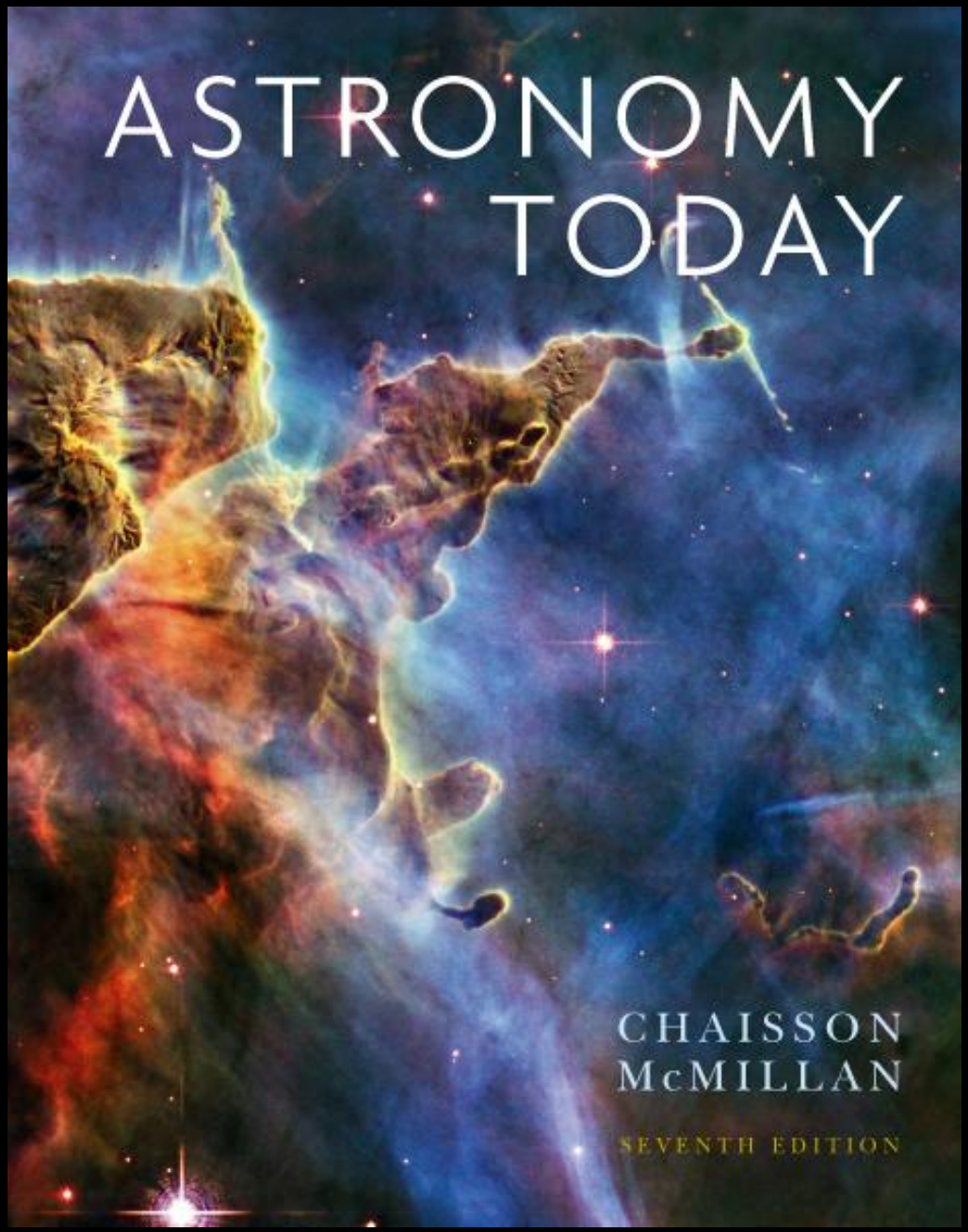


Lecture Outlines

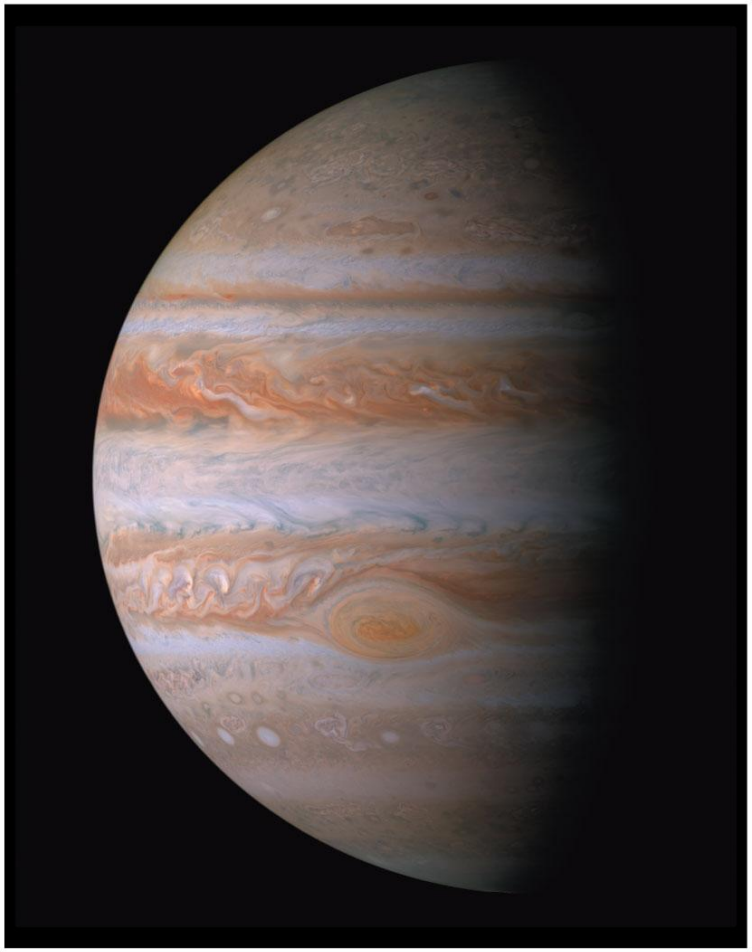
Chapter 11

Astronomy Today

7th Edition

Chaisson/McMillan

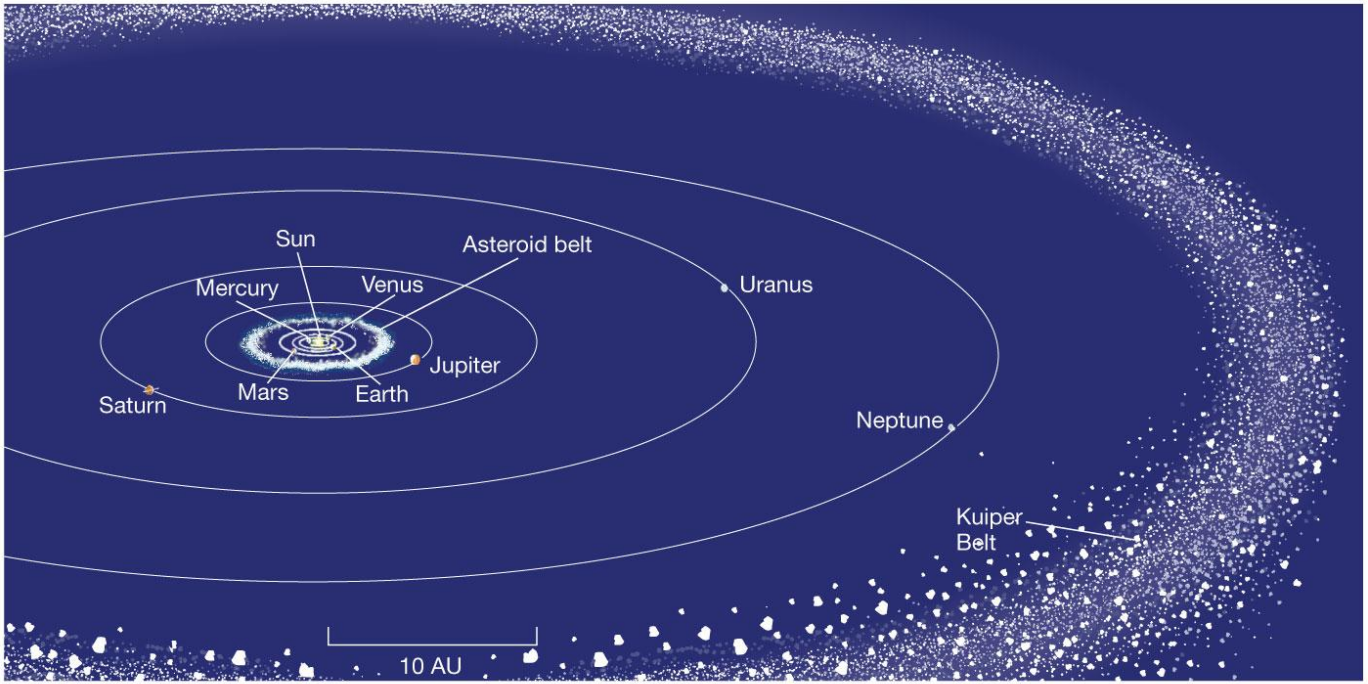
Chapter 11
Jupiter



Units of Chapter 11

11.1 Orbital and Physical Properties

This figure shows the solar system from a vantage point that emphasizes the relationship of the jovian planets to the rest of the system



