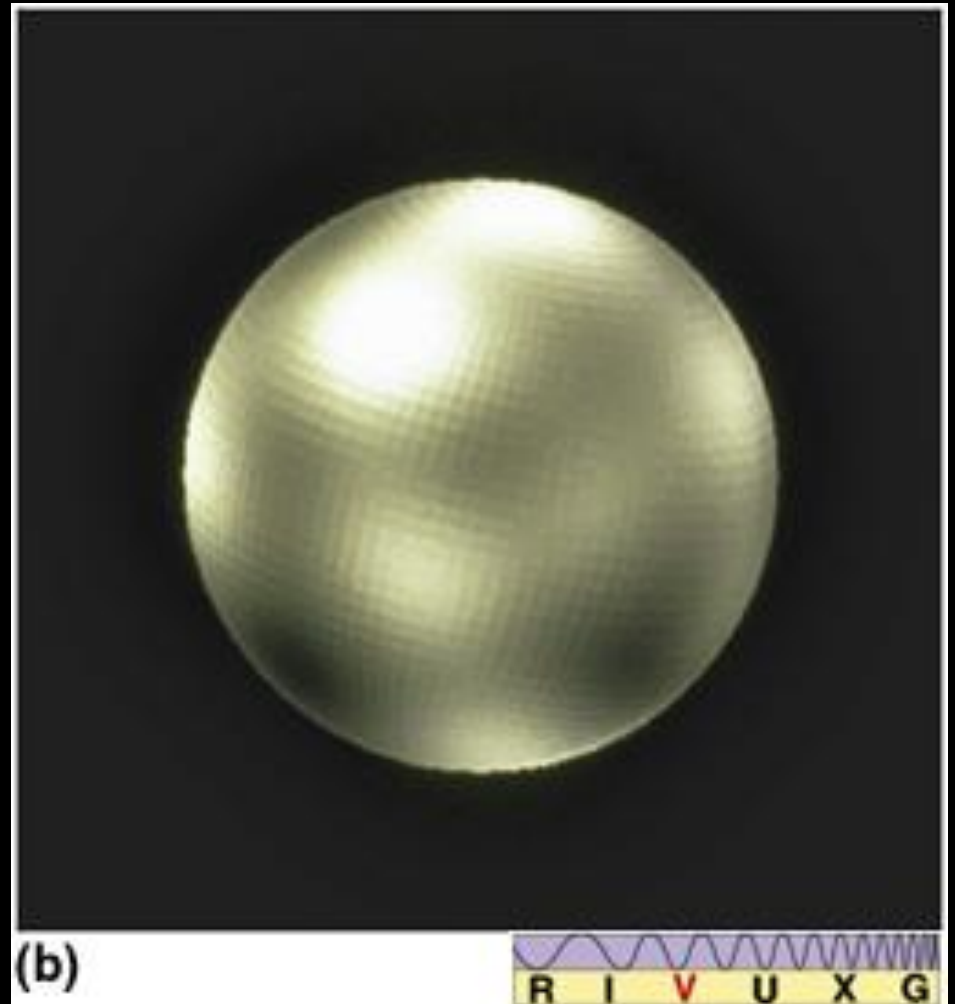
Pluto System

Hubble Space Telescope ■ *Advanced Camera for Surveys*

Pluto

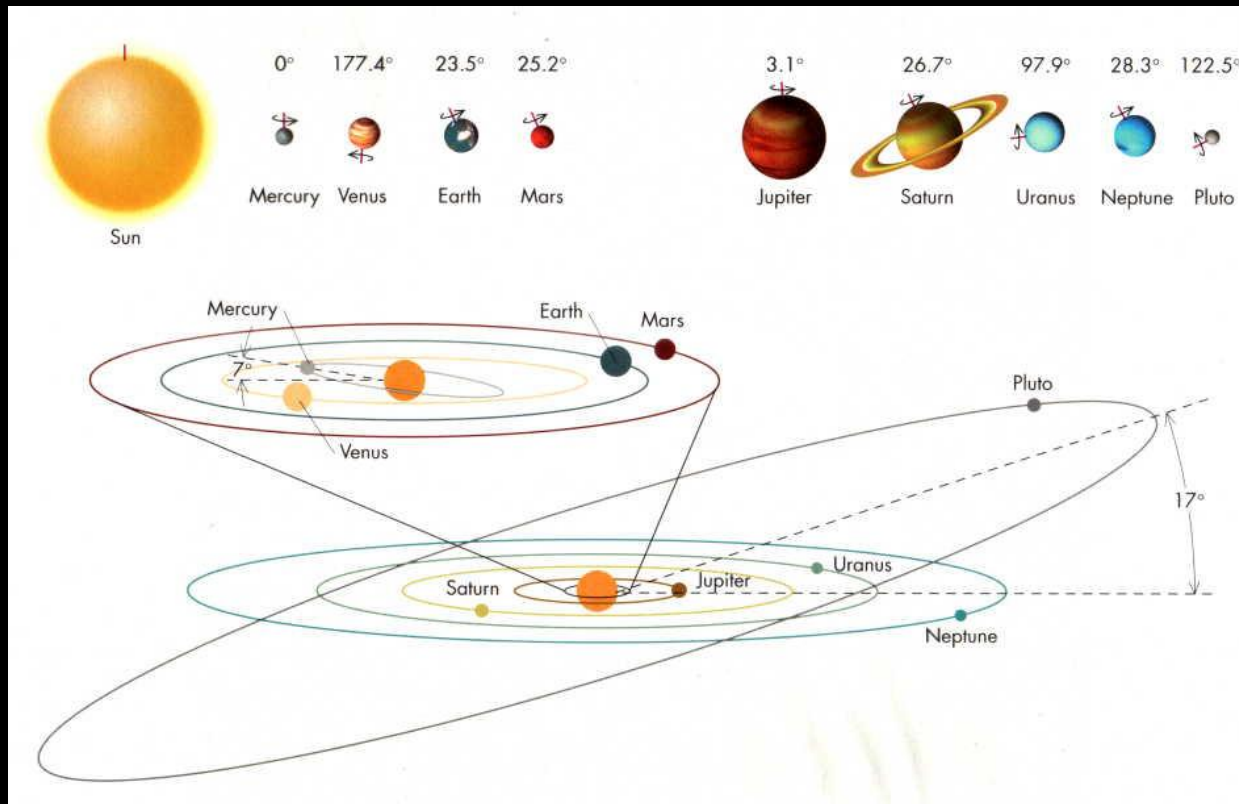
- *Less dense than our Moon*
- *About 1/5 as big as the Earth*
- *About right for a Jovian moon*
- *Maybe a Kuiper belt object*
- *Icy material like Triton, one of Neptune's moons*

