



- Homework #2 was due today at 11:50am! It's too late now.
- Planetarium observing is over.
- Solar observing is over.
- Nighttime observing starts next week.

Sept 19, 2003

Astronomy 100 Fall 2003



Outline

- Switch Gears– Solar System Introduction
- The Planets, the Asteroid belt, the Kuiper objects, and the Oort cloud objects.

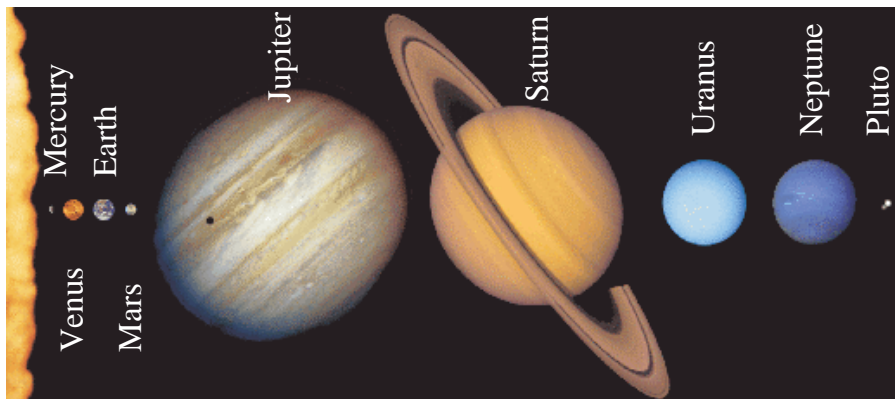
Sept 19, 2003

Astronomy 100 Fall 2003

Question of Scale



- Images of all planets (from space missions), with the correct scaling.



<http://www.jpl.nasa.gov/galileo/sepo/education/nav/ss2.gif>

Sept 19, 2003

Astronomy 100 Fall 2003



Planets Dance

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

Sept 19, 2003

Astronomy 100 Fall 2003

Facts of the Solar System



- Mass of solar system: yes, mostly in the sun, but outer planets more massive than inner
- Orbital motions in solar system are counter clockwise in a flattened system (disk)
- Orbits are actually close to circles, except Mercury and Pluto
- Chemical analysis of meteorites shows condensation sequence– variation of composition with distance from Sun

Sept 19, 2003

Astronomy 100 Fall 2003

What's this Picture of?



Sept 19, 2003

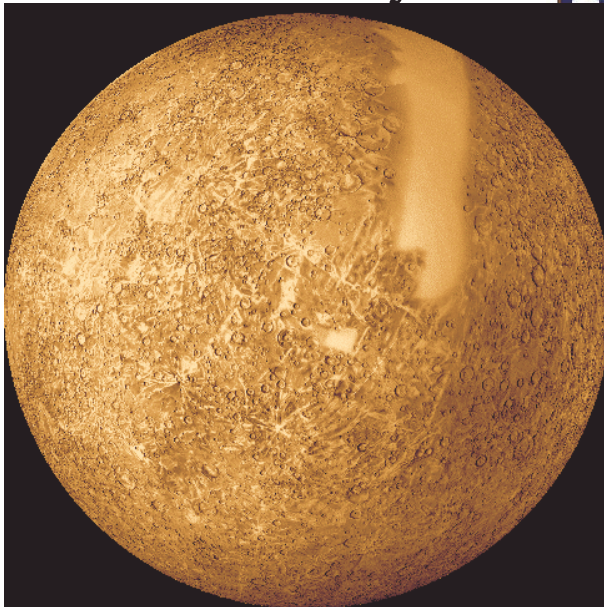
Astronomy 100 Fall 2003

<http://www.whfreeman.com/discovering/DTU/EXMOD36/F3609.HTM>

Inner Planets: Mercury



- Closest planet to Sun– 0.38 AU.
- Similar to Moon– smaller than Ganymede or Titan.
- Reaches its greatest angular separation from the Sun on Sept. 27th (rises 1 hr 20 mins before the Sun) easily visible at pre-dawn sky. Look for it below Jupiter.