11.1 Orbital and Physical Properties

Three views of Jupiter: From a small telescope on Earth; from the Hubble Space Telescope; and from the Cassini spacecraft

(a)

(b)

(c)

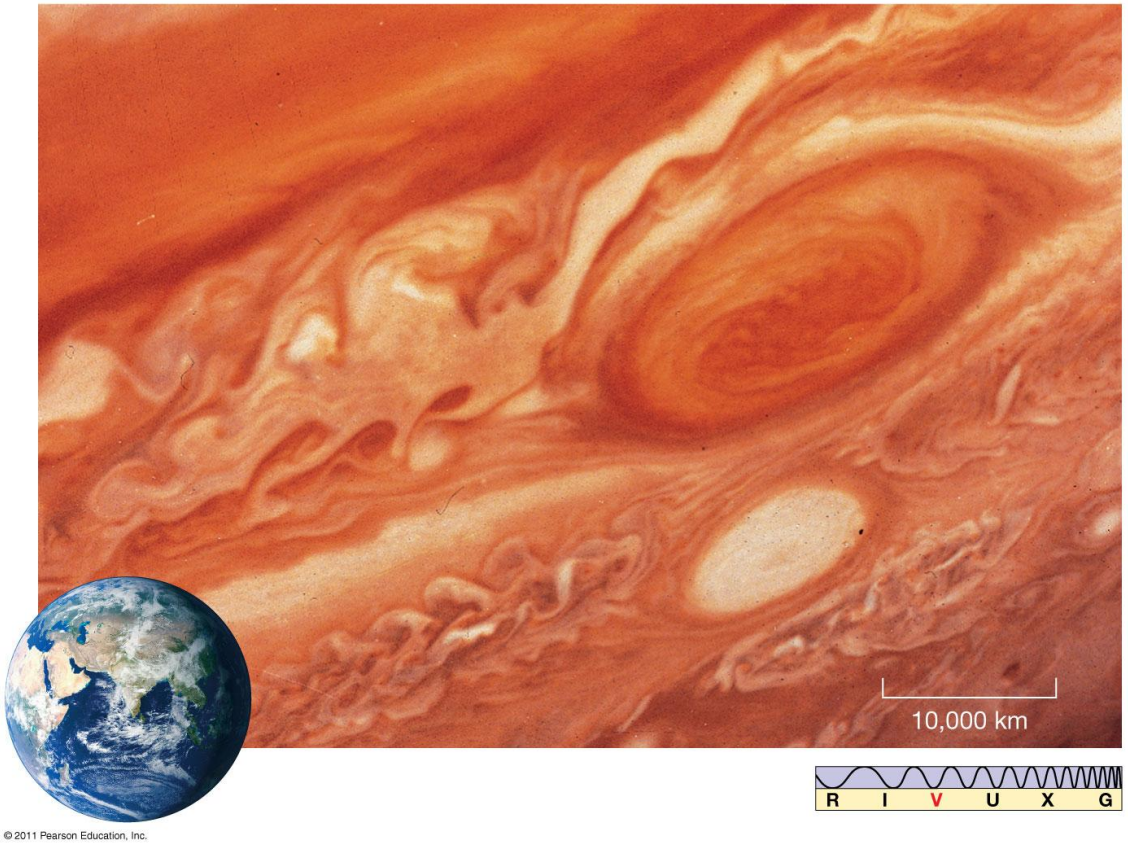
11.1 Orbital and Physical Properties

- Mass: 1.9 × 10^{27} kg (twice as much as all other planets put together)
- Radius: 71,500 km (11.2 times Earth's)
- Density: 1300 kg/m^3—cannot be rocky or metallic as inner planets are
- Rotation rate: Problematic, as Jupiter has no solid surface; different parts of atmosphere rotate at different rates
- From magnetic field, rotation period is 9 hr, 55 min

11.2 The Atmosphere of Jupiter

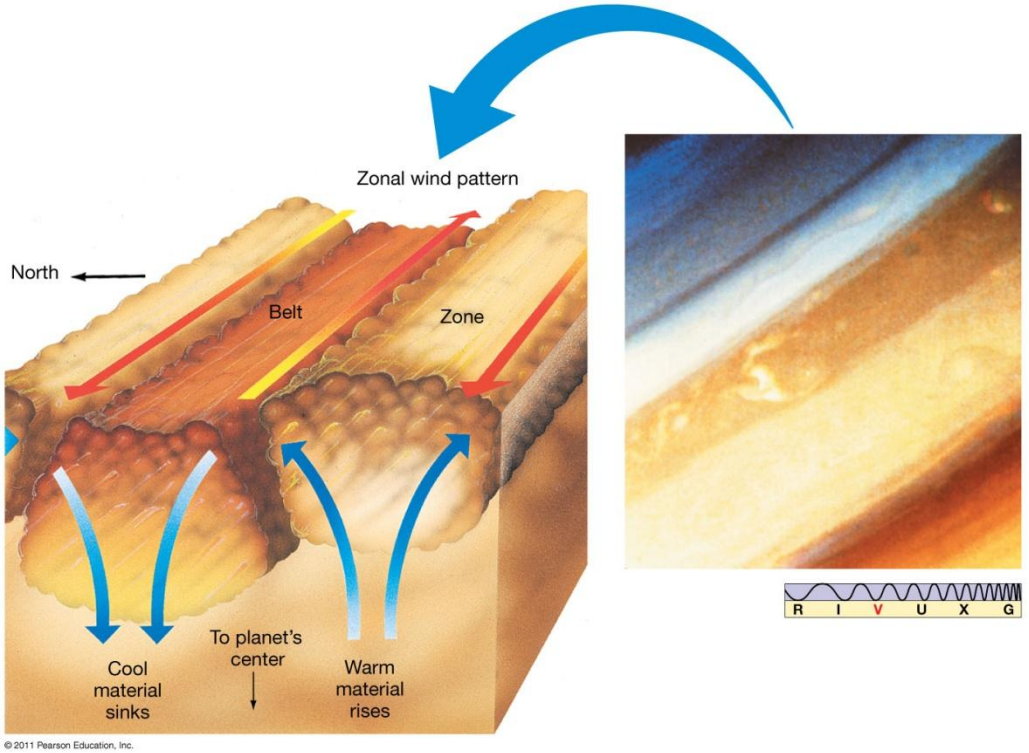
Major visible features:

Bands of clouds; Great Red Spot



11.2 The Atmosphere of Jupiter

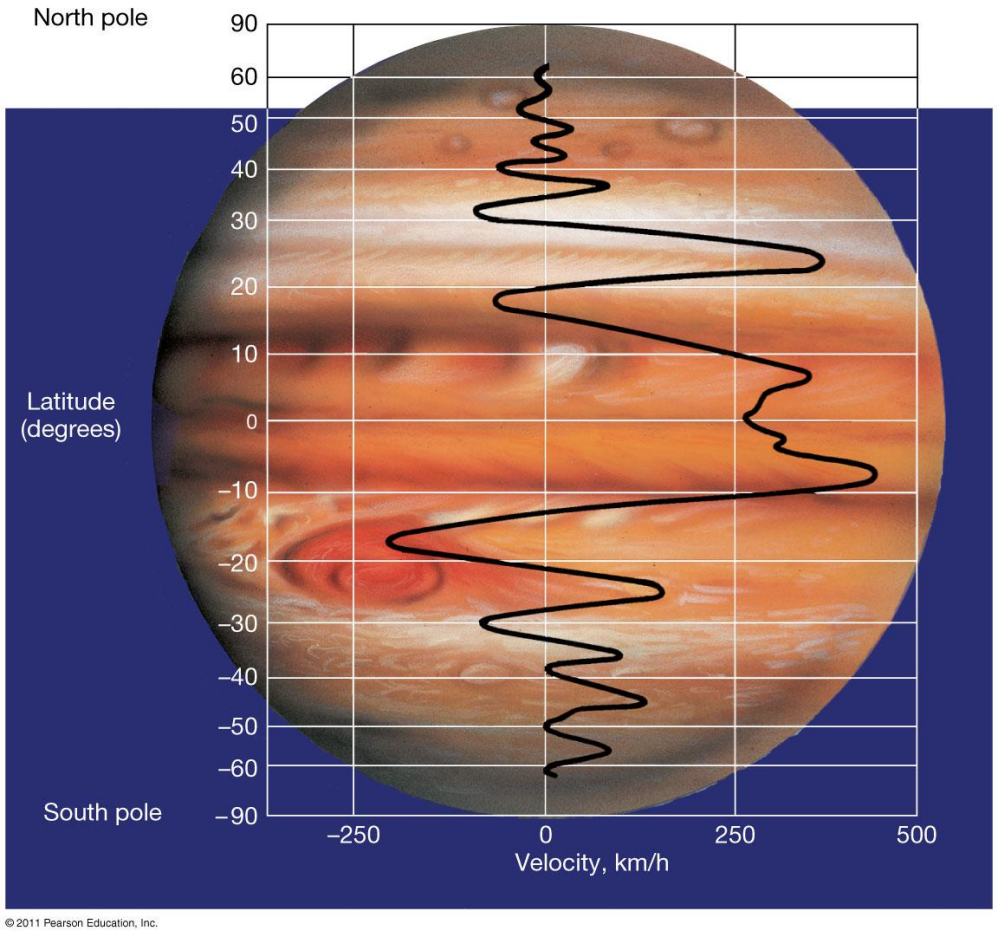
- Atmosphere has bright zones and dark belts
- Zones are cooler, and are higher than belts
- Stable flow, called zonal flow, underlies zones and bands
- Simplified model



