

Astronomy 210

Section 1 – MWF 1500-1550
134 Astronomy Building

This Class (Lecture 15):

The Solar System: Overview

HW #4 due on Friday!

**Turn in the Betelgeuse
observation!**

Next Class:

Planet Properties

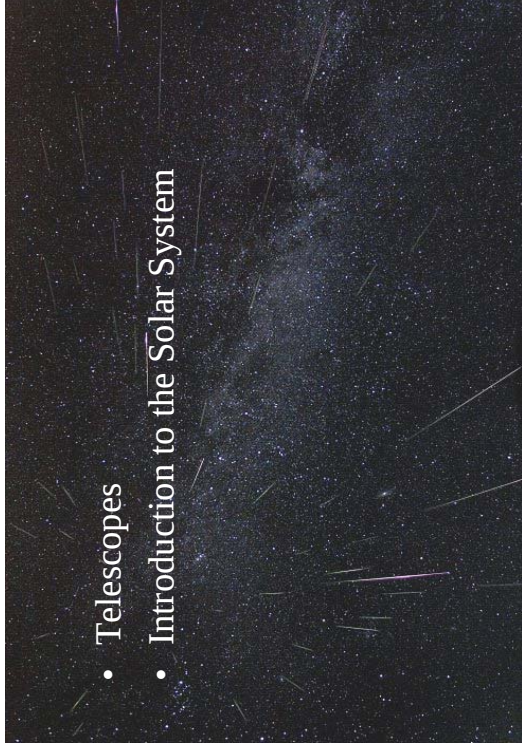
Feb 23, 2005

Astronomy 210 Spring 2005



Outline

- Telescopes
- Introduction to the Solar System



Feb 23, 2005

Astronomy 210 Spring 2005



Question

Why would it be useful to place telescopes in space?

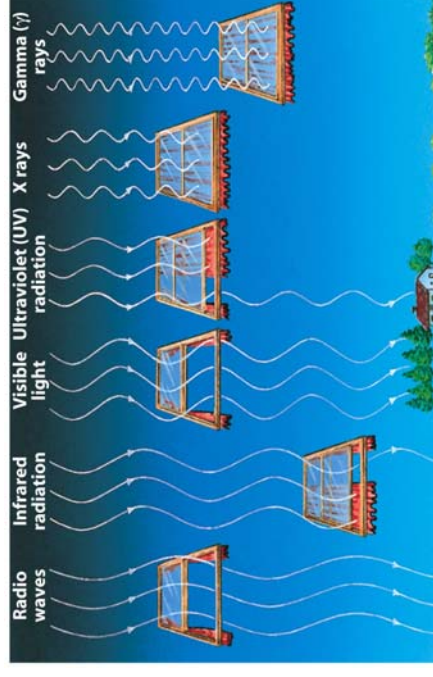
Feb 23, 2005

Astronomy 210 Spring 2005



Opaque Atmosphere

- The atmosphere blocks some wavelengths
- Must observe some wavelengths from space!



Feb 23, 2005

Hubble Space Telescope



- 2.5 meter reflecting telescope in space
- Small, but above atmosphere
 - No “twinkling” effects
 - No light pollution



Ground-based image

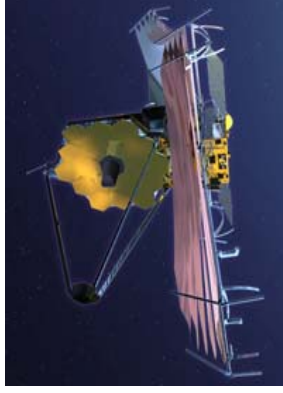


Hubble Telescope image

Astronomy 210 Spring 2005

Feb 23, 2005

James Webb Space Telescope



- The next space telescope – 2011
- Observe in the near and mid-infrared
- Will be the biggest telescope in space – 6 meters! (Must fold up for launch)
- Will take 3 months to reach position – no service missions

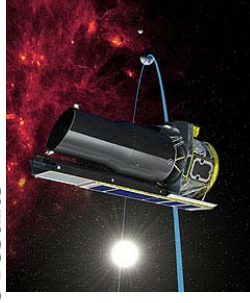
Astronomy 210 Spring 2005

Feb 23, 2005

Spitzer Space Telescope



- 0.85 meter infrared telescope
- Launched August 2003
- Cooled to near absolute zero so that its own heat doesn't confuse the results



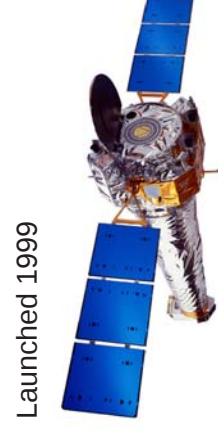
210 Spring 2005

Feb 23, 2005



Reflection Nebula NGC 7129 Spitzer Space Telescope • IRAC
Hubble and Galaxy at Infrared Wavelengths