Sept 19, 2003

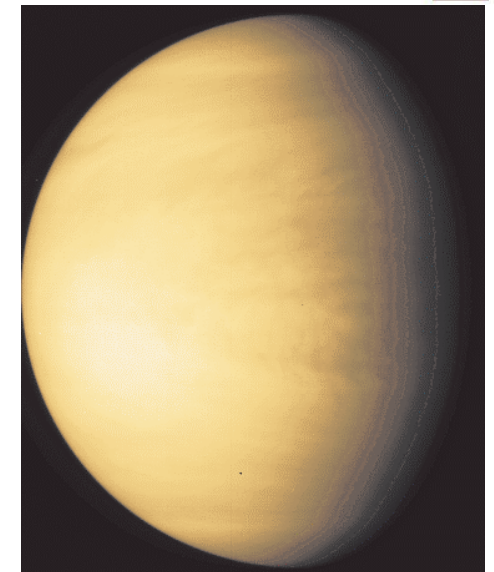
Astronomy 100 Fall 2003

<http://www.jb.man.ac.uk/public/nightsky.html>

Inner Planets: Venus



- 0.72 AU from Sun
- Similar in size and mass to Earth.
- Thick clouds make it the hottest planet.
- Often called the morning star or the evening star. 3rd brightest object in the sky.

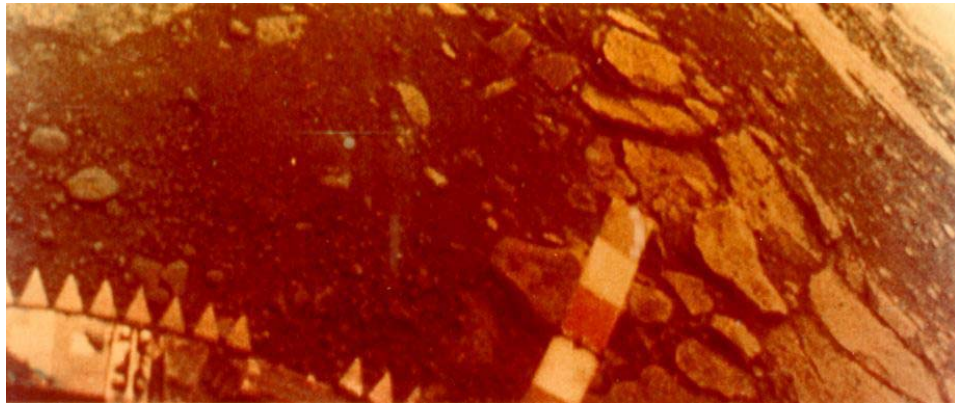


Sept 19, 2003

Astronomy 100 Fall 2003

<http://antwrp.gsfc.nasa.gov/apod/ap960923.html>

Inner Planets: Surface of Venus

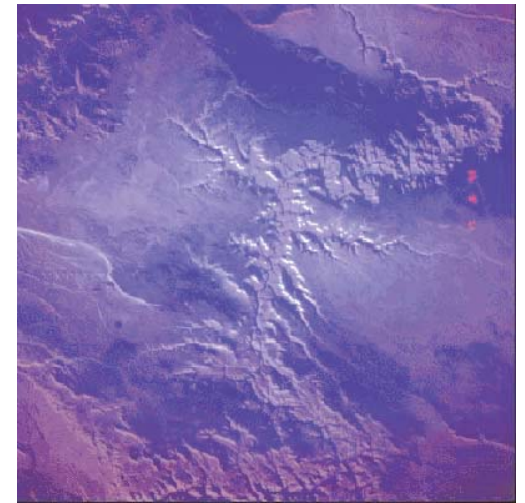


Sept 19, 2003

Astronomy 100 Fall 2003

http://nssdc.gsfc.nasa.gov/photo_gallery/photogallery-venus.html

Inner Planets: Earth as a Planet



Sept 19, 2003

Astronomy 100 Fall 2003

<http://pds.jpl.nasa.gov/planets/choices/earth1.htm>

Inner Planets: Mars



- 1.52 AU from Sun
- Only planet whose surface features can be seen from Earth-based telescopes.
- Some surface features seen from spacecraft suggest that there was once flowing water on Mars.