11.2 The Atmosphere of Jupiter

Real picture is much more complicated

Here: Wind speed with respect to internal rotation rate



11.2 The Atmosphere of Jupiter

Composition of atmosphere: mostly molecular hydrogen and helium; small amounts of methane, ammonia, and water vapor

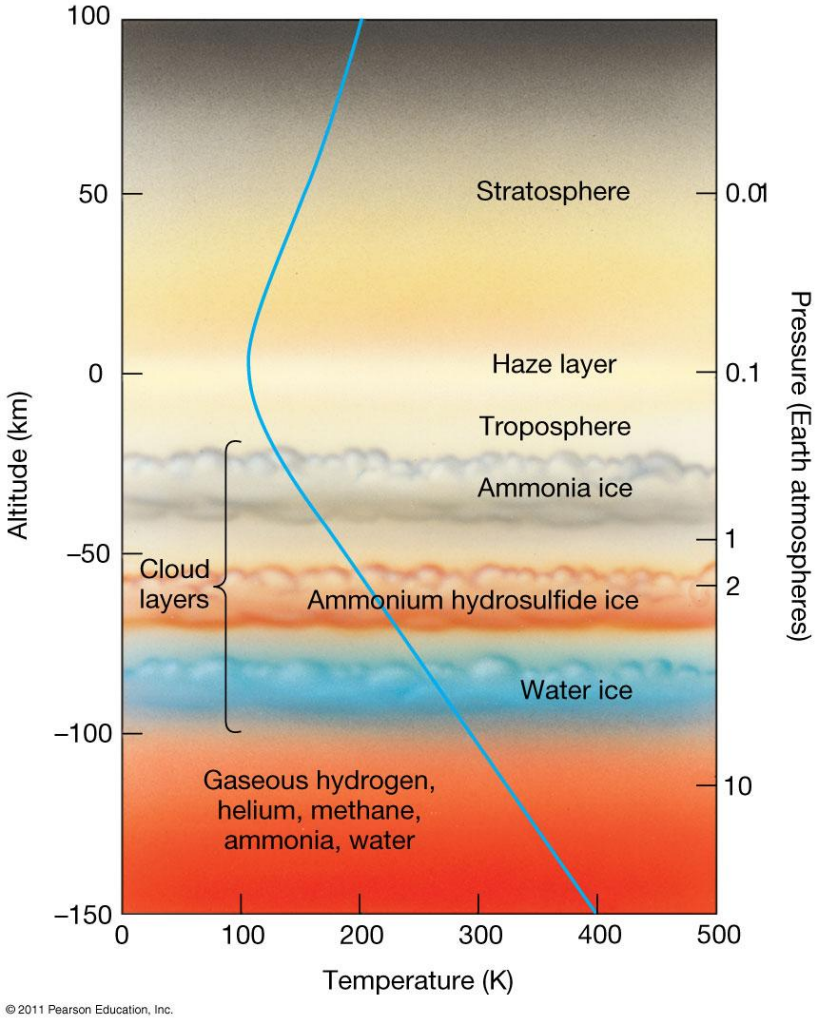
These cannot account for color; probably due to complex chemical interactions

11.2 The Atmosphere of Jupiter

No solid surface; take top of troposphere to be at 0 km

Lowest cloud layer cannot be seen by optical telescopes

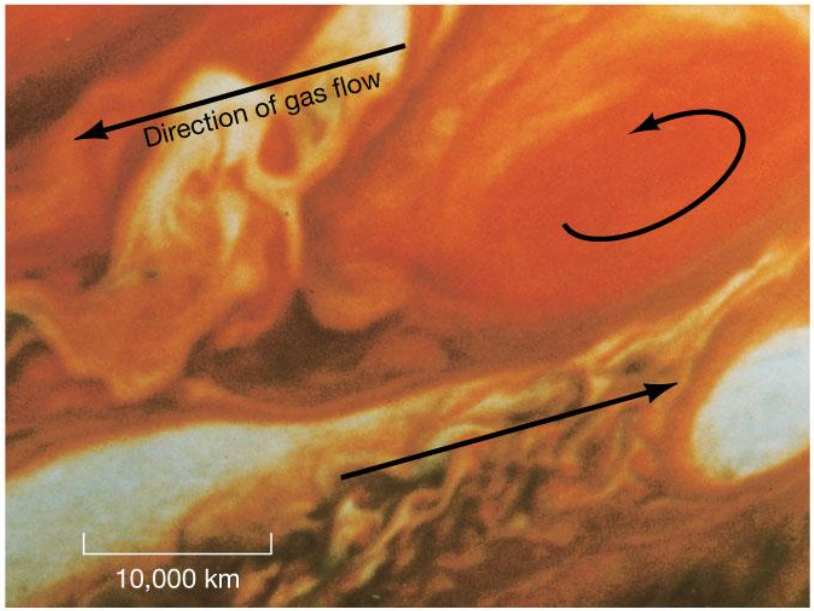
Measurements by Galileo probe show high wind speeds even at great depth—probably due to heating from planet, not from Sun

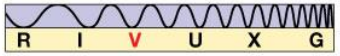


11.2 The Atmosphere of Jupiter

Great Red Spot has existed for at least 300 years, possibly much longer

Color and energy source still not understood

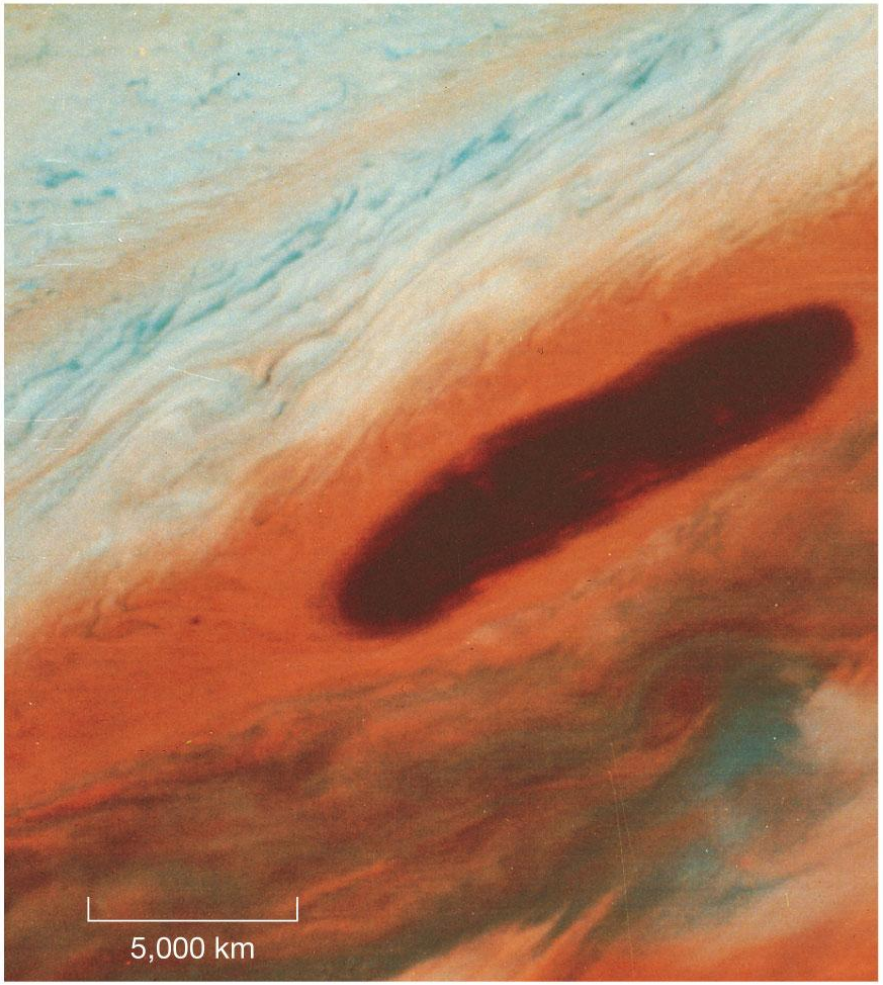


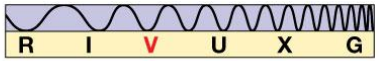


11.2 The Atmosphere of Jupiter

Lightning-like flashes have been seen; also shorter-lived rotating storms

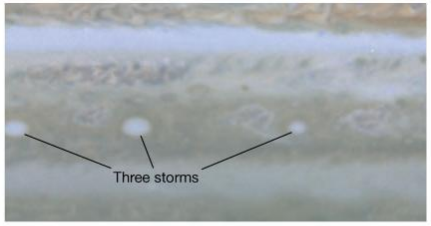
One example: Brown Oval, really a large gap in clouds





11.2 The Atmosphere of Jupiter

Recently, three white storms were observed to merge into a single storm, which then turned red. This may provide some clues to the dynamics behind Jupiter's cloud movements.