Chandra X-ray Observatory



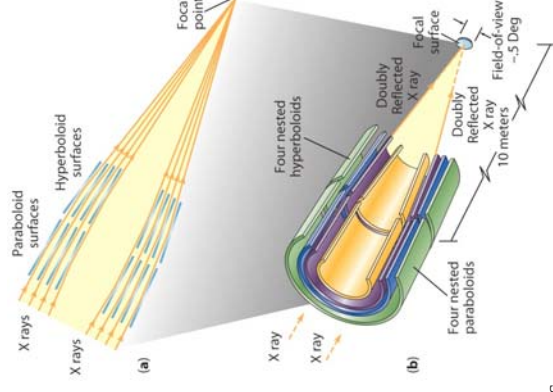
Launched 1999



Crab Nebula in X-rays

Astronomy 210 Sp

Feb 23, 2005



The Big Picture

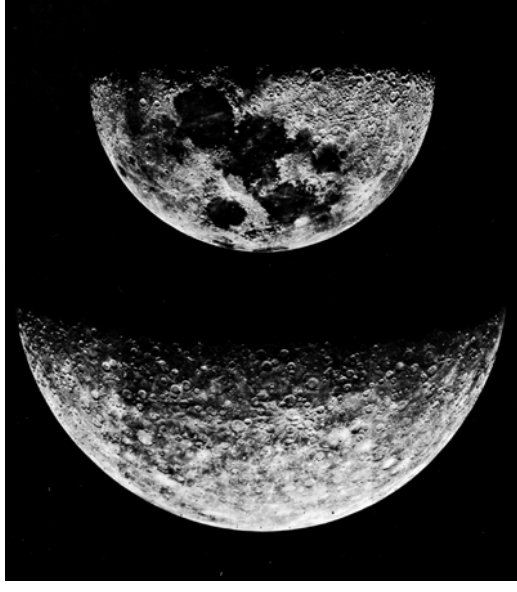


- Today, we can observe in almost every part of the electromagnetic spectrum
- Only 100 years ago, we were blind to the big picture of the Universe
- As we begin to piece together the big picture, our understanding of the cosmos grows .
- But there is more out there than photons too:
 - Neutrinos
 - Cosmic rays
 - Gravity waves
- All are useful in understanding the Solar System!

Feb 23, 2005

Astronomy 210 Spring 2005

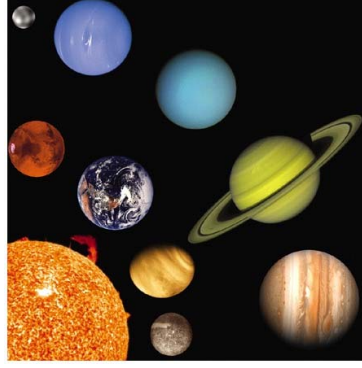
What's this Picture of?



Feb 23, 2005

Astronomy 210 Spring 2005
<http://www.whfreeman.com/discoveringDTU/EXAMOD36/F3609.HTM>

The Solar System



- We now turn our attention to the solar system— our home!
- This will be our focus for the next month
- We will study the planets by comparing them to Earth - and to each other
- To better understand our planet and its importance.
- Use the present to learn about the past.

Feb 23, 2005

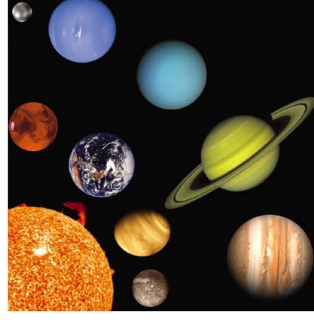
Astronomy 210 Spring 2005

It's not your parent's Solar System



The old style of teaching the Solar System

- Sun & 9 planets
- Separate section on each
- Mention asteroids and comets
- Lots of cool facts



Feb 23, 2005

Astronomy 210 Spring 2005



Mercury Mary
Venus Vincent
Earth Eats
Mars Many
Jupiter Jelly
Saturn Sandwiches
Uranus Under
Neptune Neighbors
Pluto Porches

Feb 23, 2005

Astronomy 210 Spring 2005



Mercury My
Venus Very
Earth Energetic
Mars Mother
Jupiter Just
Saturn Served
Uranus Us
Neptune Nine
Pluto Pizzas

Feb 23, 2005

Astronomy 210 Spring 2005



21st Century View

- Six families of the solar system
 - Star
 - Rocky planets
 - Asteroid belt
 - Gas giant planets
 - Kuiper belt
 - Oort cloud

Feb 23, 2005

Astronomy 210 Spring 2005



Planets Dance

<http://janus.astro.umd.edu/javadir/orbits/ssv.html>

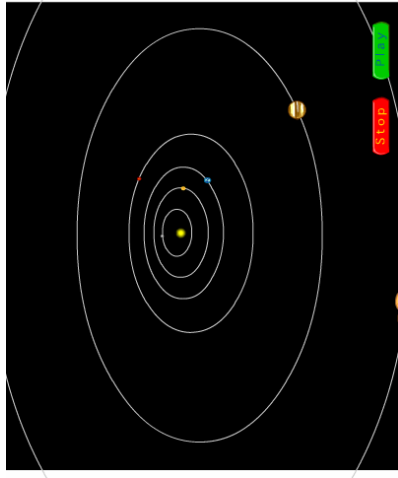
Feb 23, 2005

Astronomy 210 Spring 2005

Planetary Orbits



- Orbital (and most rotational) motions in solar system are counter clock-wise in a flattened disk
- Orbits are actually close to circles, except Mercury and Pluto