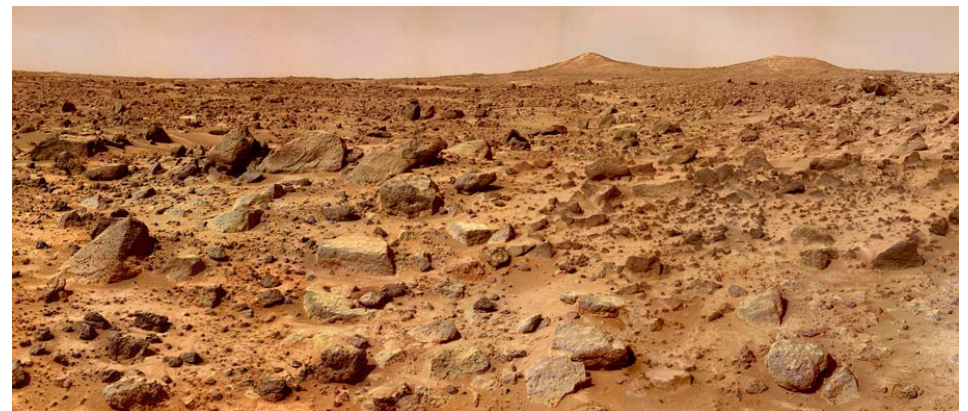


Sept 19, 2003

Astronomy 100 Fall 2003

<http://www.seds.org/nineplanets/nineplanets/mars.html>

Mars: Surface

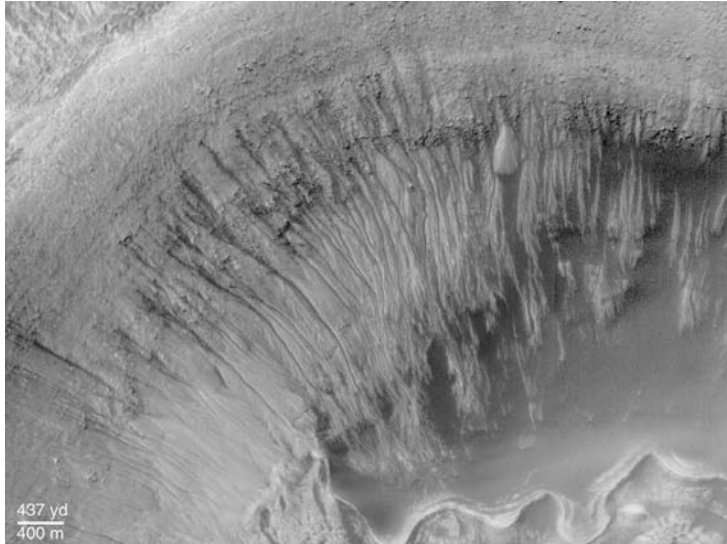


Sept 19, 2003

Astronomy 100 Fall 2003

<http://www.grc.nasa.gov/WWW/PAO/html/marspath.htm>

Mars: Surface— Evidence for Water



Sept 19, 2003

Astronomy 100 Fall 2003

http://antwrp.gsfc.nasa.gov/apod/image/0006/marsnewton_mgs_big.jpg

Mars: Olympus Mons



- The largest mountain in the Solar System rising 24 km (78,000 ft.).



- Its base is more than 500 km in diameter and is rimmed by a cliff 6 km (20,000 ft) high (right).