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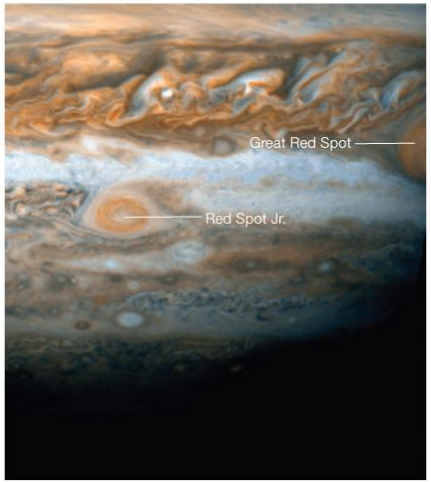

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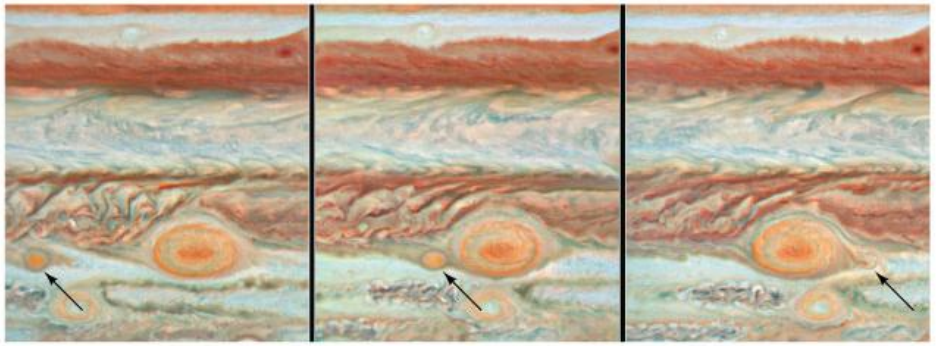
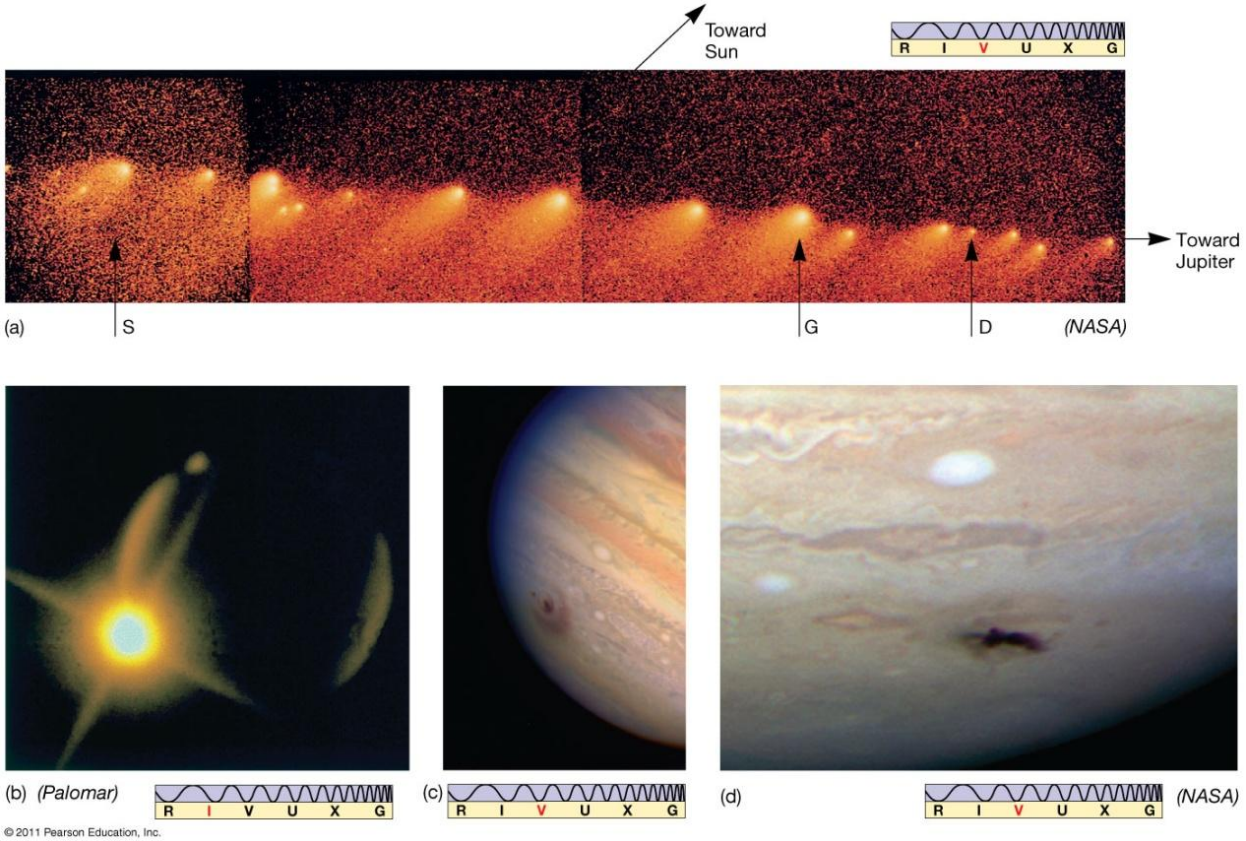


(c)

Discovery 11-1: A Cometary Impact

July 1994: Comet Shoemaker-Levy 9, in fragments, struck Jupiter, providing valuable information about cometary impacts



11.3 Internal Structure

Find that Jupiter radiates more energy than it receives from the Sun:

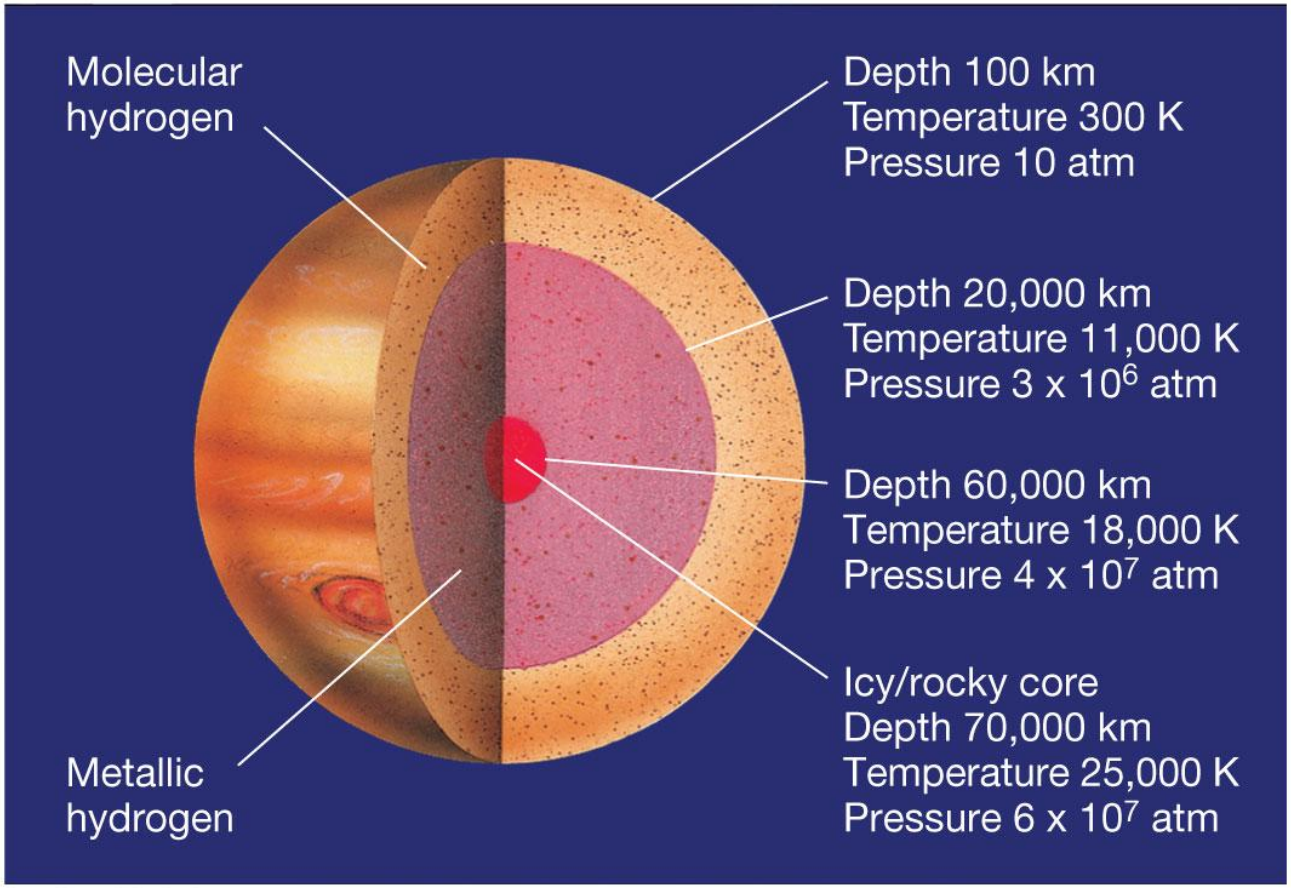
- Core is still cooling off from heating during gravitational compression

Could Jupiter have been a star?

- No; it is far too cool and too small for that. It would need to be about 80 times more massive to be even a very faint star.

11.3 Internal Structure

No direct information is available about Jupiter's interior, but its main components, hydrogen and helium, are quite well understood. The central portion is a rocky core.



Discovery 11-2: Almost a Star?

Jupiter is much too small to have become a star—needs 80 times more mass!

