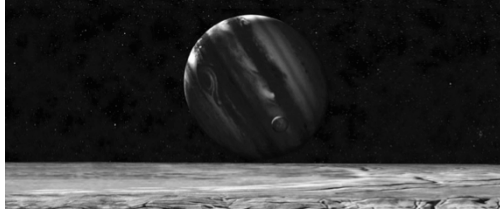


Chapter 11 Jovian Planet Systems



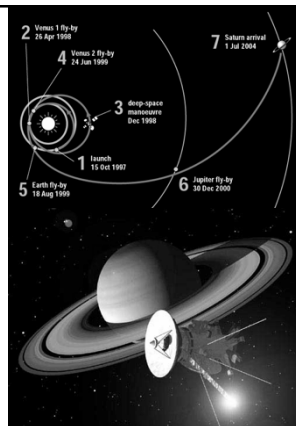
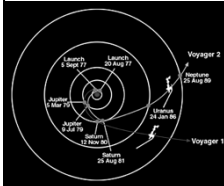
Jovian Planet Interiors and Atmospheres

- How are jovian planets alike?
- What are jovian planets like on the inside?
- What is the weather like on jovian planets?
- Do jovian planets have magnetospheres like Earth's?

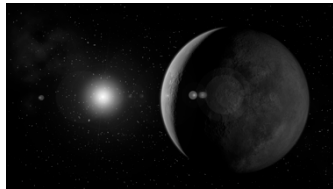
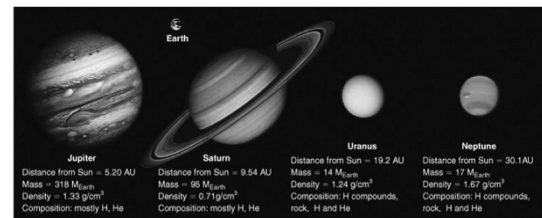
Spacecraft Missions

Cassini (Saturn, 2004:
enter atmosphere 2017)

Voyager 1 and 2
(all four, 1979 -1989);
Galileo (Jupiter, 1995)



Comparing the Jovian Planets

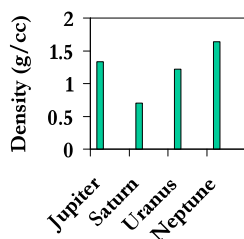


- Possible other planet? Suggested by boundaries of the Kuiper Belt objects and the common orbital properties of several big KBOs
- 10 Earth Mass (smaller than Uranus at 14)
- $a = 700$ AU (20x farther than Neptune)

Jovian Planet Composition

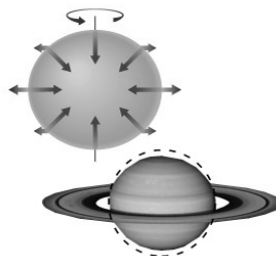
- Reflect conditions of formation in the solar nebula: icy planetessimals in H, He gas
- Jupiter and Saturn
 - Mostly H and He gas surrounding rocky core
- Uranus and Neptune
 - Mostly hydrogen compounds: water (H₂O), methane (CH₄), ammonia (NH₃)
 - Some H, He, and rock

Density Differences



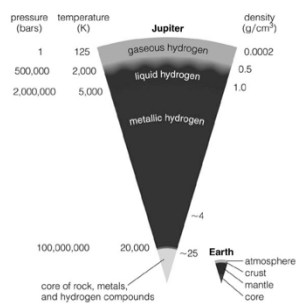
- Uranus and Neptune are denser than Saturn because they have less hydrogen and helium
- Jupiter is denser than expected because outer layers compress interior

Rotation and Shape



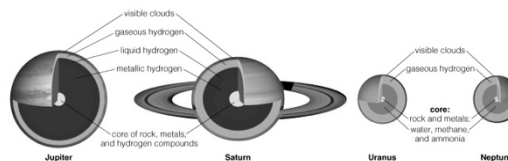
- Jovian planets are flattened because of their rapid rotation (from 10 hours - Jupiter - to 17 hours - Uranus)

Inside Jupiter



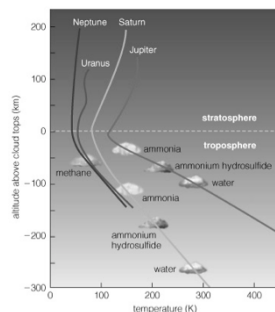
- No solid surface
- High pressures inside Jupiter cause phase of hydrogen to change with depth
- Hydrogen acts like a metal at great depths because its electrons move freely
- Core is about same size as Earth but 10 times as massive