Best picture of Pluto so far



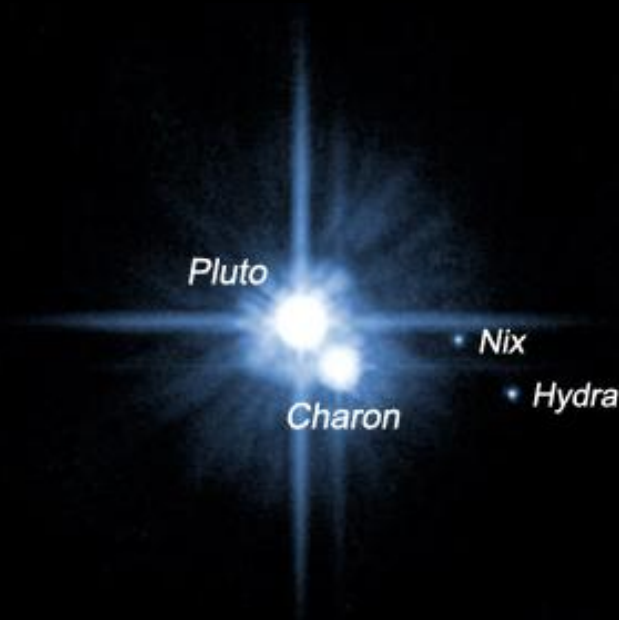
Pluto's strange Orbit

- *Very far out there: 40 A.U.*
- *Pluto's year = 248 Earth years*
- *Orbit inclined 17° w.r.t. ecliptic*
- *Very eccentric orbit:*
- *Perihelion: 30 A.U.*
(inside the Neptune orbit!)
- *Aphelion: 50 A.U.*