But its energy output was larger in the past; could have been 100 times brighter than the Moon as seen from Earth

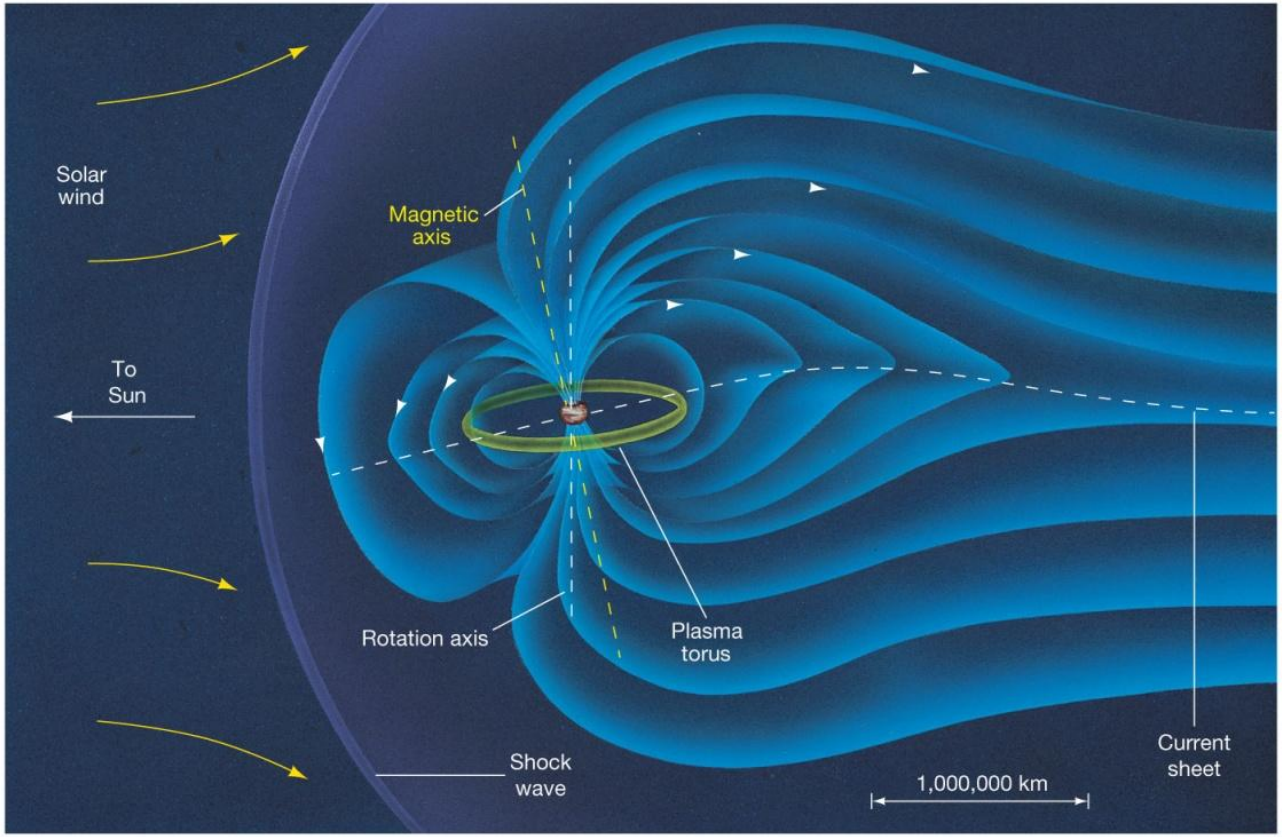
Dwarf star in Jupiter's place probably would have made stable planetary orbits impossible

Jupiter played invaluable role in sweeping solar system clear of debris before too much reached Earth—otherwise life on Earth might not have been possible

11.4 Jupiter's Magnetosphere

Jupiter is surrounded by belts of charged particles, much like the Van Allen belts but vastly larger

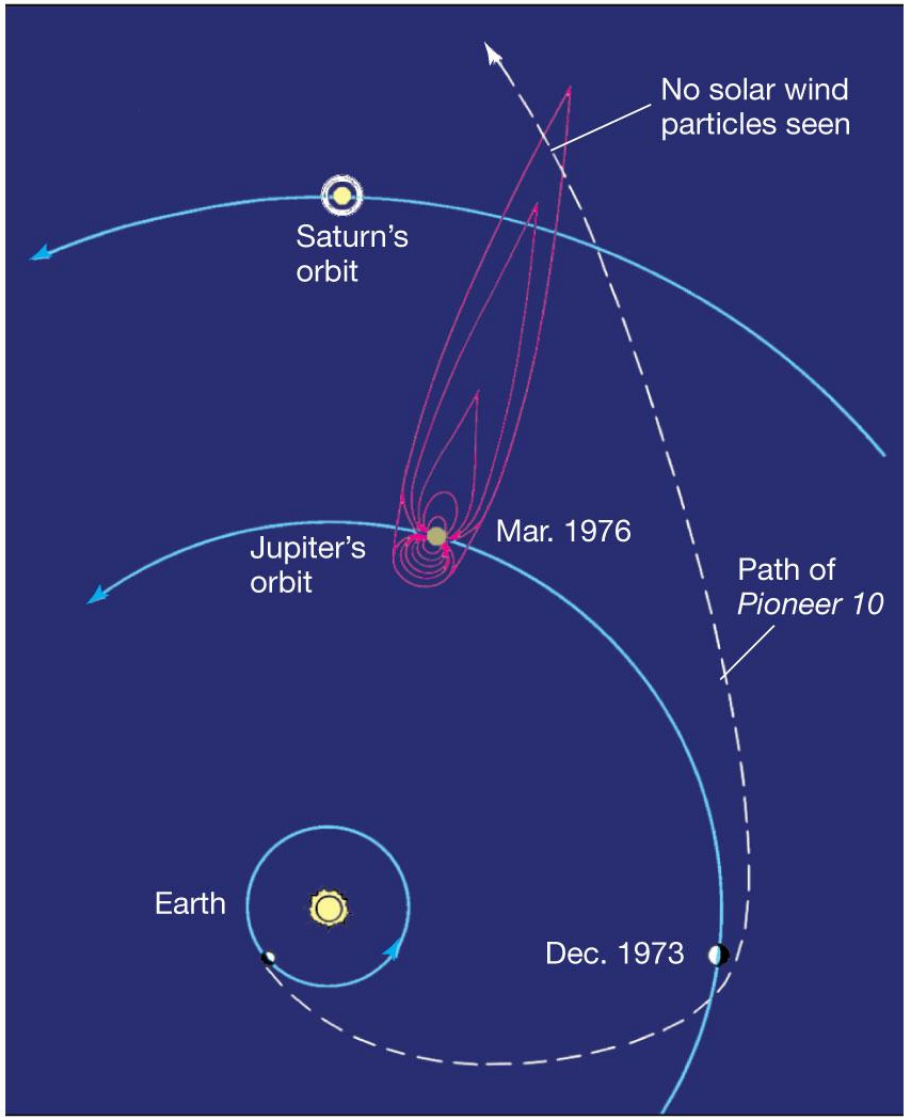
Magnetosphere is 30 million km across



11.4 Jupiter's Magnetosphere

Intrinsic field strength is 20,000 times that of Earth

Magnetosphere can extend beyond the orbit of Saturn



11.5 The Moons of Jupiter

63 moons have now been found orbiting Jupiter, but most are very small

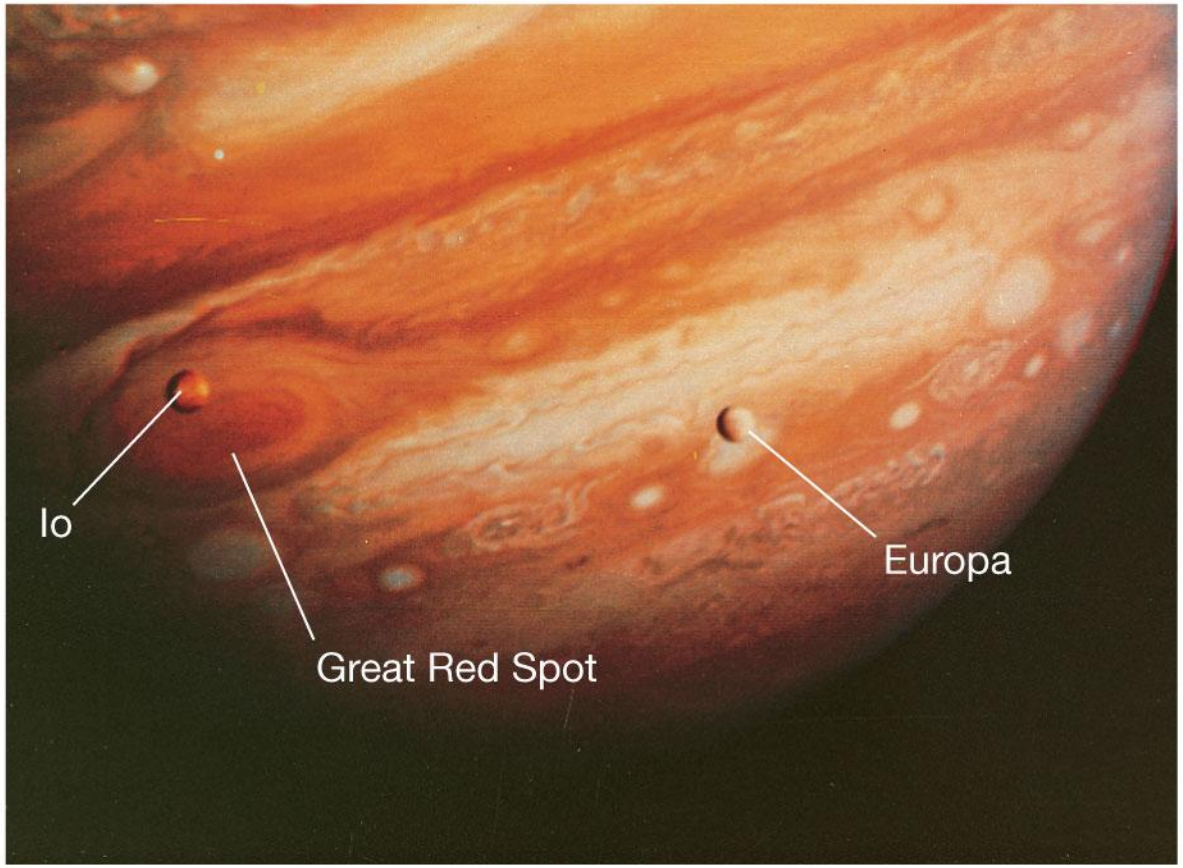
The four largest are the Galilean moons, so called because they were first observed by Galileo:

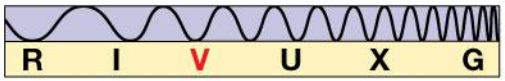
- Io, Europa, Ganymede, Callisto

Galilean moons have similarities to terrestrial planets: orbits have low eccentricity, largest is somewhat larger than Mercury, and density decreases as distance from Jupiter increases

11.5 The Moons of Jupiter

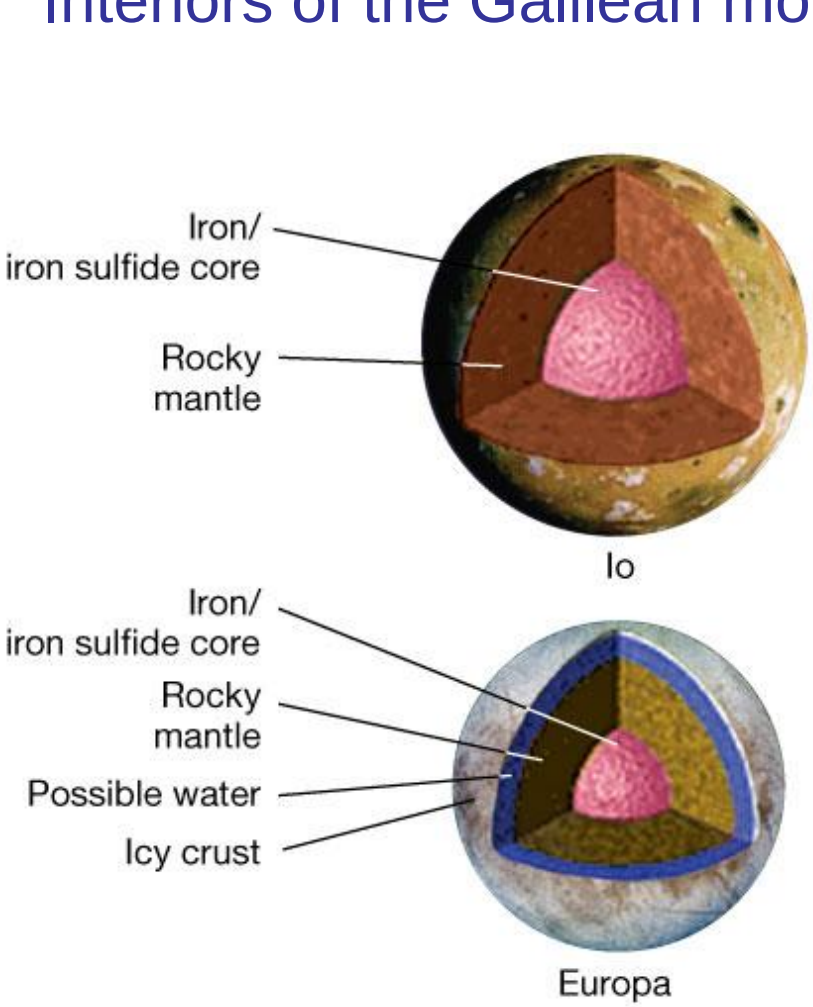
Jupiter with Io and Europa. Note the relative sizes!

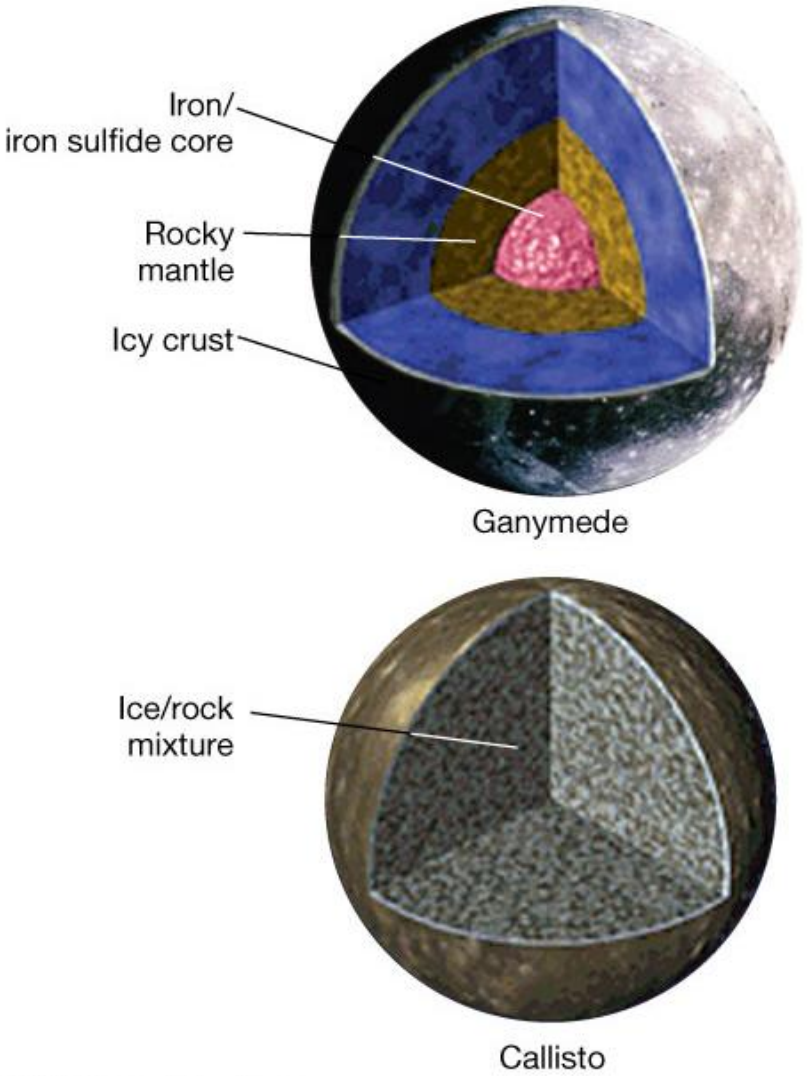




11.5 The Moons of Jupiter

Interiors of the Galilean moons





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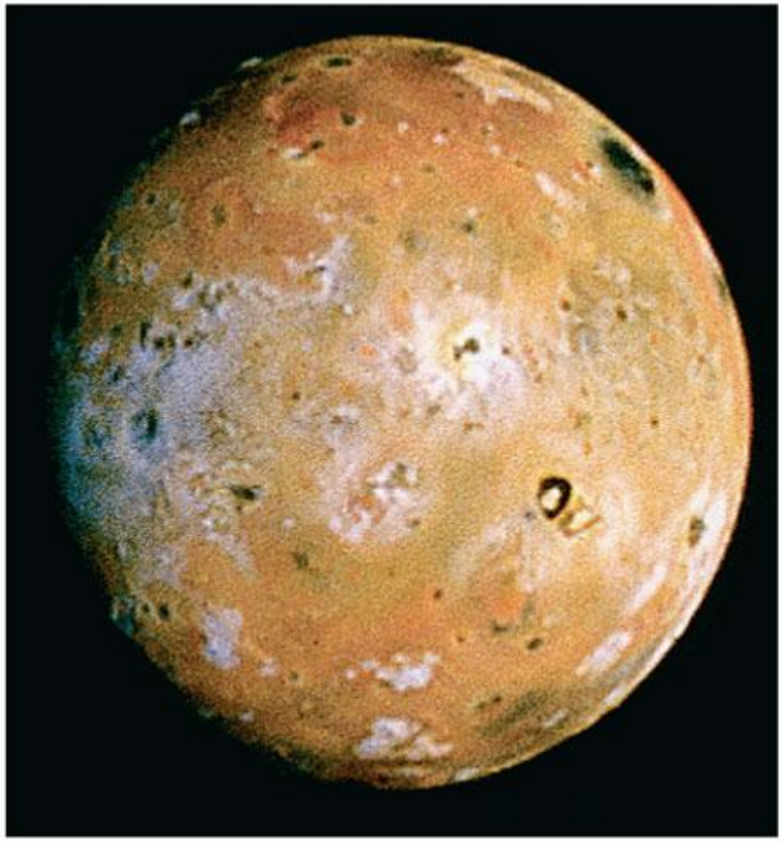
11.5 The Moons of Jupiter

Io is the densest of Jupiter's moons, and the most geologically active object in the solar system:

- Many active volcanoes, some quite large
- Can change surface features in a few weeks
- No craters; they fill in too fast—Io has the youngest surface of any solar system object