Comparing Jovian Interiors

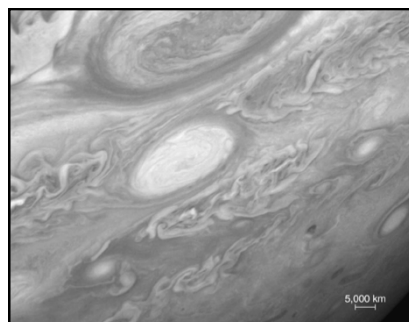


- Models suggest cores of jovian planets have similar composition
- Lower pressures inside Uranus and Neptune mean no metallic hydrogen

Jovian Planet Atmospheres



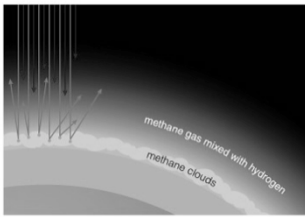
- Different cloud layers correspond to freezing points of different hydrogen compounds
- These compounds make clouds of different colors



Jupiter's colors

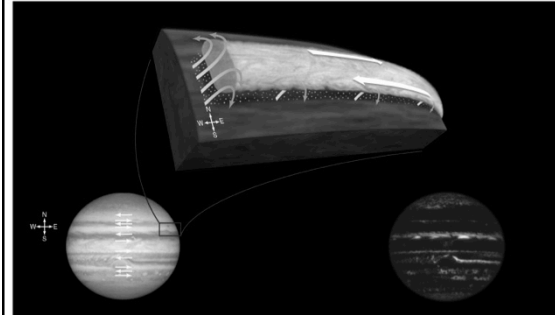
- Ammonium sulfide clouds (NH_4SH) reflect red/brown.
- Ammonia (NH_3), the highest, coldest layer, reflects white.

Methane on Uranus and Neptune

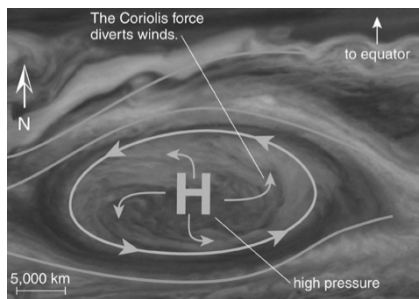


- In very cold gas, methane (CH_4) forms clouds
- Methane gas of Neptune and Uranus absorbs red light but transmit blue light
- Blue light reflects off methane clouds, making planets look blue

Jupiter's Bands



Jupiter's Great Red Spot

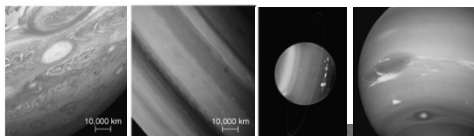


- A storm twice as wide as Earth
- Has existed for at least 3 centuries, but now declining in size

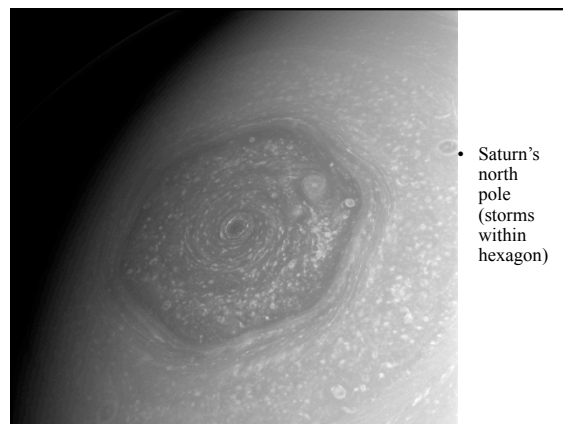
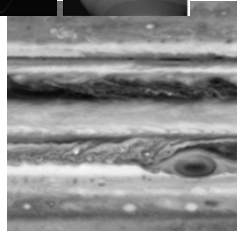
Voyager 1 Approach to Jupiter



Weather on Jovian Planets

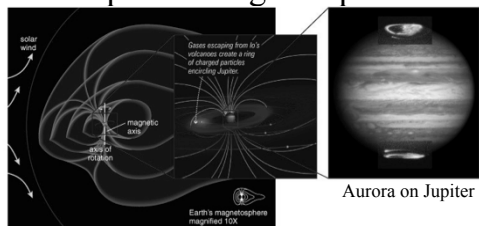


- All the jovian planets have strong winds and storms



- Saturn's north pole (storms within hexagon)

Jupiter's Magnetosphere



- Jupiter's strong magnetic field gives it an enormous magnetosphere (also found in Saturn, Uranus, Neptune)
- Gases escaping Io feed the donut-shaped Io torus

Satellites of Ice and Rock

- What kinds of moons orbit jovian planets?
- Why are Jupiter's Galilean moons so geologically active?
- What is special about Saturn's moon Titan?
- Why are small icy moons more geologically active than small rocky planets?