Sept 19, 2003

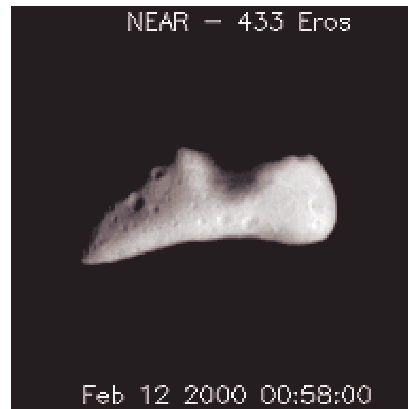
Astronomy 100 Fall 2003

<http://hyperphysics.phy-astr.gsu.edu/hbase/solar/marsoly.html>

Junk? Asteroids-- Eros



- Between Mars and Jupiter, there are millions of asteroids ranging in size from dust to 900 km in size.
- Eros is actually labeled a near-Earth asteroid, as its orbit brings it close to Earth. 33 x 13 x 13 km in size.
- Semimajor Axis: 1.458 AU



Sept 19, 2003

Astronomy 100 Fall 2003

<http://near.jhuapl.edu/iod/20000222/index.html>

Jupiter— Big Boy



- 5.2 AU from Sun
- By far the largest and most massive planet.
- No solid surface. The gas just gets denser as we get deeper.
- 90% Hydrogen and 10% Helium with traces— like the early solar system.
- Has 61 known moons.



Sept 19, 2003

Astronomy 100 Fall 2003

<http://www.ast.cam.ac.uk/hubblepics/>

Jupiter



<http://www.solarviews.com/raw/jup/vjupitr5.mpg>

<http://www.solarviews.com/raw/jup/vjupitr2.mov>

Sept 19, 2003

Astronomy 100 Fall 2003

Outer Planets: Saturn



- 9.54 AU from Sun
- The Lord of the Rings
- Ring has gaps
- Only planet less dense than water
- Broad atmosphere banding is similar to Jupiter
- <http://www.solarviews.com/raw/sat/vsaturn1.mpg>
- <http://www.solarviews.com/raw/sat/spoke.mov>



Sept 19, 2003

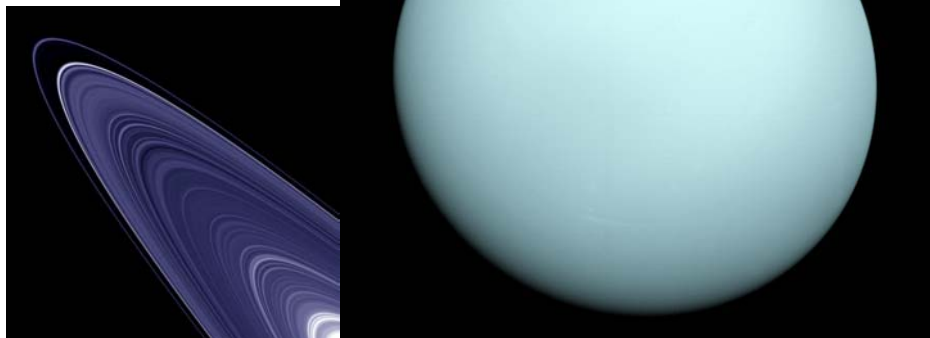
Astronomy 100 Fall 2003

<http://www.solarviews.com/cap/sat/saturn.htm>

Outer Planets: Uranus



- 19.2 AU from Sun
- In 1777 the rings of Uranus were discovered.
- Tilted axis of rotation (98 degrees)



Sept 19, 2003

Astronomy 100 Fall 2003

<http://www.solarviews.com/eng/uranus.htm>

Outer Planets: Neptune



- 30.06 AU from Sun
- Outermost Gas Giant
- Methane gives it the blue color
- Has the fastest record wind speed of 2000 km/hr.
- Also has a faint ring system
- Seasons last 40 years!