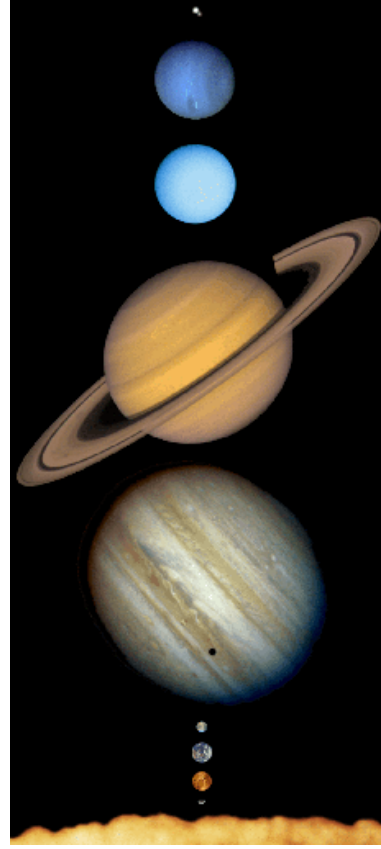
Feb 23, 2005

Astronomy 210 Spring 2005

A Sense of Scale



- Most pictures of the Solar System look something like this...



<http://www.jpl.nasa.gov/galileo/sepo/education/hav/as2.gif>

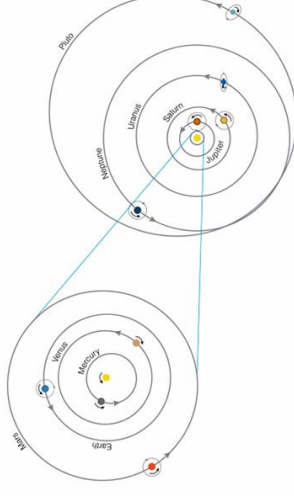
Feb 23, 2005

Astronomy 210 Spring 2005

Planetary Orbits



- Orbital (and most rotational) motions in solar system are counter clock-wise in a flattened disk
- Orbits are actually close to circles, except Mercury and Pluto



Feb 23, 2005

Astronomy 210 Spring 2005

Not to Scale!



- While the planets' sizes are scaled correctly, their distances are not
- Take a little blue ball, 1cm across
- Imagine that the Earth is this ball
- The Moon is 30cm (1 foot) away, and about $\frac{1}{4}$ the size of the blue ball

1 cm across

Feb 23, 2005

Astronomy 210 Spring 2005

Continuing the Scale Image



- On this scale, the Sun is about the size of a wagon wheel
- It is a football field away from the Earth
- Mercury is on the Sun's 40-yard line
- Venus is on Earth's 30-yard line



Feb 23, 2005
Astronomy 210 Spring 2005

Continuing the Scale Image



- To put the other planets on this scale, we need to add more football fields
- Mars would lie on the 50-yard line of the next football field
- Jupiter would be 5 football fields from the Sun, and about the size of a softball
- To get to Saturn, we need to jump out to 10 football fields from the Sun

Feb 23, 2005
Astronomy 210 Spring 2005

Continuing the Scale Image



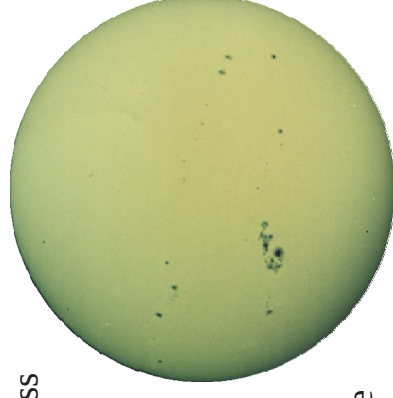
- Uranus would be about 20 football fields from the Sun
- Neptune would be about 30 football fields away
 - Both about the size of a golfball
- Pluto would lie an average of 40 football fields from the Sun, and be about 2 millimeters across
- Now let's look at the solar system in a little more detail...

Feb 23, 2005
Astronomy 210 Spring 2005

The Sun

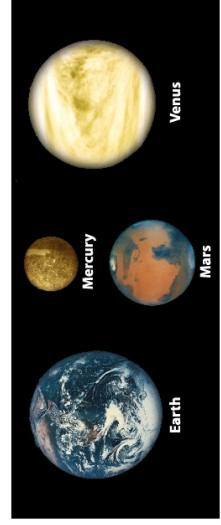


- Dominates the solar system
 - 99.85% of the total mass
- Without the Sun's energy, life on Earth could not exist
- But the Sun is a fairly typical star
 - Understanding the Sun is vital to unlocking the secrets of the stars