Medium & Large Moons

- Enough self-gravity to be spherical.
- Have substantial amounts of ice.
- Formed in orbit around jovian planets.
- Circular orbits in same direction as planet rotation.

Small Moons (example: 5 of Saturn's moons)



- Far more numerous than the medium and large moons.
- Not enough gravity to be spherical: "potato-shaped"
- Captured asteroids or comets, so orbits do not follow usual patterns.

Why are Jupiter's Galilean moons so geologically active?

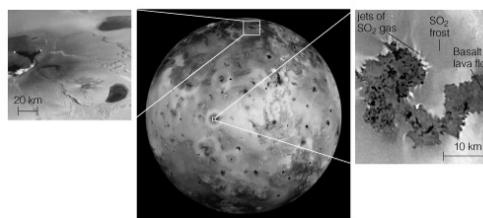


Closest to Jupiter
Youngest surface

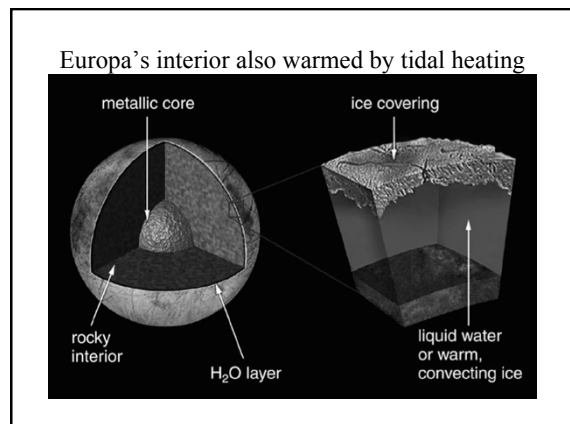
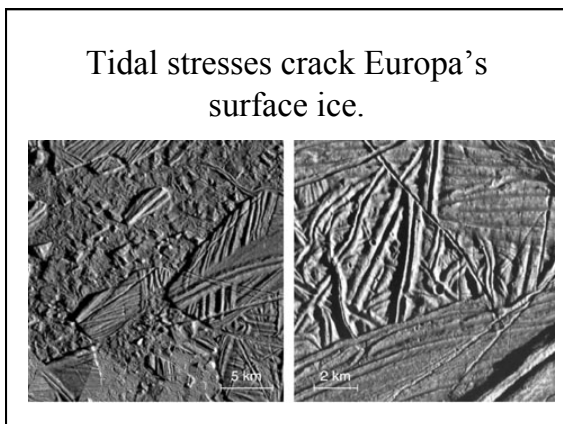
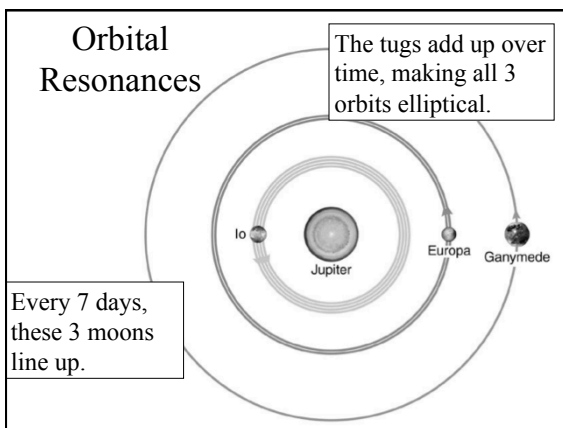
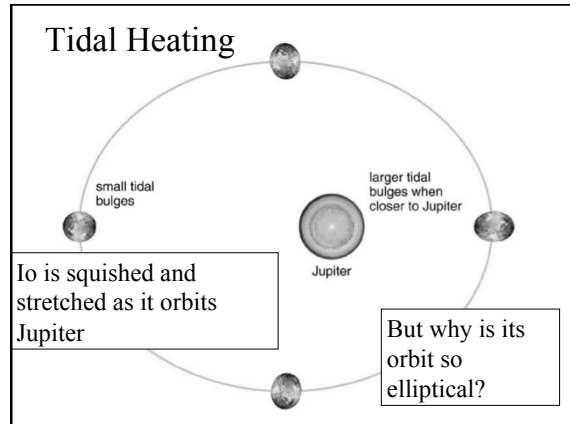
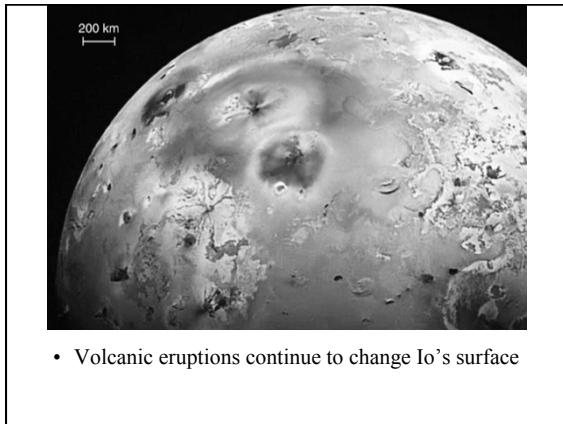
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Farthest from Jupiter
Oldest surface