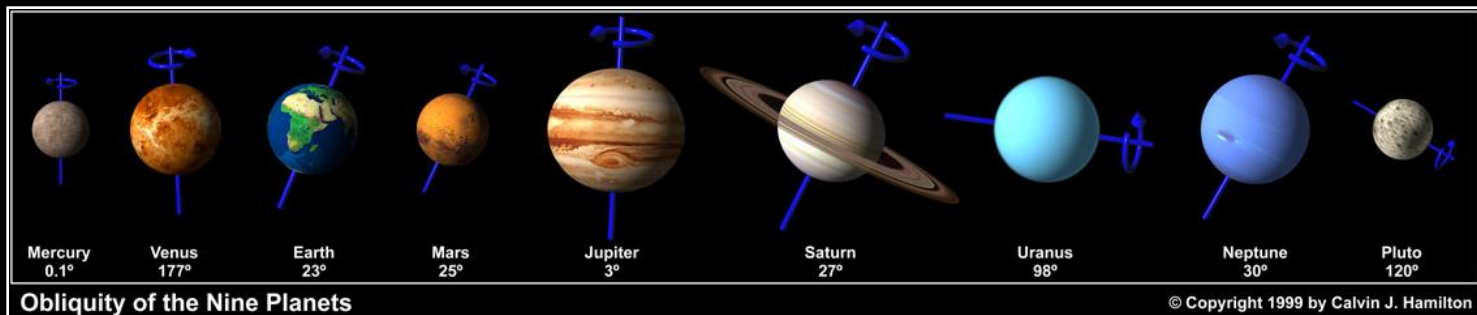
PLUTO

The smallest of all the planets but also the furthest at 4 billion miles. It has one moon, Charon that is half the size of Pluto making it hard to detect. Its strange orbit actually takes it within Neptune's orbit.



PLUTO

- *Pluto is very small as planets go, Pluto's orbit is elliptical: it varies from 29 to 49 A.U. from the Sun, crossing inside of Neptune's orbit.*
- *Pluto's orbit is inclined 17deg to the ecliptic, so it goes farther above and below the plane in which the other planets formed than any other planet.*



Pluto



density = 2.1 g/cm³

Since Pluto is so far away it is hard to see the planet. Since it is good at reflecting light scientists suspect there is ice at the surface, possibly frozen Nitrogen