Feb 23, 2005
Astronomy 210 Spring 2005

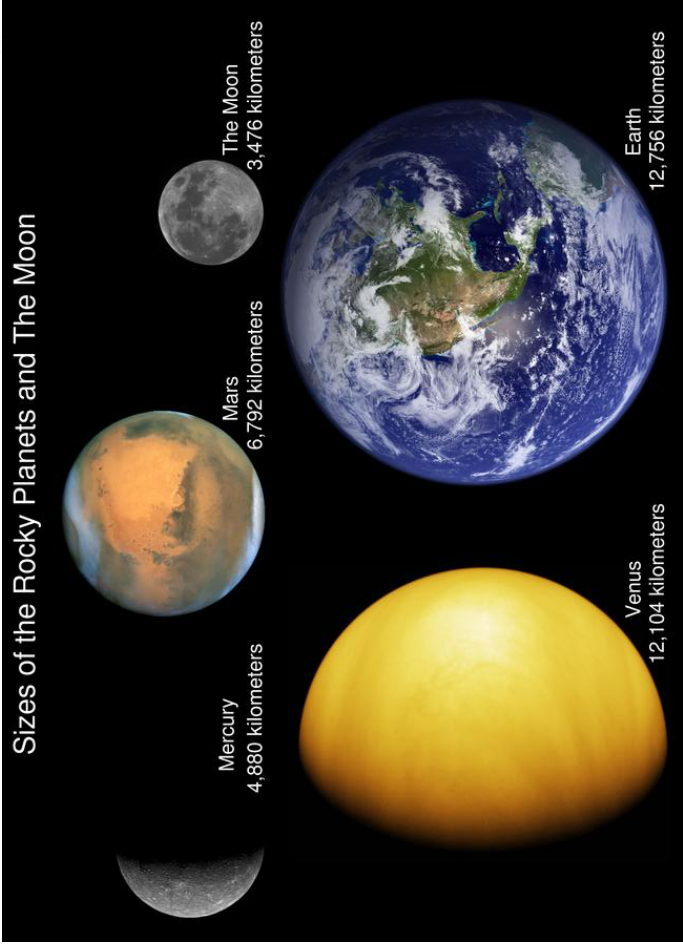
The Terrestrials



- Mercury, Venus, Earth, & Mars
 - Plus the Moon, if you want
- The closest planets to the Sun
- Small bodies, made mostly of rock and iron
- Very similar to each other in overall composition and structure
- Vastly differing surface conditions

Feb 23, 2005

Astronomy 210 Spring 2005



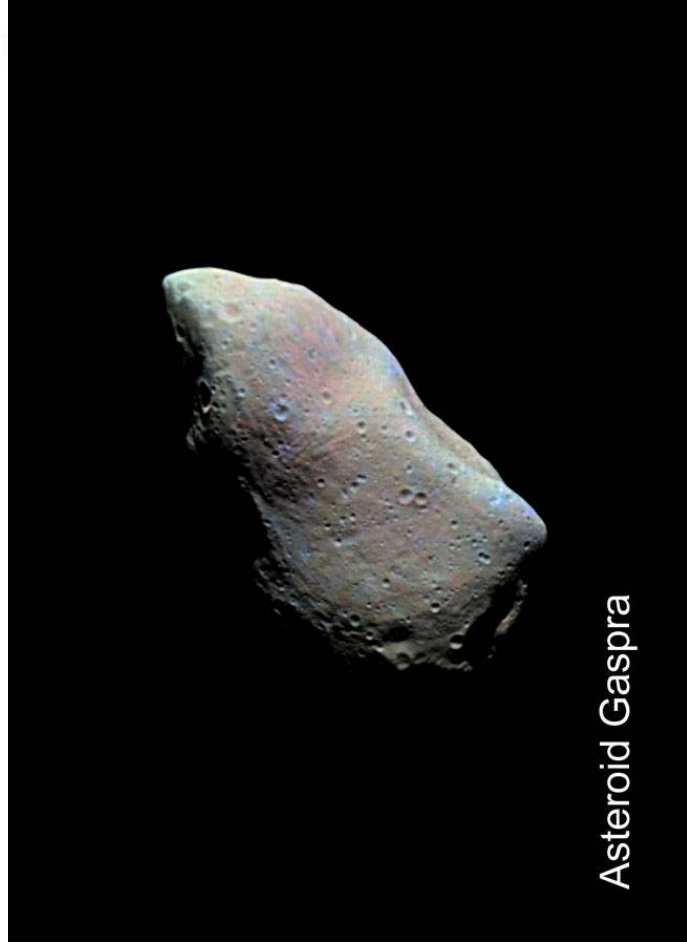
The Asteroids



- Mostly between the orbits of Mars and Jupiter
- Rocky debris left over from the formation of the solar system
- Some of the most ancient rocks in the solar system
- They hold the key to understanding its formation

Feb 23, 2005

Astronomy 210 Spring 2005





Hollywood's View of the Asteroid Belt

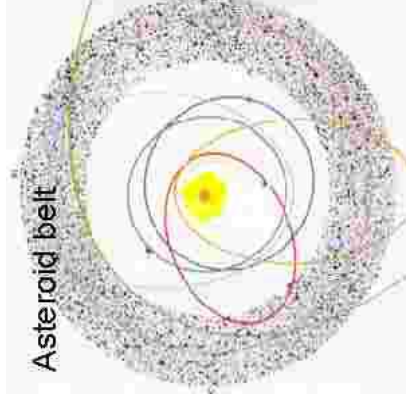
Astronomy 210 Spring 2005

Feb 23, 2005



Thousands of
asteroids ...

On average, about
a million miles
apart!