Sept 19, 2003

Astronomy 100 Fall 2003

<http://www.solarviews.com/cap/nep/neptunes.htm>

Outer Planets: Neptune



<http://www.solarviews.com/raw/nep/vneptune.mov>

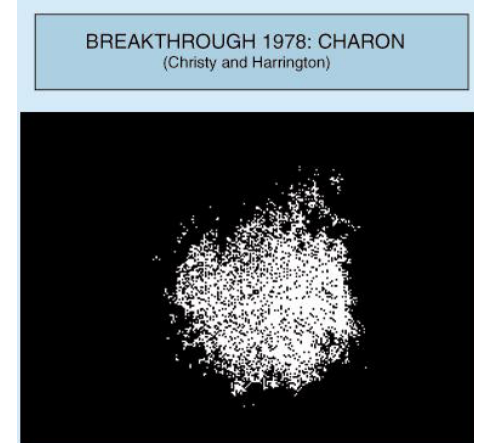
Sept 19, 2003

Astronomy 100 Fall 2003

Pluto



- 39.53 AU from Sun
- Discovered in 1930 by telescope in AZ.
- A blob was noticed in 1978 that circled Pluto every 6 days. It proved that Pluto had a moon. Later named Charon.



Sept 19, 2003

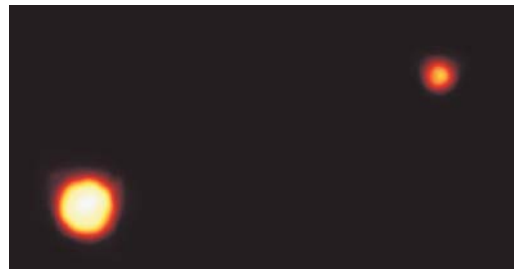
Astronomy 100 Fall 2003

<http://www.solarviews.com/cap/pluto/hstpluto.htm>

Pluto



- The only planet not yet visited by a spacecraft
- Has tilted and very eccentric orbit
- Moon Charon and Pluto always face each other
- Gravity pull is only 8% of Earth's.
- Smallest Planet? Or not?



Sept 19, 2003

Astronomy 100 Fall 2003

<http://www.solarviews.com/cap/pluto/hstpluto.htm>

Pluto



<http://www.solarviews.com/raw/pluto/vpluchar.mpg>

Sept 19, 2003

Astronomy 100 Fall 2003

The Structure of the Solar System



- What are the furthestmost solar system objects from the sun?
 - icy objects/comets

Furthermost objects form the Oort cloud

Sept 19, 2003

Astronomy 100 Fall 2003

Outer: Comets



- Beyond orbit of Pluto, there are hundreds of billions of comets. Many of these are in a flat disk-like structure called the Kuiper belt. But more are in a spherical cloud further out called the Oort cloud.

Sept 19, 2003

Astronomy 100 Fall 2003

Space Junk? Comets



Sept 19, 2003

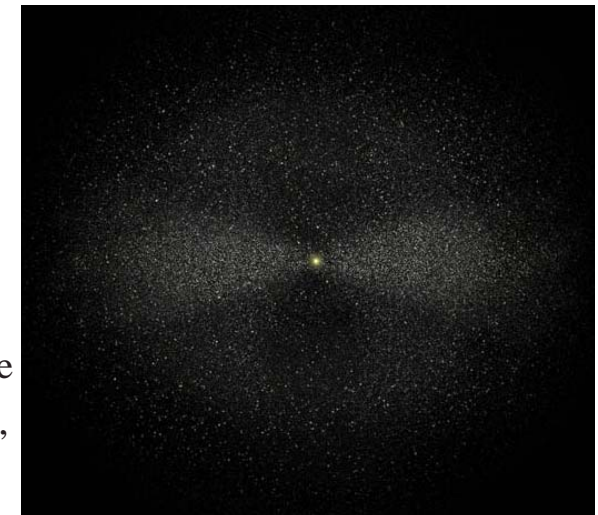
Astronomy 100 Fall 2003

<http://www.jpl.nasa.gov/comet/gif/pach15.jpg>

Oort Cloud



- Most comets located in the outer solar system
- Source of long term comets
- 100000 AU outward
- Edge of Sun's gravitational influence
- Spherical distribution, not only in ecliptic