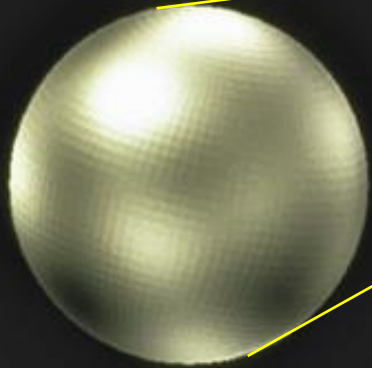
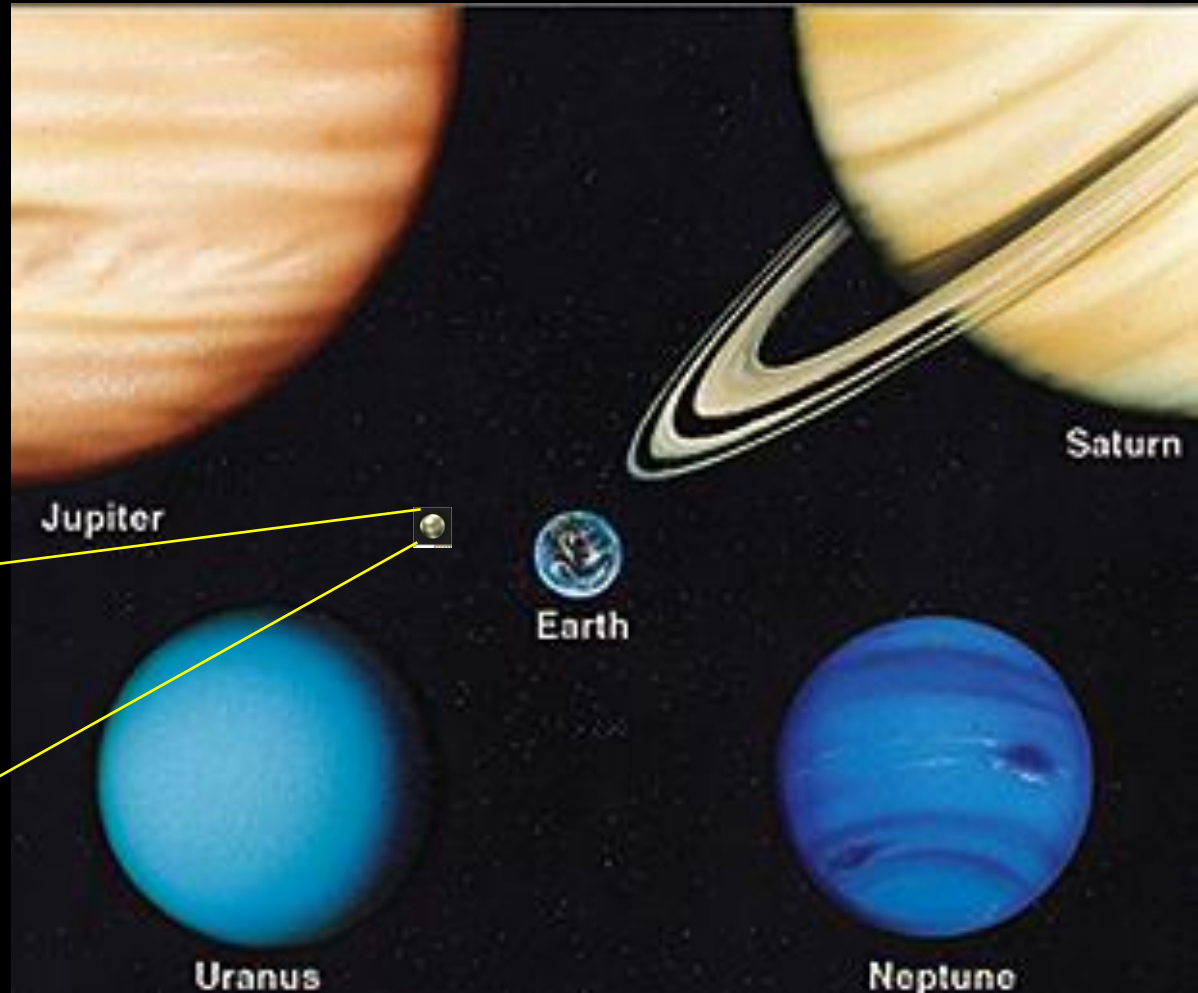
Is Pluto a Planet?

What Makes a Planet a Planet?

- *Orbits a star*
- *Round*
- *Not a star or a moon*
- *“Cleared Out” its orbit*

Pluto is different!