11.5 The Moons of Jupiter

Orange color is probably from sulfur compounds in the ejecta



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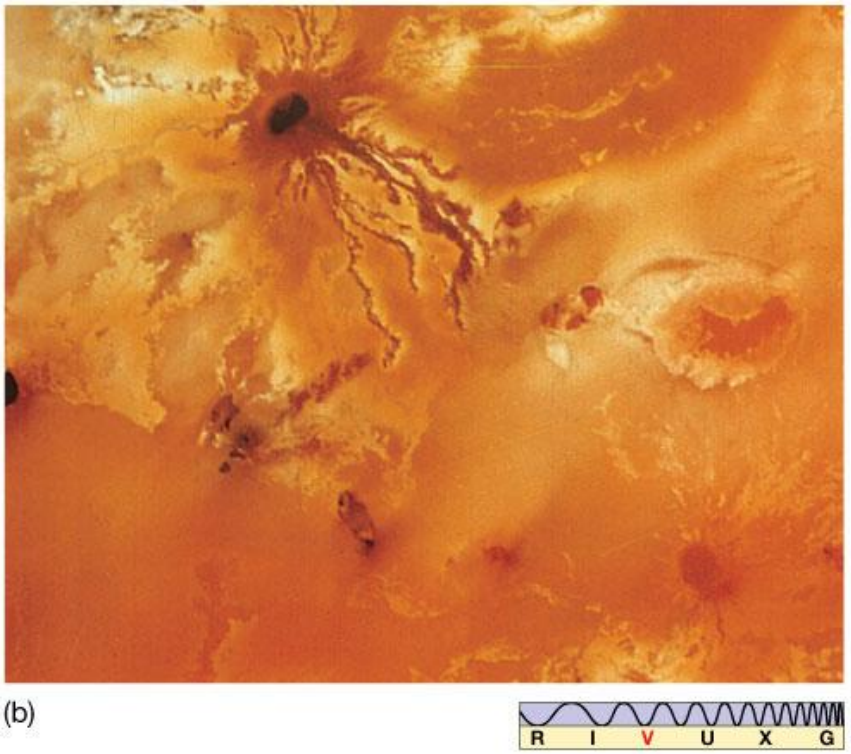

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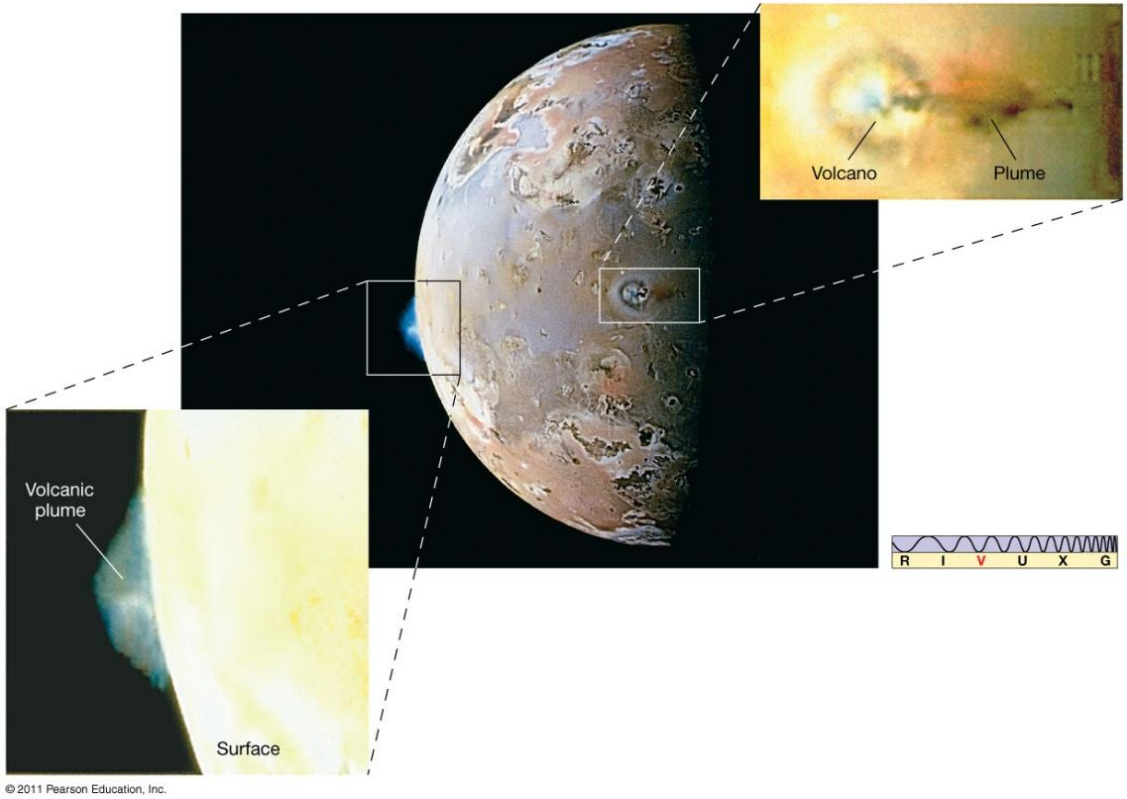
11.5 The Moons of Jupiter

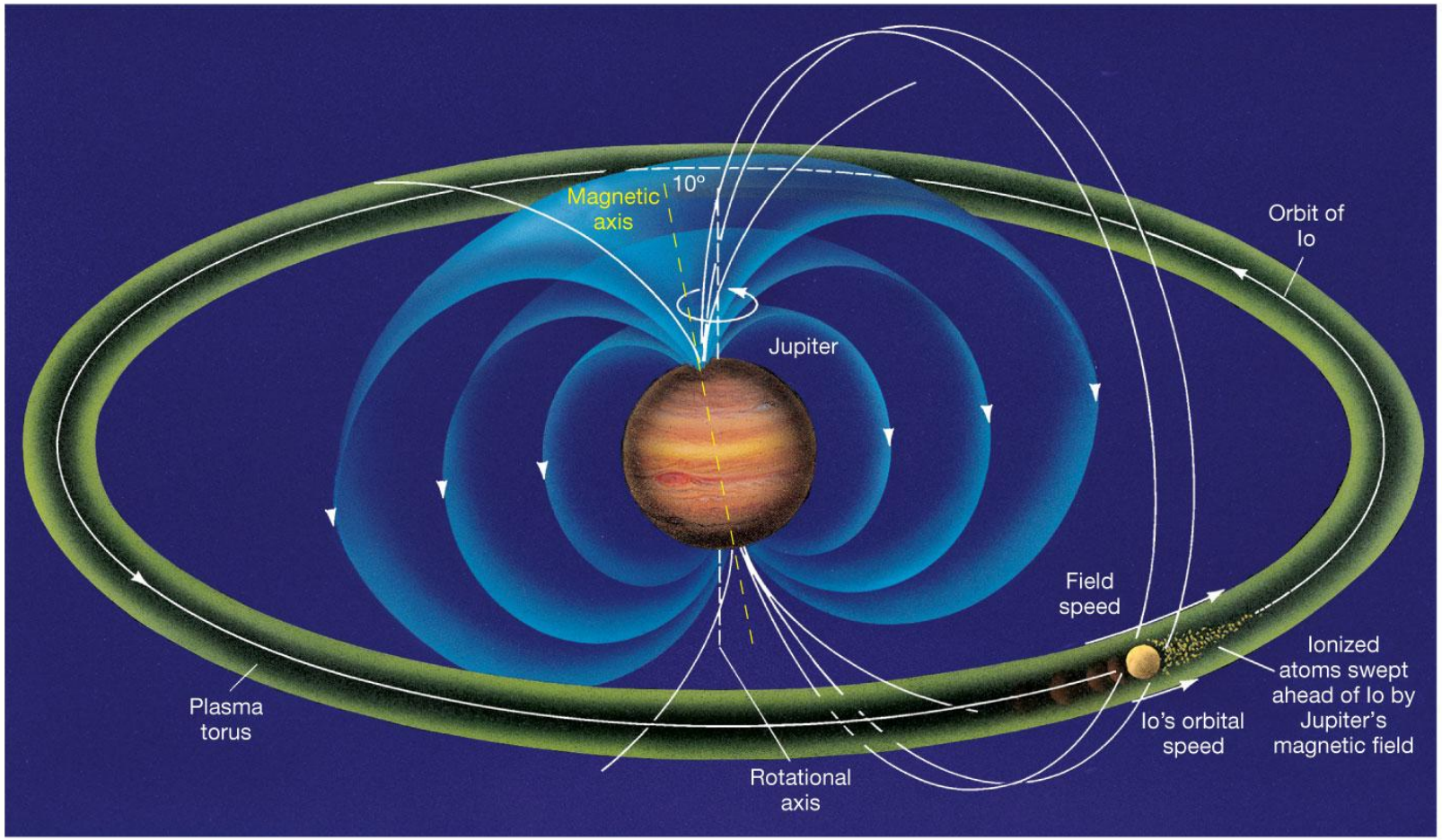
Cause of volcanism: Gravity!

Io is very close to Jupiter and also experiences gravitational forces from Europa. The tidal forces are huge and provide the energy for the volcanoes.