Sept 19, 2003

Astronomy 100 Fall 2003

<http://www.etsimo.uniovi.es/solar/cap/comet/oort.htm>

Example



Passing star perturbs Oort cloud

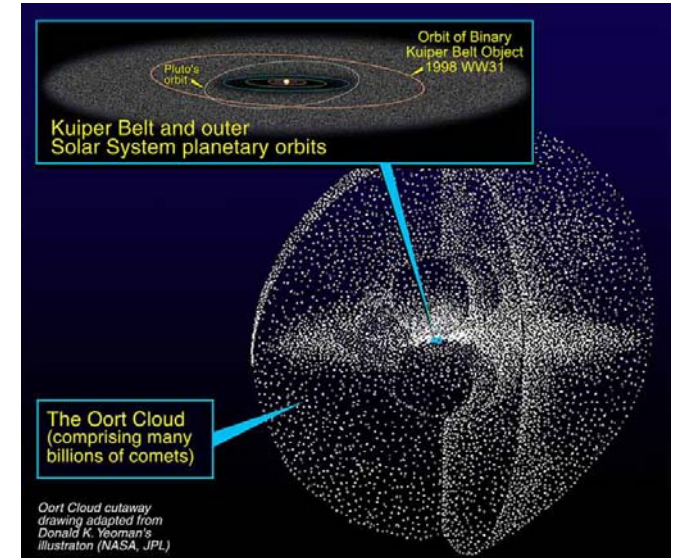
Sept 19, 2003

Astronomy 100 Fall 2003

Kuiper Belt



- Source of short term comets
- Doughnut-like in ecliptic plane
- 30-100 AU
- Can detect these objects!



Sept 19, 2003

Astronomy 100 Fall 2003

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



- No. Even at this age, we are still discovering new comets, or large asteroids, or even?