500 million miles

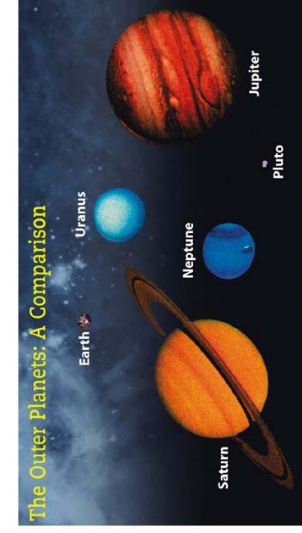
Scientific View of the Asteroid Belt

Astronomy 210 Spring 2005

Feb 23, 2005



The Outer Planets



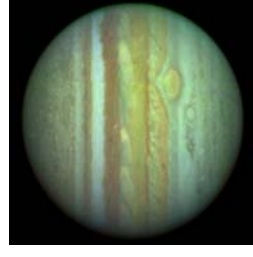
- You've probably heard the outer planets referred to as a single group
 - The Jovians
 - The Gas Giants
- However, Jupiter and Saturn are very different worlds than Uranus and Neptune
- We will consider them as two groups

Astronomy 210 Spring 2005

Feb 23, 2005



The Jovians



- Jupiter and Saturn are very similar planets
- Both are immense planets, 100-300 times the mass of the Earth
 - But, they are composed mainly of the lightest stuff in the Universe, hydrogen and helium
- We can only see the upper cloud layers, no "surface"
- Mostly made of *liquid* hydrogen

Astronomy 210 Spring 2005

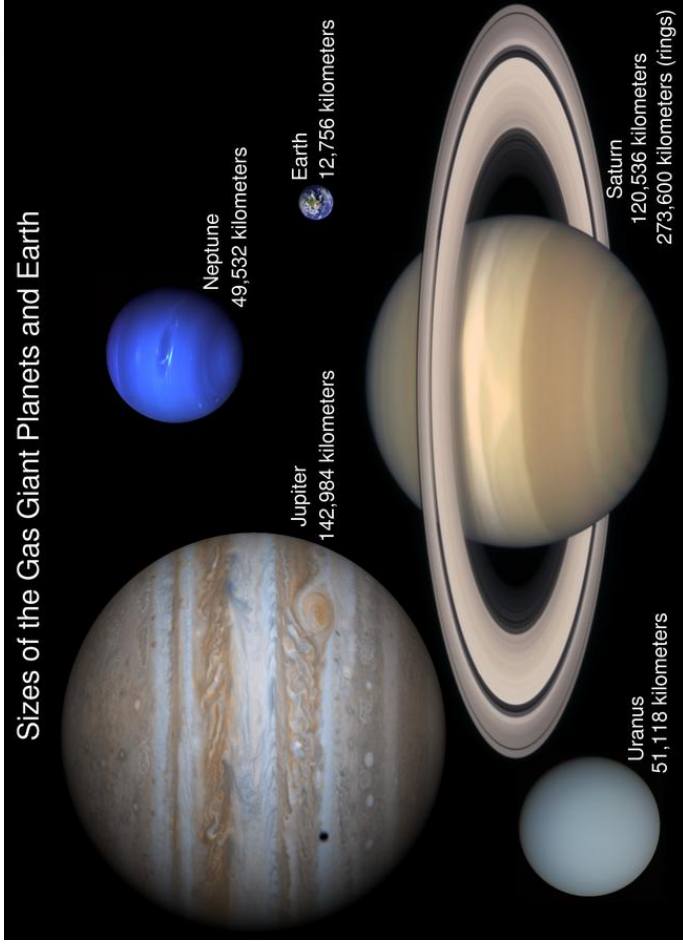
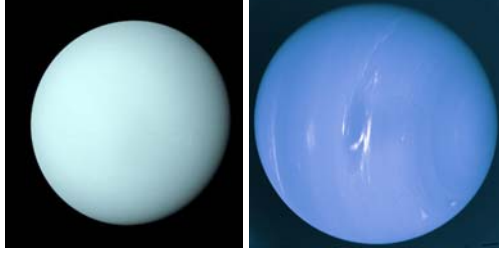
Feb 23, 2005

The Neptunians

- Uranus and Neptune are very similar to each other
- Have extremely large quantities of *water*
 - In addition to hydrogen and helium
 - Makes them a bit more compact than Jupiter and Saturn
- Blue tint comes from methane in the atmosphere

Feb 23, 2005

Astronomy 210 Spring 2005

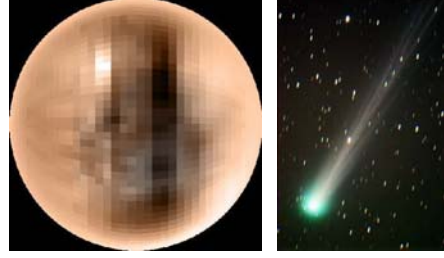


The Outer Reaches

- Beyond the orbit of Neptune lie countless bodies of rock & ice
- Pluto is the largest of these bodies
 - Not a rocky planet
 - Not an ice giant