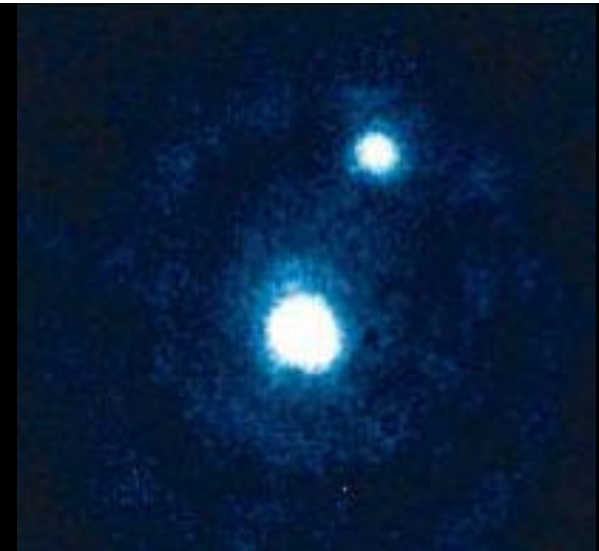
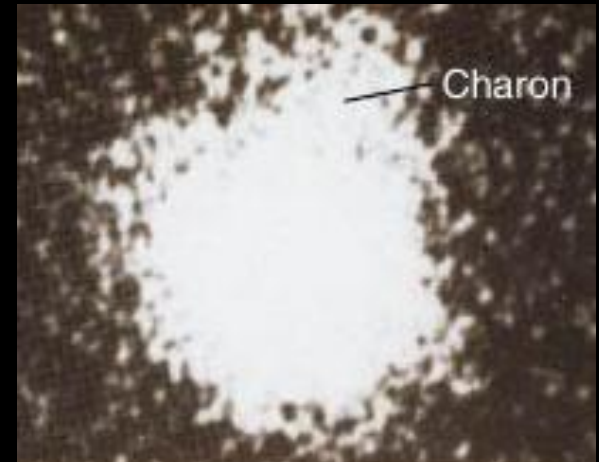
- *Pluto is only 2200 km in diameter*
- *Much smaller than the Earth's Moon*



