Class Announcements

- Please fill out an evaluation for this class.
- If you release your name I'll give you quiz credit.

Will you read Chap 32 before Wed. class?

a) Yes
b) No

Objectives for today

- Know the basic structure of the solar system and how it formed
- Differentiate between the different types of planets
- Understand how we determine distance on astronomical scales
- Compare Earth to other planets

Solar System

- Our solar system is incredibly small compared to the galaxy in which we live
One star among billions

- The Sun is just one small star out of about 400 billion stars in our galaxy – the Milkyway.

Where are we in the Milkyway?

1. ~400 billion stars
2. Diameter = 100,000 light years
3. Almost all objects visible at night with naked eye are in our own galaxy

Nearby galaxies

- We estimate that there are a few hundred billion galaxies that we can visually see from Earth
- In reality the total number of galaxies in the universe is probably more like trillions

HST Deep Field

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The Solar System: 3 Kinds of Worlds

1. Terrestrial Planets
   - High Density
   - Rocky Surfaces
   - Thin Atmospheres
2. Jovian Planets
   - Low Density
   - Gaseous atmospheres with possible solid interiors
   - Thick Atmospheres
3. Ice Dwarfs
   - Intermediate Density
   - Icy Surfaces
   - Volatile, changing atmosphere
The Terrestrial Planets

The Jovian Planets

The interior of the Jovian Planets

Kuiper Belt

There are over a thousand known ice/rock bodies out by Pluto in what we call the Kuiper Belt.

Pluto and a few of the Ice Dwarfs

Pluto was demoted because we didn’t want to have to make all these objects new planets!

Science in action – we define things based on what we observe, regardless of tradition.

How did the Solar System Form?

1. Cloud of gas and dust collapses
2. Angular momentum forms a disk
3. Dust and ice particles collide and stick forming planets
4. Large planets sweep up H₂ and He
5. Sun blows away the extra gas
Why do we think the Solar System formed this way?
- Through Observation and modeling.
- A good model must explain:
  - The difference between the Jovian and Terrestrial Planets
  - The rotation of the planets and their location in a disk
  - The existence and orbits of asteroids, comets and tiny ice dwarf planets (Pluto)
  - It should also obey all of the known laws of nature…none of our models are quite there yet.

Small rocky bodies colliding
- Form your terrestrial planets and the cores of your giant planets through the collision of small rocks and dust.
- Where the giant planets formed we also had ice to work with.

Temperature Gradient in the Solar Nebula
- Where the terrestrial planets formed only rocks and metals existed as solids. You can’t make planets out of gas.
- The Jovian Planets also had ices that condensed out of their gaseous phase, these planets became larger because with the ices they had more solid materials to work with.
- Once the Jovian Planets were large enough, they could gravitationally capture the hydrogen and helium gases.

Characteristics of Terrestrial Planets
- High density – 3.9 to 5.5 g/cm³
- Layers
  - Silicate crust and mantle
  - Iron core
  - Some have atmospheres
  - Most highly cratered
  - Low numbers of moons

Characteristics of Jovian Planets
- Low density – 0.7 to 1.6 g/cm³
- Layers
  - Gas hydrogen and helium layer
  - Liquid hydrogen and helium layer
  - Ice layer in some (water, methane, nitrogen)
  - Possible solid rock core
- Lots of Moons, some are quite unusual
  - Most have outer layer of ice
  - Exceptions are Io, and maybe Titan

Finding Distances Precisely
- Within the Solar System use Radar Ranging.
  - Radiation from radar travel at the speed of light
  - Measure time from transmission to detection
  - Distance = (speed of light) x (time delay) / 2
- Using communication with space probes we have found distances to all planets but Pluto to within a few meters!
Can you bounce a radio wave off of the sun?

- Yes
- No
- It really doesn’t matter because you couldn’t detect your wave in comparison to all of the EM radiation the sun generates.

**Triangulation**

- Used to find distances to nearest stars.
- Same techniques used in land surveys.
- For astronomy, it builds upon the fact that we know the orbital radius of the earth very precisely.

**Small bodies**

- Meteorite
- Comet
- Asteroid

**Highlands**

- Old, original land.
- Heavily cratered.
- Made of lighter, aluminim-rich anorthosite.
- Much impact breccia from cratering.

**The Moon**

- Three basic types of terrain:
  - Maria
  - Highlands
  - Craters
Maria
- Younger terrain
- Lava flows from ancient impacts.
- Made of heavier mare basalt

Mercury
- Small, cratered like the moon

Venus
- Similar in size to the earth
- Volcanoes and a greenhouse effect make it very hot.
- Sulfuric Acid clouds in a thick CO₂ atmosphere.
- Softer crust, no tectonics. It wrinkles instead of creating boundaries.

Craters

Volcanic Domes (Pancake Structures)

Wrinkled faulting
Shield volcanoes on corona

Volcanic Plains With Lava channels

Folded Mountain Belt

Mars

- Smaller than earth, thin atmosphere of CO₂, huge volcanos, past water erosion.
Jupiter and Saturn are “mini-solar systems”

Jupiter’s moons

- Io and Europa are both relatively active.
- Ganymede, Callisto are dead and frozen.

Io

- Sulfurous active surface

Europa

- Icy, smooth surface.
- Ice “rafts”
  - Moving Ice
Saturn’s Moon Titan

- Thick Hazy Atmosphere. A “hydrological system”..