11.5 The Moons of Jupiter

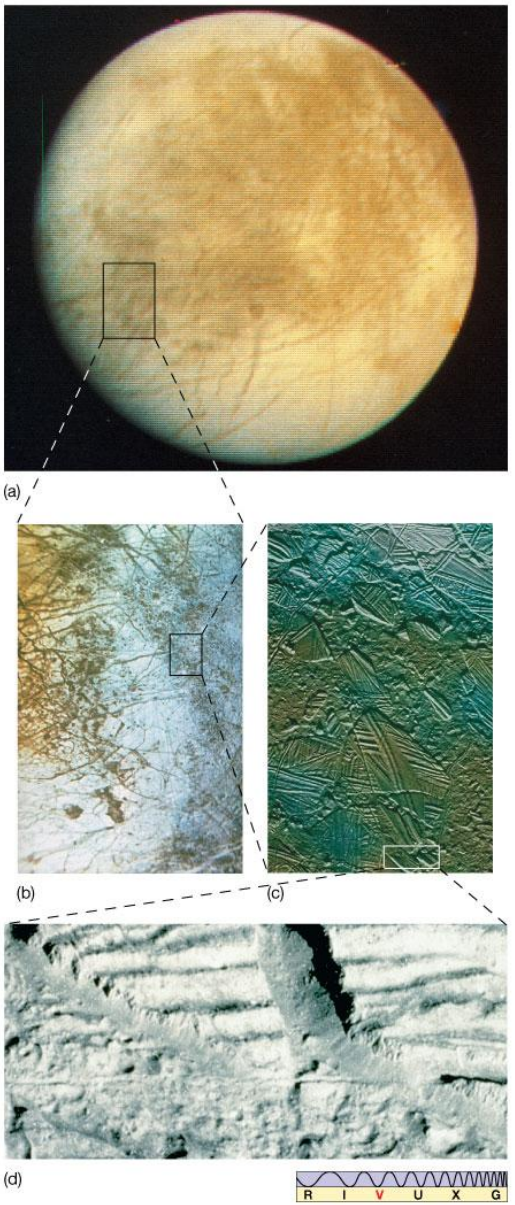
Volcanic eruptions also eject charged particles; these interact with Jupiter's magnetosphere and form a plasma torus



11.5 The Moons of Jupiter

Europa has no craters; surface is water ice, possibly with liquid water below

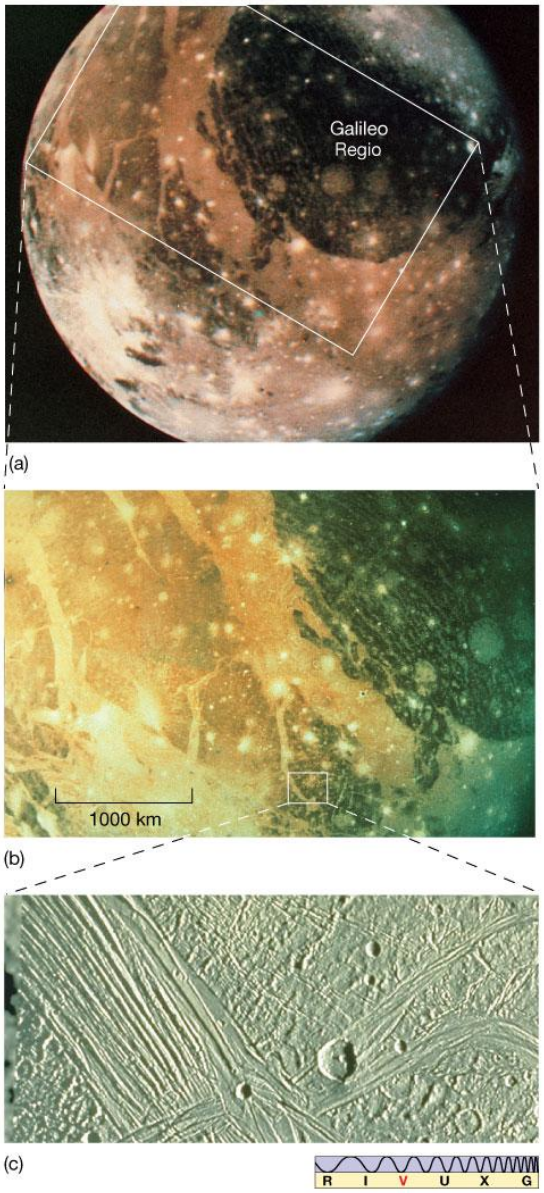
Tidal forces stress and crack ice; water flows, keeping surface relatively flat



11.5 The Moons of Jupiter

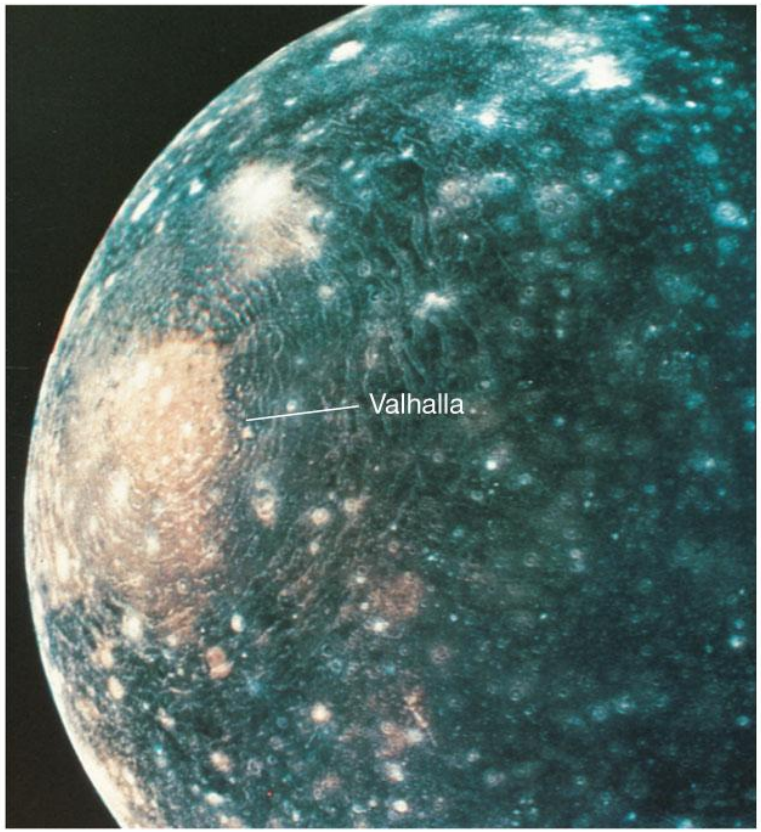
Ganymede is the largest moon in the solar system—larger than Pluto and Mercury

History similar to Earth's Moon, but water ice instead of lunar rock



11.5 The Moons of Jupiter

Callisto is similar to Ganymede; no evidence of plate activity



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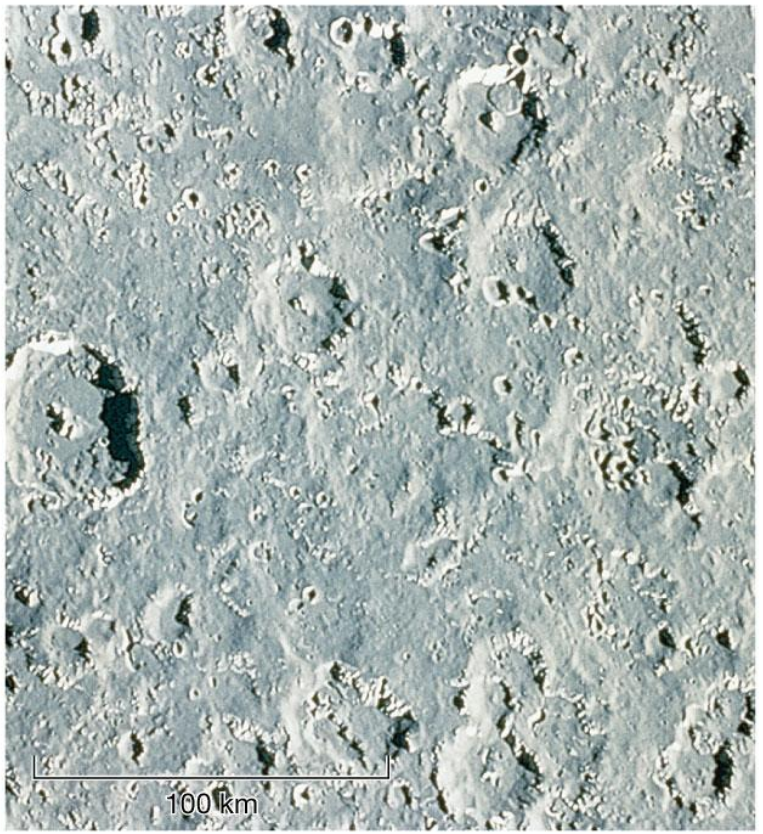

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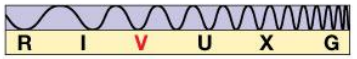
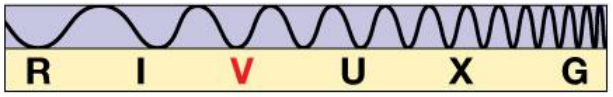


11.6 Jupiter's Ring

Jupiter has been found to have a small, thin ring



Summary of Chapter 11

- Jupiter is the largest planet in the solar system
- Rotates rapidly
- Cloud cover has three main layers, forms zone and band pattern
- Great Red Spot is a very stable storm
- Pressure and density of atmosphere increase with depth; atmosphere becomes liquid and then “metallic”

Summary of Chapter 11 (cont.)

- Relatively small rocky core (but still about 10x size of Earth)
- Still radiating energy from original formation
- 63 moons, four very large
- Io: active volcanoes, due to tidal forces
- Europa: cracked, icy surface; may be liquid water underneath
- Ganymede and Callisto: similar; rock and ice