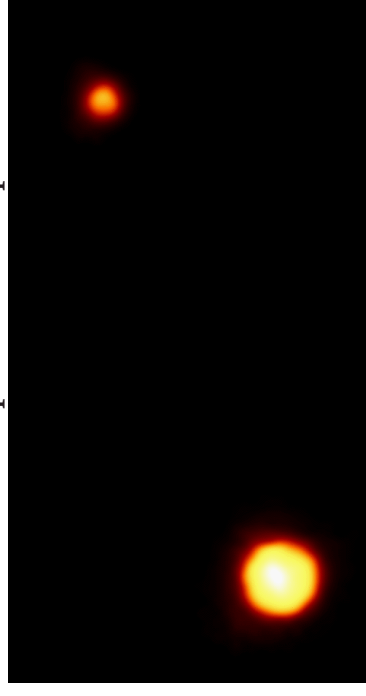
Feb 23, 2005

Astronomy 210 Spring 2005



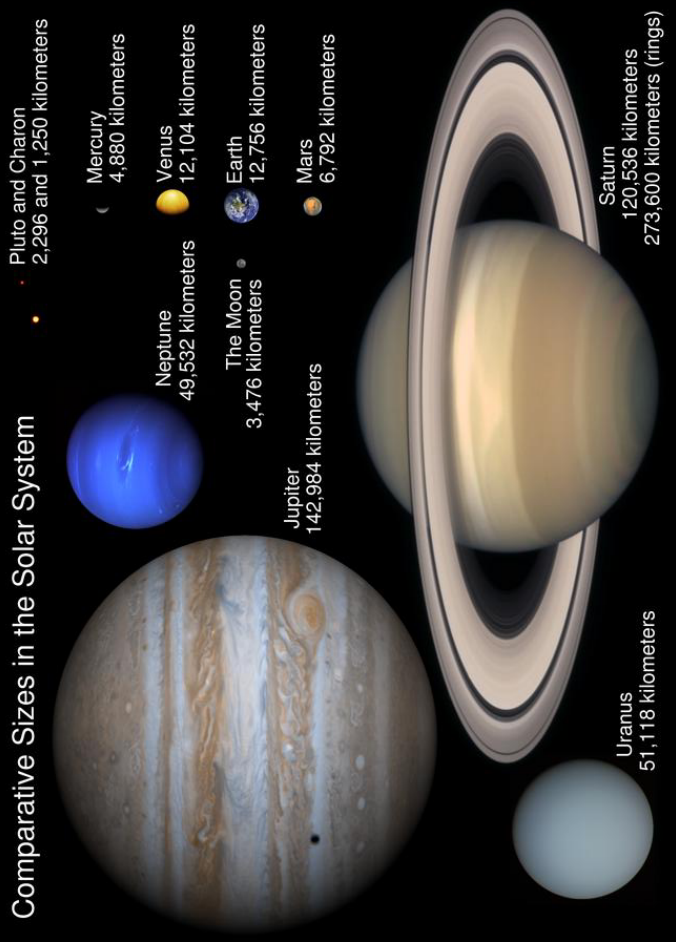
First Pictures of Pluto/Charon

- 1995 – Hubble Space Telescope infrared
- 1996 – Hubble Space Telescope visible



Feb 23, 2005

Astronomy 210 Spring 2005



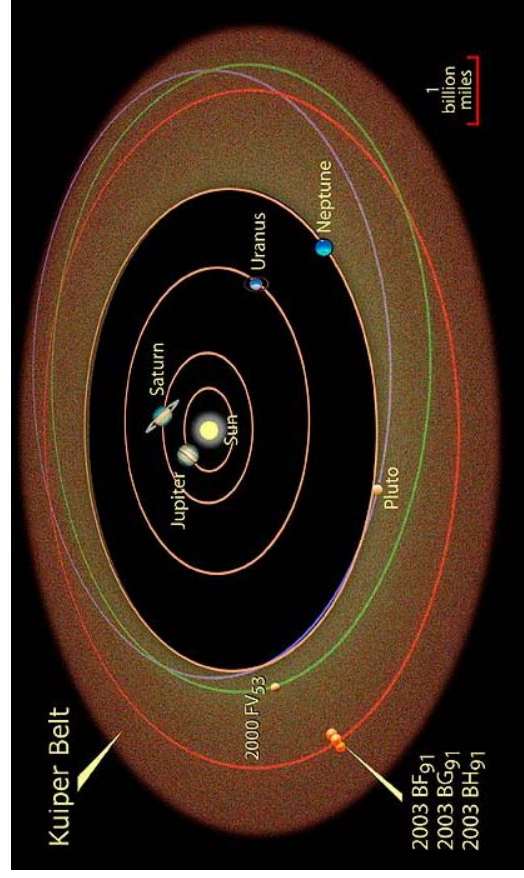
Do we know of all of the Bodies in our Solar System?

- **No.** Even at in the 21st century, we are still discovering new comets, or large asteroids, or even large planet-like objects?