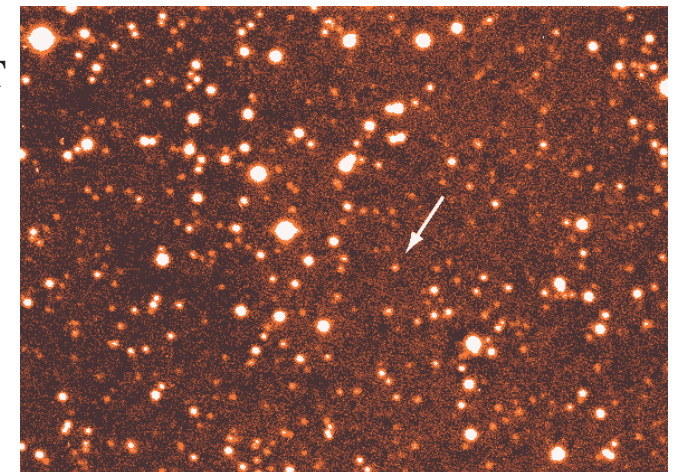
Sept 19, 2003

Astronomy 100 Fall 2003

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

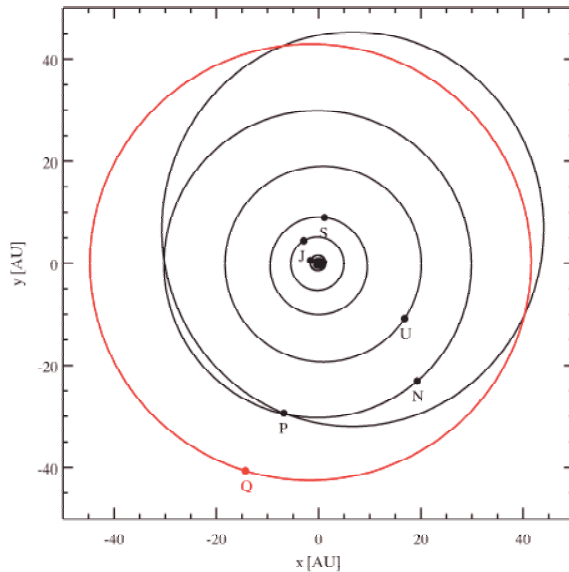


Sept 19, 2003

Astronomy 100 Fall 2003

<http://antwrp.gsfc.nasa.gov/apod/ap021009.html>

Quaoar Orbit

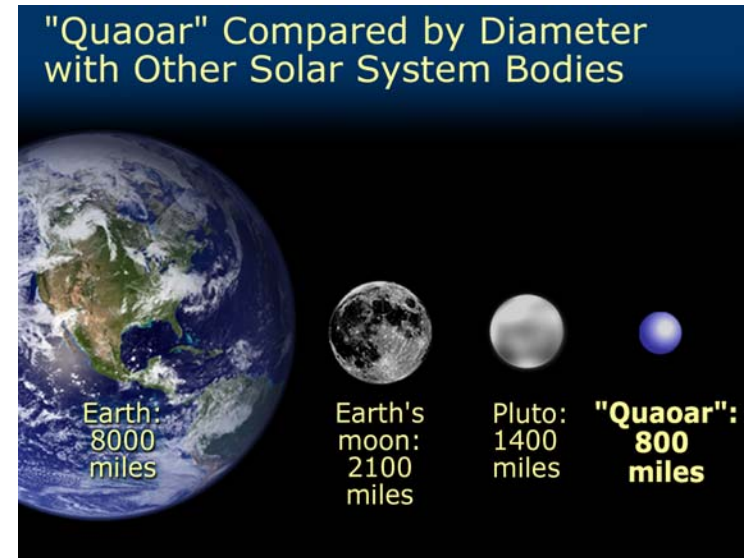


Sept 19, 2003

Astronomy 100 Fall 2003

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

Quaoar Comparison



Sept 19, 2003

Astronomy 100 Fall 2003

Or Huya (Venezuelan Rain God)



- Discovered in March 2000, but only recently named.
- About 600 km in diameter (1/4 that of Pluto)
- 256 years to orbit
- Reddish in color
- Semi-major axis of 39 AU

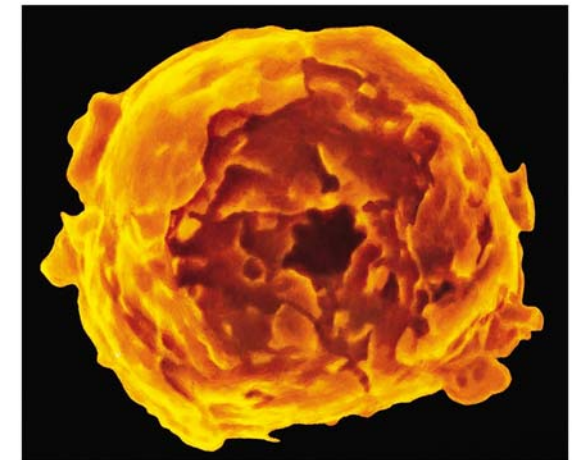
Sept 19, 2003

Astronomy 100 Fall 2003

Lots of Dust



- Interplanetary Dust is abundant and similar in composition to what we see outside of our solar system.
- About 2-20 microns in size— a human hair is 100 microns in diameter



Sept 19, 2003

Astronomy 100 Fall 2003

Planet Comparisons



TABLE II-1 Orbital Characteristics of the Planets

| | Average distance from Sun | | Orbital period (yr) |
|---------|---------------------------|----------------------|------------------------|
| | (AU) | (10 ⁶ km) | |
| Mercury | 0.39 | 58 | 0.24 |
| Venus | 0.72 | 108 | 0.62 |
| Earth | 1.00 | 150 | 1.00 |
| Mars | 1.52 | 228 | 1.88 |
| Jupiter | 5.20 | 778 | 11.86 |
| Saturn | 9.54 | 1427 | 29.46 |
| Uranus | 19.19 | 2871 | 84.01 |
| Neptune | 30.06 | 4497 | 164.79 |
| Pluto | 39.53 | 5914 | 248.54 |