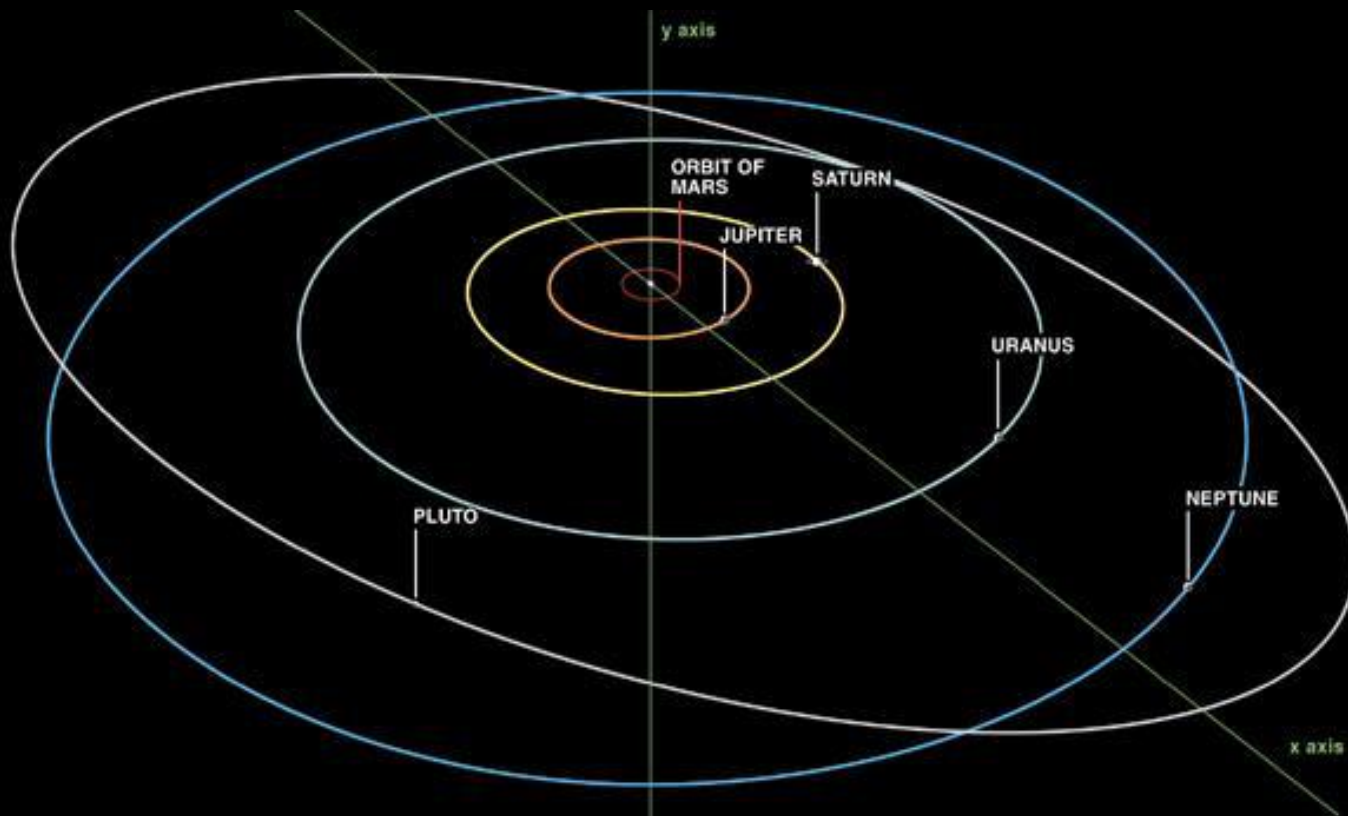
Pluto

- *Sought by Percival Lowell, discovered by Clyde Tombaugh in 1930*
 - *Existence discovered based on perturbations of Uranus's and Neptune's orbits*
 - *The calculations were wrong, but it was there anyway!*
- *Satellite Charon discovered in 1978*
 - *Mutual eclipses of Pluto and Charon reveal sizes and masses*

Resolution 1"



Space Telescope: distance 0.9"



Is Pluto a Planet?

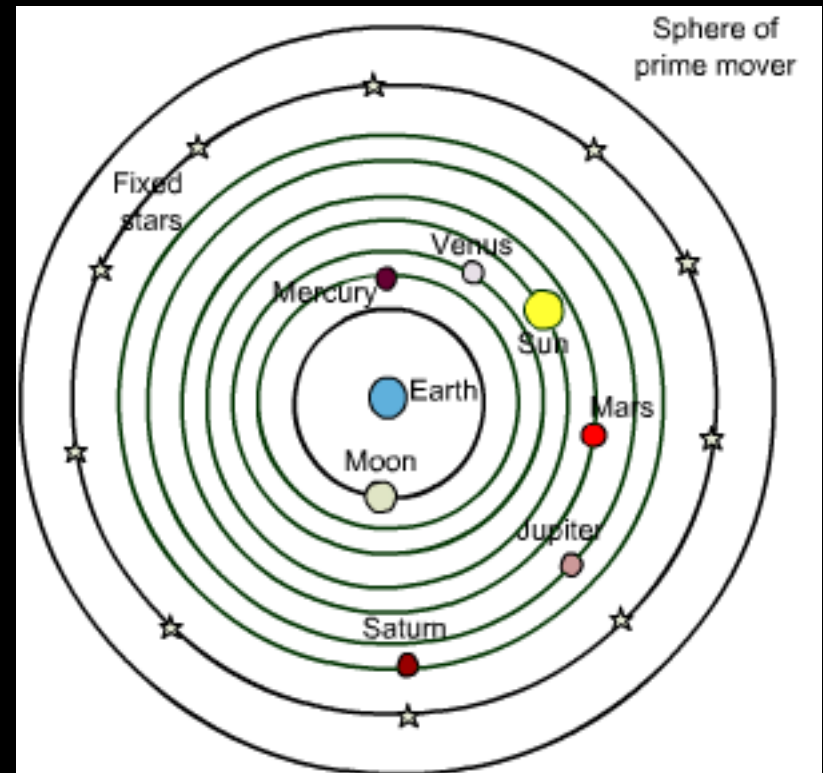
Yes	No
<p>It has always been considered a planet</p>	<p>Very small Very elliptical orbit Out of plane of ecliptic Same material as Kuiper belt objects Found other “non-planets” that were larger</p>