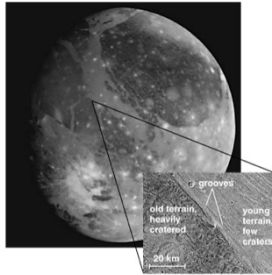
Io's Volcanic Activity



- Io is the most volcanically active body in the solar system

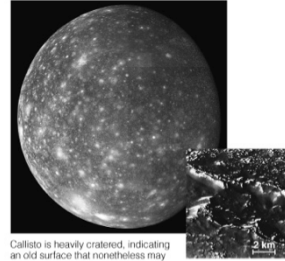


Ganymede



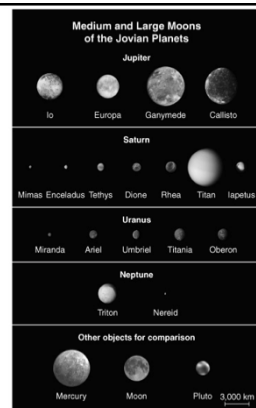
- Largest moon in the solar system
- Clear evidence of geological activity
- Tidal heating plus heat from radioactive decay?

Callisto



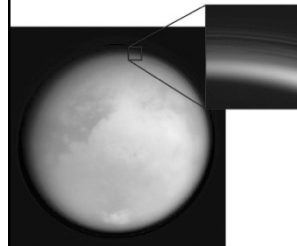
Callisto is heavily cratered, indicating an old surface that nonetheless may hide a deeply buried ocean.

- Cratered iceball with oldest surface (little geological activity)
- No tidal heating, no orbital resonances.



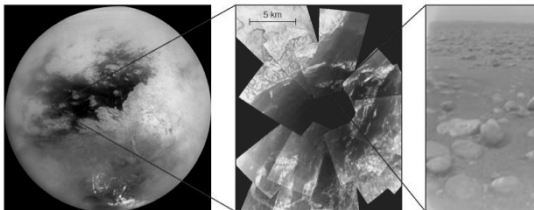
Saturn's Moons
as seen from the
Cassini
Spacecraft
(>53 known)

Titan, Moon with an Atmosphere



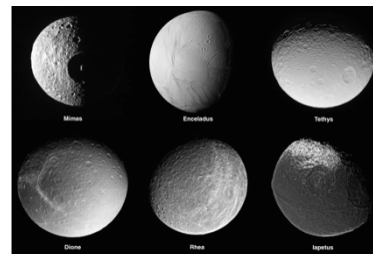
- Titan is the only moon in the solar system to have a thick atmosphere
- It consists mostly of nitrogen with some argon, methane, and ethane

