Assignments

• Read secs. 11.1-11.2 of Ch. 11 (“Our Star”)

• To give more time to focus on MT1 exam:
  • No labs next week
Very Large Array (VLA)
The solar system exhibits clear patterns of composition and motion. These patterns are far more important and interesting than numbers, names, and other trivia.
Relative sizes of planets, sun
Sun

- Over 99.8% of solar system's mass
- Made mostly of H/He gas (plasma)
- Converts 4 million tons of mass into energy each second
What features of our solar system provide clues to how it formed?
Nebular theory for Formation of Solar System
The rotation speed of the cloud from which our solar system formed must have increased as the cloud contracted.
Collisions between particles in the cloud caused it to flatten into a disk.
Collisions between gas particles in a cloud gradually reduce random motions.
Disks Around Other Stars

- Observations of disks around other stars support the nebular hypothesis.
Why are there two major types of planets?

Planets fall into two major categories: Small, rocky terrestrial planets and large, hydrogen-rich jovian planets.

<table>
<thead>
<tr>
<th>Type</th>
<th>Examples</th>
<th>Can condense at temperatures below</th>
<th>Relative abundance (by mass)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen and Helium Gas</td>
<td>hydrogen, helium</td>
<td>do not condense in nebula</td>
<td>98%</td>
</tr>
<tr>
<td>Hydrogen Compounds</td>
<td>water (H₂O), methane (CH₄), ammonia (NH₃)</td>
<td>150 K</td>
<td>1.4%</td>
</tr>
<tr>
<td>Rock</td>
<td>various minerals</td>
<td>500–1300 K</td>
<td>0.4%</td>
</tr>
<tr>
<td>Metals</td>
<td>iron, nickel, aluminum</td>
<td>1000–1600 K</td>
<td>0.2%</td>
</tr>
</tbody>
</table>
As gravity causes the cloud to contract, it heats up.

Conservation of Energy

Collapse of the Solar Nebula

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• Inside the **frost line**: Too hot for hydrogen compounds to form ices

• **Outside the frost line**: Cold enough for ices to form

*Within the solar nebula, 98% of the material is hydrogen and helium gas that doesn’t condense anywhere.*
• Moons of jovian planets form in miniature disks.
Asteroids and Comets

- Leftovers from the accretion process
- Rocky asteroids inside frost line
- Icy comets outside frost line
Heavy Bombardment

- Leftover planetesimals bombarded other objects in the late stages of solar system formation.
Origin of Earth's Water

- Water may have come to Earth by way of icy planetesimals from the outer solar system.
Giant Impact

A Mars-sized planetesimal crashes into the young Earth, shattering both the planetesimal and our planet.

Hours later, our planet is completely molten and rotating very rapidly. Debris splashed out from Earth’s outer layers is now in Earth orbit. Some debris rains back down on Earth, while some will gradually accrete to become the Moon.

Less than a thousand years later, the Moon’s accretion is rapidly nearing its end, and relatively little debris still remains in Earth orbit.

...then accreted into the Moon.
• Review of the nebular theory
Thought Question

How would the solar system be different if the solar nebula had cooled with a temperature half its current value?
A. Jovian planets would have formed closer to the Sun.
B. There would be no asteroids.
C. There would be no comets.
D. Terrestrial planets would be larger.
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Our Oasis in Space
by Stan Owocki
How do we know the age of the solar system?

- We cannot find the age of a planet, but we can find the ages of the rocks that make it up.
- We can determine the age of a rock through careful analysis of the proportions of various atoms and isotopes within it.
Radioactive Decay

- Some isotopes decay into other nuclei.
- A half-life is the time for half the nuclei in a substance to decay.
Thought Question

Suppose you find a rock originally made of potassium-40, half of which decays into argon-40 every 1.25 billion years. You open the rock and find 15 atoms of argon-40 for every atom of potassium-40. How long ago did the rock form?

A. 1.25 billion years ago
B. 2.5 billion years ago
C. 3.75 billion years ago
D. 5 billion years ago
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Dating the Solar System

Age dating of meteorites that are unchanged since they condensed and accreted tells us that the solar system is about 4.6 billion years old.
Dating the Solar System

• Radiometric dating tells us that the oldest moon rocks are 4.4 billion years old.
• The oldest meteorites are 4.55 billion years old.
• Planets probably formed 4.5 billion years ago.