Sept 19, 2003

Astronomy 100 Fall 2003

Planet Comparisons



TABLE II-2 Physical Characteristics of the Planets

| | Diameter | | Mass | | Average density (kg/m ³) |
|---------|----------|-------------|----------------------|-------------|---|
| | (km) | (Earth = 1) | (kg) | (Earth = 1) | |
| Mercury | 4,878 | 0.38 | 3.3×10^{23} | 0.06 | 5430 |
| Venus | 12,100 | 0.95 | 4.9×10^{24} | 0.81 | 5250 |
| Earth | 12,756 | 1.00 | 6.0×10^{24} | 1.00 | 5520 |
| Mars | 6,786 | 0.53 | 6.4×10^{23} | 0.11 | 3950 |
| Jupiter | 142,984 | 11.21 | 1.9×10^{27} | 317.94 | 1330 |
| Saturn | 120,536 | 9.45 | 5.7×10^{26} | 95.18 | 690 |
| Uranus | 51,118 | 4.01 | 8.7×10^{25} | 14.53 | 1290 |
| Neptune | 49,528 | 3.88 | 1.0×10^{26} | 17.14 | 1640 |
| Pluto | 2,300 | 0.18 | 1.3×10^{22} | 0.002 | 2030 |

Sept 19, 2003

Astronomy 100 Fall 2003

Planet Comparisons



- Mercury, Venus, Earth, and Mars are crowded close to the Sun.
- The four large planets– Jupiter, Saturn, Uranus, and Neptune– are widely spaced
- Pluto tends to be in unusual space
- Mostly circular orbits, except Mercury and Pluto
- Orbits all lie in a plane
- Size varies considerably– smallest giant is 4 times larger than Earth, the largest inner planet
- Pluto is smaller than the 7 largest moons
- Gas giants are all massive

Sept 19, 2003

Astronomy 100 Fall 2003

Planet Comparisons



- 4 inner planets have higher average densities
- Gas giants have low density– made from light elements
- Pluto is an oddity– rock and ice
- 3 groups of planets– inner (terrestrial), the gas giants (Jovian), and Pluto
- Only Mercury and Venus do not have moons

Sept 19, 2003

Astronomy 100 Fall 2003

Terrestrial vs. Jovian Planets



| <u>Terrestrial Planets</u> | <u>Jovian Planets</u> |
|--|--|
| Small size, low mass | Large and massive |
| Dense, rocky solid surfaces | Low density, huge gaseous atmospheres |
| Close to the Sun (within 1.5 AU) | Farther away (from 5.2 to 30 AU) |
| Heavy gas atmospheres (N ₂ , O ₂ , CO ₂) | Lighter elements, H and He |
| Slow rotators | Faster rotators, differential rotation |
| Few satellites (3) | Many moons (over 60) |
| Weak magnetic fields | Strong magnetic fields |
| No ring system | Planetary rings |

Sept 19, 2003

Astronomy 100 Fall 2003

What is Stuff?



- One of the biggest questions has been: What is stuff made out of?
- We know that things can be broken into small bits that defines the stuff– Atoms.

Sept 19, 2003

Astronomy 100 Fall 2003

Atoms In Perspective



- Imagine yourself on a beach. You see the smallest grain of sand that you can find– stuck between your toes. How many atoms does it have? More than...
1. All the people in this room?
 2. All the people in the Memorial Stadium during a Football game.
 3. The population of Chicago.
 4. The population of the World.

Sept 19, 2003

Astronomy 100 Fall 2003