Titan's Surface

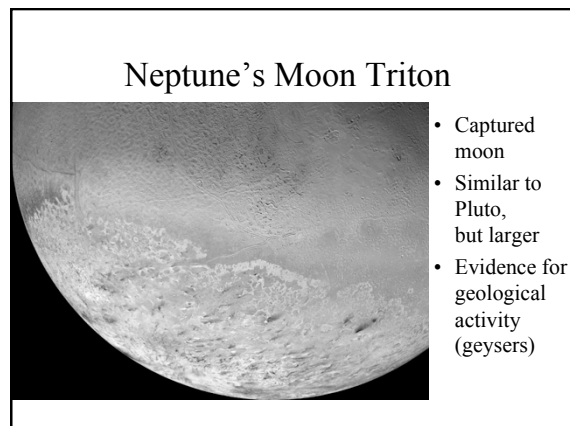
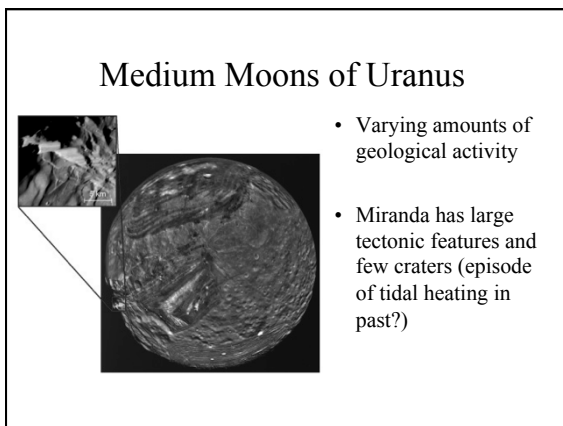
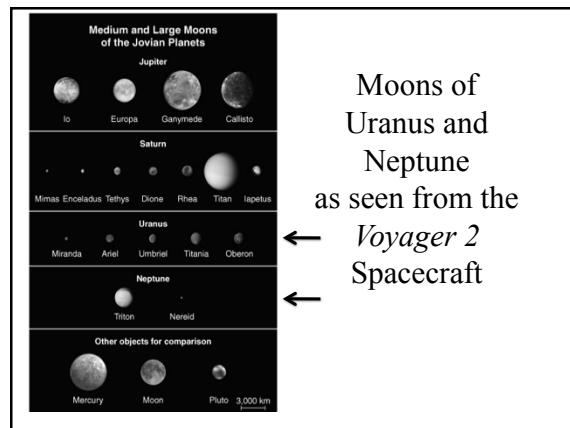
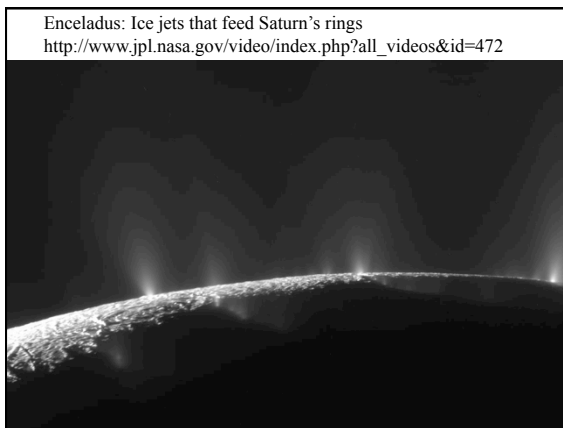
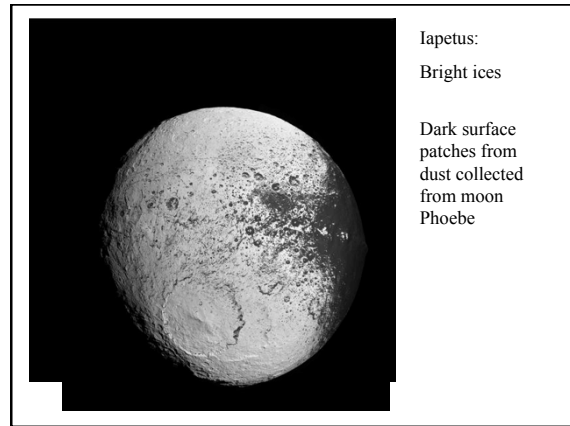
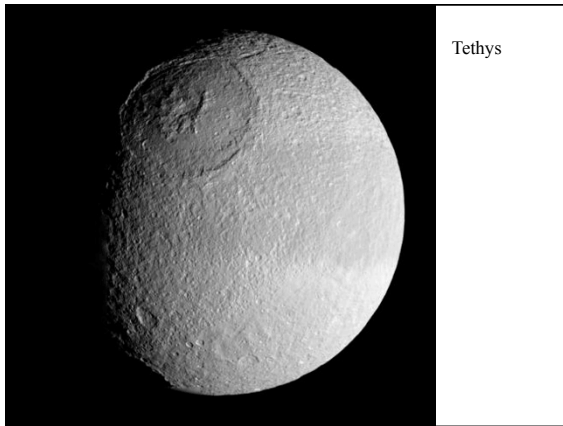


