AST 105
Intro Astronomy
The Solar System
Jovian Systems
Recall…..

**Why only 2 types of planets?**

- **Small Inner Rocky Planets**
- **Giant Outer Gas Planets**
Why Only 2 Types of Planets?

• Cosmic Abundance of Elements
• Temperature Drops Farther from Sun
  - Inside the frost line
    • Small amounts of rock & metal condense & accrete = terrestrial planets
  - Outside the frost line
    • Rocks, metals, AND ices condense
    • Bigger snowballs
    • Giant snowballs have enough gravity to capture H/He = Jovian Planets (gas giants)
# Jovian Planets

<table>
<thead>
<tr>
<th></th>
<th>Distance AU</th>
<th>Mass $E_{Mass}$</th>
<th>Radius $E_{Radii}$</th>
<th>Density $g/cm^3$ (1=water)</th>
<th>Composition (primarily)</th>
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Density of the Jovian Planets

Density (g/cm$^3$)

Jupiter
Saturn
Uranus
Neptune

WHY?

• Why is Jupiter denser than Saturn?
Sizes of Jovian Planets
- Cold Gas Bags

• Adding mass to a jovian planet compresses the underlying gas layers
  - *Like pillows...*

• Adding mass does not make gas planets much bigger - just more compressed
Density of the Jovian Planets

**Why?**
- Jupiter denser than Saturn because its larger mass compresses its gas.
- Uranus & Neptune?

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Why are Uranus/Neptune denser than Saturn?

A. The extra mass of U&N compresses their interior more than Saturn
B. They have a higher percentage of hydrogen compounds
C. Their cores are much larger than Saturn’s
D. They have more hydrogen compounds than Saturn
E. They have a greater ratio of helium to hydrogen than Saturn
Clicker Question

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Density of the Jovian Planets

WHY?

- Jupiter denser because its larger mass compresses H/He gas.
- Uranus & Neptune denser because they have a higher percentage of hydrogen compounds - not more H-compounds but higher percentage!
Over 4000 planets have been detected around other stars - So far, we believe most are gas giants and many are more massive than Jupiter. These massive planets must be...

A. smaller than Jupiter
B. about the same size as Jupiter or slightly larger—but more dense
C. about the same size as Jupiter - but less dense
D. significantly bigger than Jupiter.
E. we have no idea of the size of these extra-solar planets because we can’t see them directly.
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Sizes of Jovian Planets
- Big Gas Bags

- Greater compression is why Jupiter is not much larger than Saturn even though it is three times more massive

- Jovian planets with even more mass are only slightly larger than Jupiter
Rotation and Shape

- J & S rotate every ~10 hours
- U&N rotate every ~15 hours
  - this rapid spin stretches out the planet
What's Inside?

High pressures inside Jupiter cause phase of hydrogen to change with depth.

Hydrogen acts like a metal at great depths because its electrons move freely. But it is NOT SOLID!
Inside the Jovian Planets

- All Jovian planet cores appear to be similar.
  - Rock, Metal, & Hydrogen Compounds
  - About 10x mass of Earth
- U & N captured less material from the Solar nebula.
  - Slower accretion, material more spread out
  - Less amount of gas captured before solar wind cleared nebula
  - Mostly hydrogen compounds (by percentage)
- Only J & S have enough pressure for liquid & metallic H
Inside the Jovian Planets: Heat sources

Unlike terrestrial planets, internal heat is **LARGE**

- Jupiter, Saturn and Neptune give off **more** heat than they receive from the Sun
- More than can be attributed to radioactive decay

**Contribute to convection & weather**
- Great Red Spot on Jupiter, Great White Spot on Saturn, Great Dark Spot on Neptune
Internal energy sources: How do they work?

- **Radioactivity** - Elements breaking down
  - All planets
- **Accretion** - Collisions
  - All planets (early on)
- **Differentiation** - Heavy stuff sinks
  - All planets (early on), Saturn still(?)
- **Contraction** - Entire object shrinks
  - Jupiter & Neptune(?)
Hydrogen compounds form clouds in Jupiter's atmosphere.

Different cloud layers correspond to condensation temps of different hydrogen compounds.
• Hydrogen compounds form clouds in Jovian atmospheres

• Different cloud layers correspond to condensation temps of different hydrogen compounds
Different colors on jovian planets actually show different levels of the atmosphere.
Jupiter as seen from the Cassini satellite.
Why are Neptune and Uranus so blue?

- Methane gas in the upper atmospheres absorbs red light, allowing mostly blue light to penetrate and being reflected off methane clouds.
Clicker Question

Why are Uranus & Neptune bluer than Saturn and Jupiter?

A. Like Earth, their atmospheres scatter blue light more effectively.
B. Their thermal emission appears at shorter wavelengths because they are warmer
C. They contain atoms that give off blue emission lines
D. Their methane atmospheres absorb red light
E. They have thicker atmospheres than Jupiter or Saturn and thus more gas to scatter blue light
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Hubble images of Saturn's aurora (UV)