Feb 23, 2005
Astronomy 210 Spring 2005



The Kuiper Belt



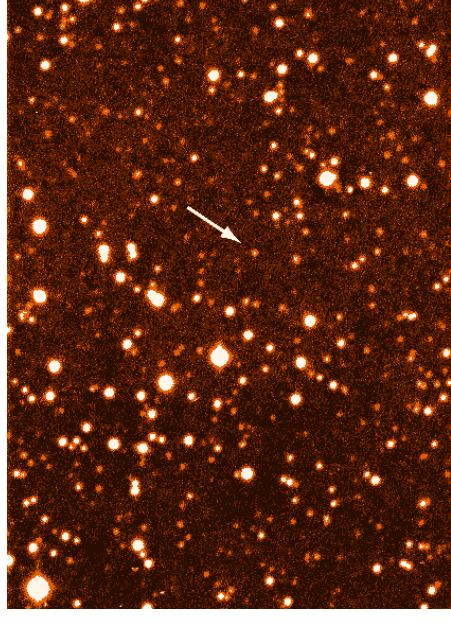
Astronomy 210 Spring 2005

Feb 23, 2005



New Data-- Kuiper Object Quaoar : Found 2002

- Most recent and BIGGEST discovered yet
- pronounced kwa-whar
- diameter of about 800 miles (half of Pluto)
- 42 AU orbit

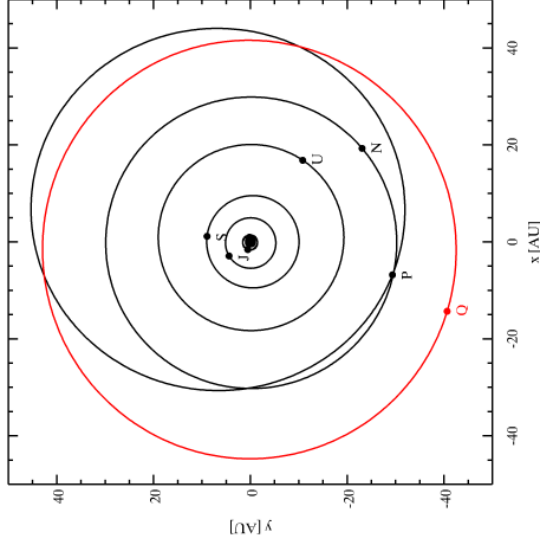


Astronomy 210 Spring 2005

Feb 23, 2005

<http://antwip.gsfc.nasa.gov/apod/ap021005.html>

Quaoar Orbit



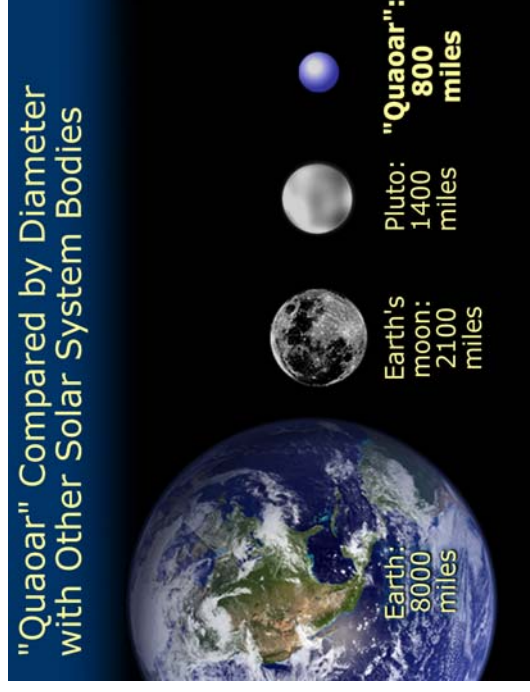
<http://www.gps.caltech.edu/~chad/quaoar/>

Astronomy 210 Spring 2005

Feb 23, 2005



Quaoar Comparison

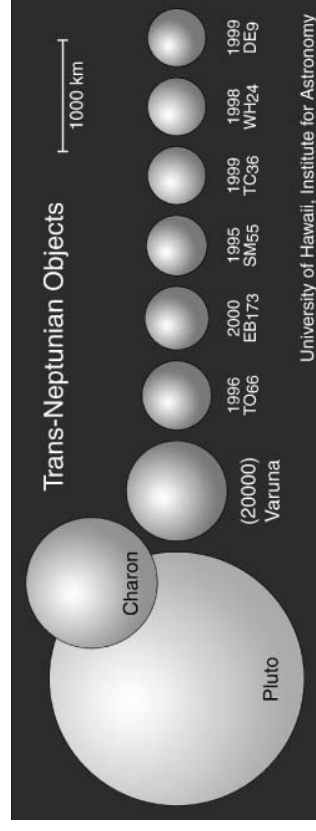


Astronomy 210 Spring 2005

Feb 23, 2005

Large KBOs

- Pluto still larger, but not by that much
- Note: plot below doesn't include Quaoar