- *Huygens* probe to Titan's surface (2005)
- Movie: <http://www.jpl.nasa.gov/video/index.php?id=487>
- Liquid methane lakes
- <http://saturn.jpl.nasa.gov/multimedia/videos/movies/PIA17656anno-640.mov>

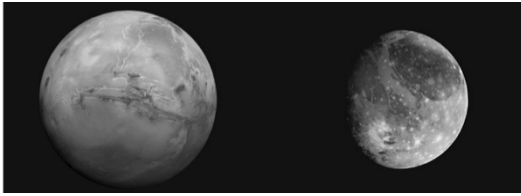
Medium Moons of Saturn



- Almost all show evidence of past volcanism and/or tectonics



Rocky Planets vs. Icy Moons



- Rock melts at higher temperatures
- Only large rocky planets have enough heat for activity
- Ice melts at lower temperatures
- Tidal heating can melt internal ice, driving activity

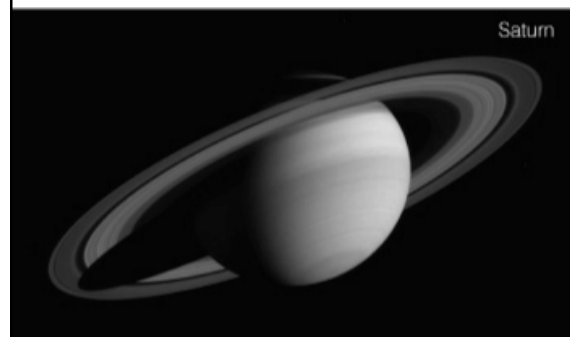
Jovian Planet Rings

- Nature of Saturn's rings
- How do other jovian ring systems compare to Saturn's?
- Why do the jovian planets have rings?

What are Saturn's rings like?

- They are made up of numerous, tiny (microscopic to meter) individual particles of rock and ice
- They orbit over Saturn's equator according to Kepler's Laws (faster closer to Saturn)
- They are very thin (about 30 m)

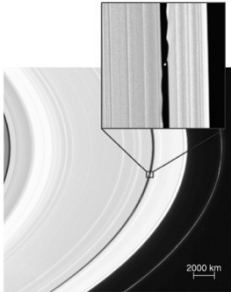
View from *Cassini* Spacecraft



Artist's conception of close-up (see animation)

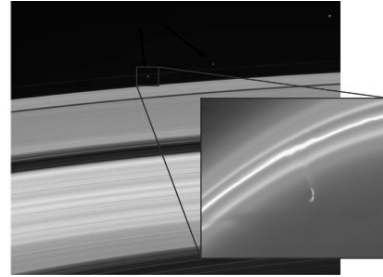


Ring Structure: Gap Moons



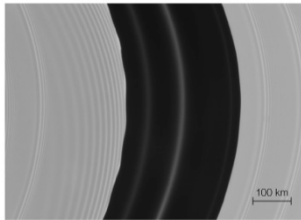
- Some small moons create gaps within rings

Ring Structure: Shepherd Moons



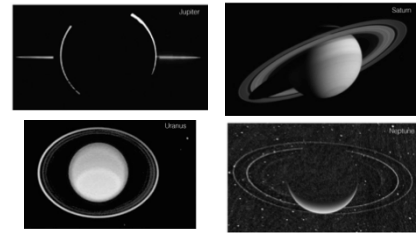
- Pair of small moons can force particles into a narrow ring

Ring Structure: Resonance Gaps



- Orbital resonance with a larger moon can also produce a gap
- Example: Cassini Division occurs where ring particles have half the orbital period of moon Mimas

Other Jovian Ring Systems

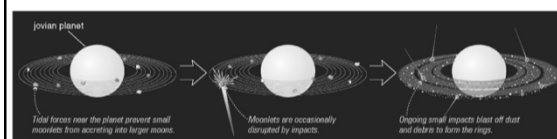


- All four jovian planets have ring systems
- Others have smaller, darker ring particles than Saturn

Why do the jovian planets have rings?

- They formed from ice/ rock/ dust created in impacts on moons orbiting those planets
- Rings aren't leftover from planet formation because the particles are too small to have survived this long.
- There must be a continuous replacement of tiny particles.
- The most likely source is impacts with the jovian moons.

Ring Formation



- Jovian planets all have rings because they possess many small moons close-in
- Impacts on these moons are random
- Saturn's incredible rings may be an "accident" of our time

Next time:

- Chapter 12:
Small Objects in the Solar System
please read pages 340 – 361
in text.