The Ancients (before ~1500 AD)

- The Ancients had no telescopes (all naked-eye observing).
- They noted that the stars remained "fixed" relative to each other, though they all went around the sky every ~24 hours...
- ...except for exactly seven, the "wanderers" (*planets*).
- (There were also random objects like comets and novae, but that's another story for another talk...)
- Planets: Objects which wandered across the sky.
- Identified with gods.
- The Seven Ancient Planets:
 - The Moon
 - The Sun
 - Mercury
 - Venus
 - Mars
 - Jupiter
 - Saturn

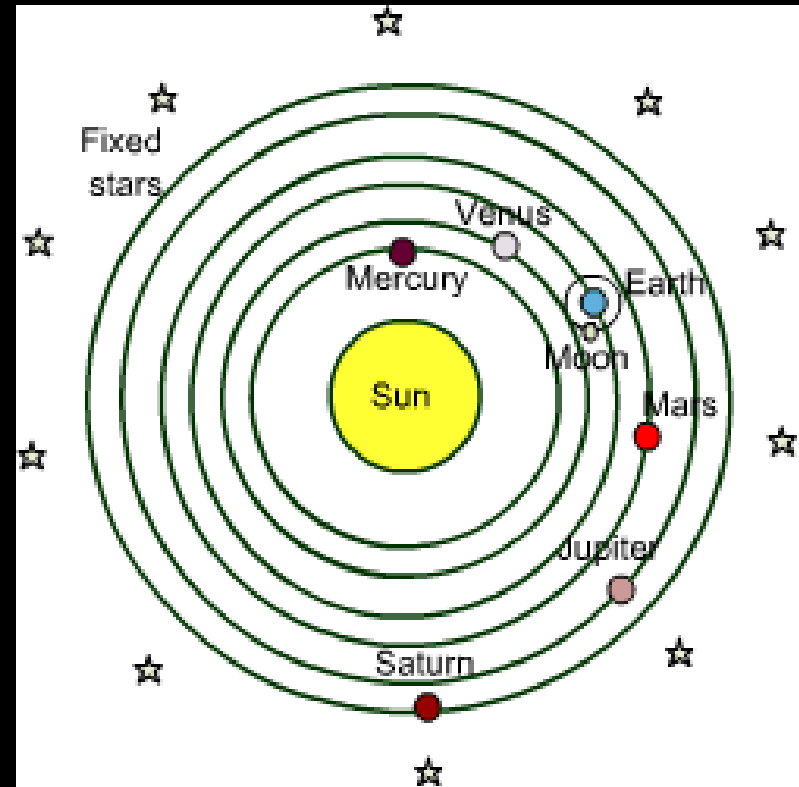
The Ancient Solar System

- **Geocentric - Earth at center** (pretty reasonable to assume)
- **The seven "planets" orbit the earth in circles, surrounded by the "fixed stars."**
- Appeared to explain the observed motion of the planets... fairly well.
- **But Mercury and Venus followed *strange* paths in the sky, and the Sun and Moon just looked *different* from the others.**



The first modern astronomers (~1500-1600)

- By the 1500's, Tycho Brahe's naked-eye observations made it clear the old model wasn't working too well.
- Copernicus proposes a Sun-centered (heliocentric) model.
- Still the same seven "planets" (plus the Earth), only rearranged.
- Earth is the third planet, with the Moon going around it. Everything else orbits the Sun.
- Orbits not circles, but *ellipses* (Kepler's modification to better fit Tycho's data)



The Solar System ~1600

- Sun

	Dist. from Sun (AU)
1. Mercury	0.3
2. Venus	0.7
3. Earth	1.0
Moon	
4. Mars	1.5
5. Jupiter	5
6. Saturn	10

- Planets - the six known objects that orbit the sun.
- If it goes around a planet, then it's a moon.
- Officially six planets plus one moon, all known since ancient times.
- Planets move in elliptical orbits around the sun according to Kepler's Laws.