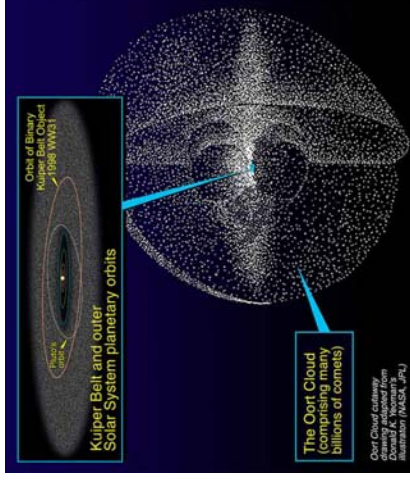
Astronomy 210 Spring 2005

Feb 23, 2005

Oort Cloud



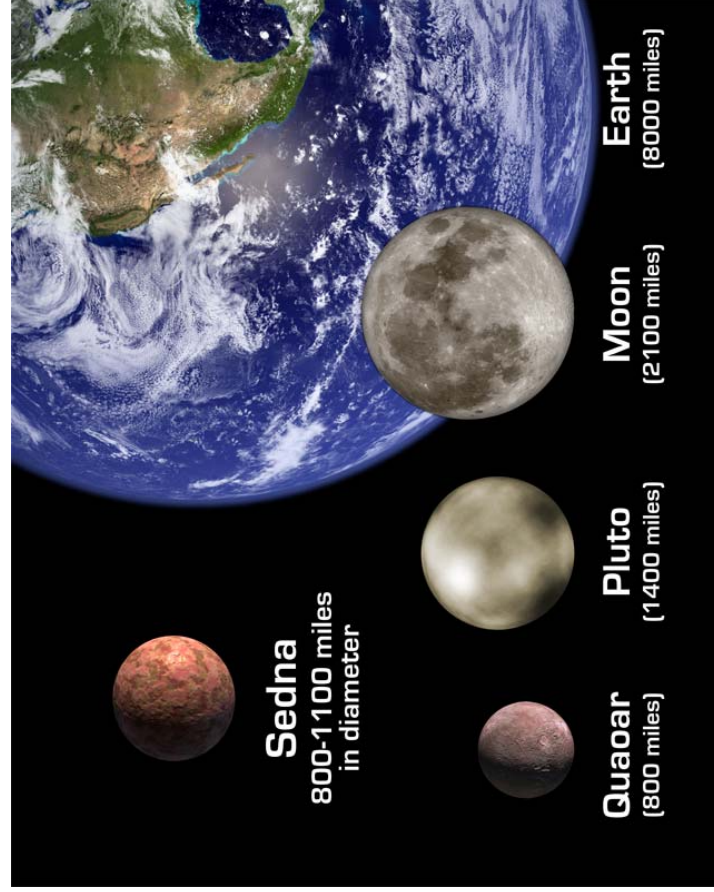
- Billions of icy minor planets – comet nuclei
- Roughly spherical out to 50,000 AU
- Predicted by Jan Oort
- Explains long-period comets
- No observations to date. Or is there?



<http://www.solarviews.com/browse/comet/kuiper3.jpg>

Astronomy 210 Spring 2005

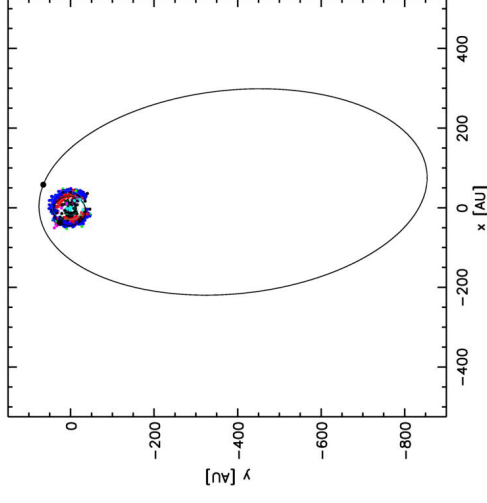
Feb 23, 2005



Sedna – the Inner Oort Cloud?



- Orbit 76 – 840 AU
 - outside Kuiper Belt
 - inside Oort Cloud
- Very red color
- Slow rotation



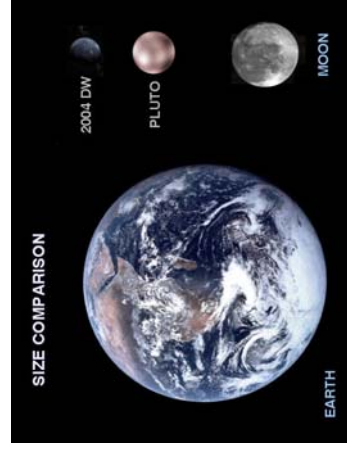
Astronomy 210 Spring 2005

Feb 23, 2005

Black Sheep of the Planets



- Pluto is the oddball
 - Size
 - Companion
 - Composition
 - Orbit
- Pluto/Charon as double ice planet?



Astronomy 210 Spring 2005

Feb 23, 2005

What is Pluto?



- You make the call
 - Singular ice planet
 - Mutant giant double comet
 - King of the Kuiper Belt
 - ???

Feb 23, 2005

Astronomy 210 Spring 2005

IAU Official Position



- IAU defines Pluto to be a planet
- IAU cannot define “planet”
 - Upper limit: not massive enough to produce any form of fusion at its core
 - Deuterium fusion occurs for objects about 15 times Jupiter’s mass
 - No lower limit specified
- Reasonable lower limit?
 - Massive enough for gravity to make it spherical
 - At least 14 planets
 - No reasonable definition produces 9 planets

Feb 23, 2005

Astronomy 210 Spring 2005