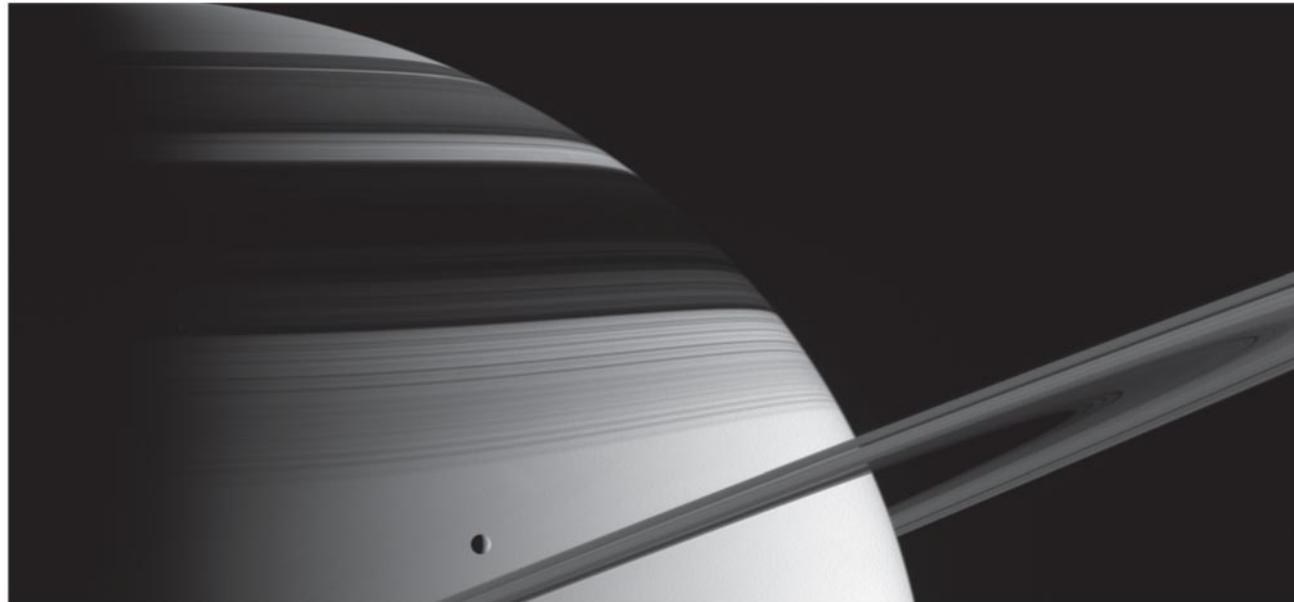


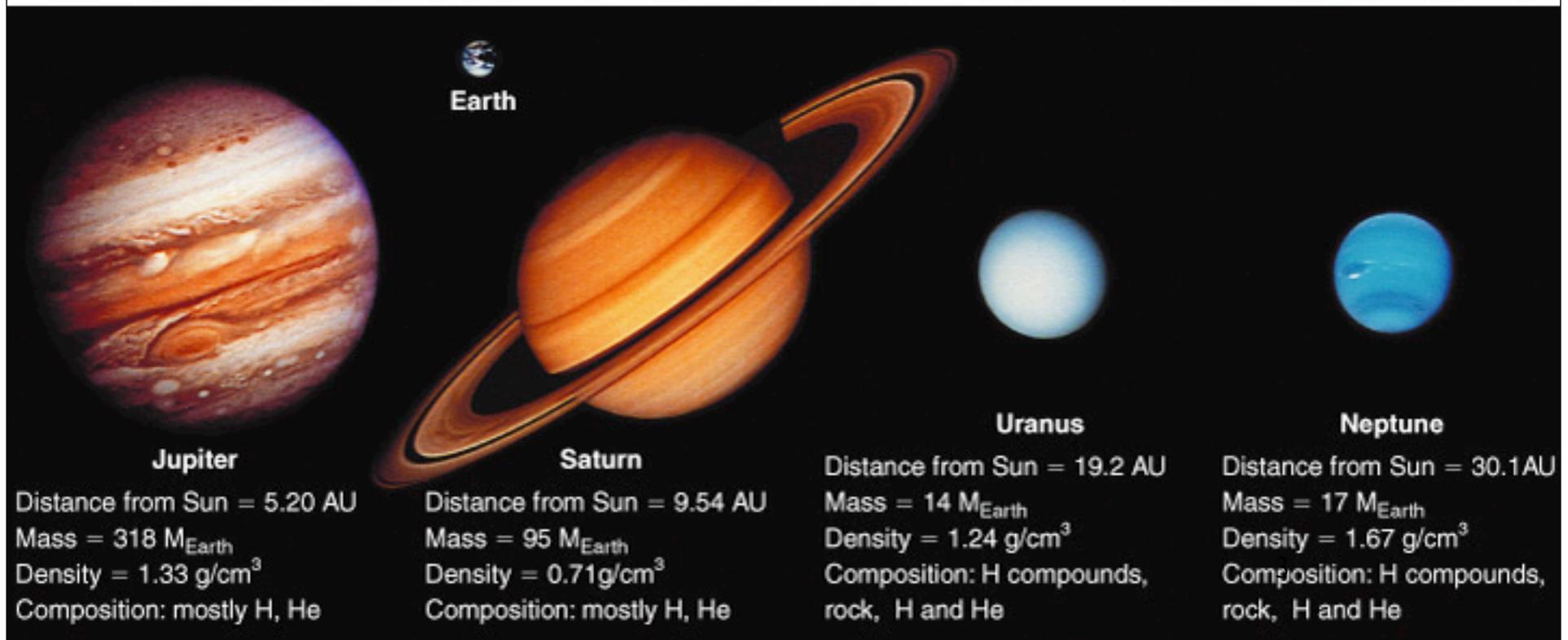
The Jovian Planets



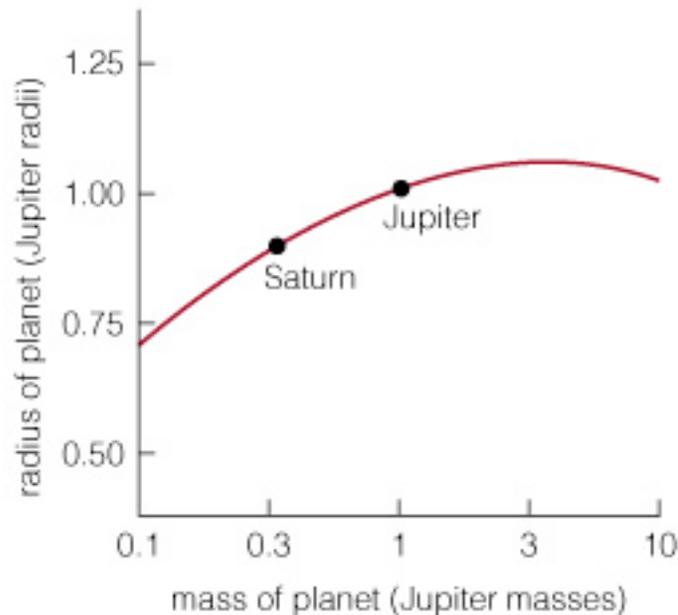
Great Exam Performance!

- Class average was 79.5%
- This is the highest average I've ever had on any ASTR 100 exam
Wonderful job!
- Exams will be handed back in your sections
- Don't let up; next exam has more concepts and is likely to be tougher

The Jovian planets are *gas giants* - much larger than Earth



Sizes of Jovian Planets



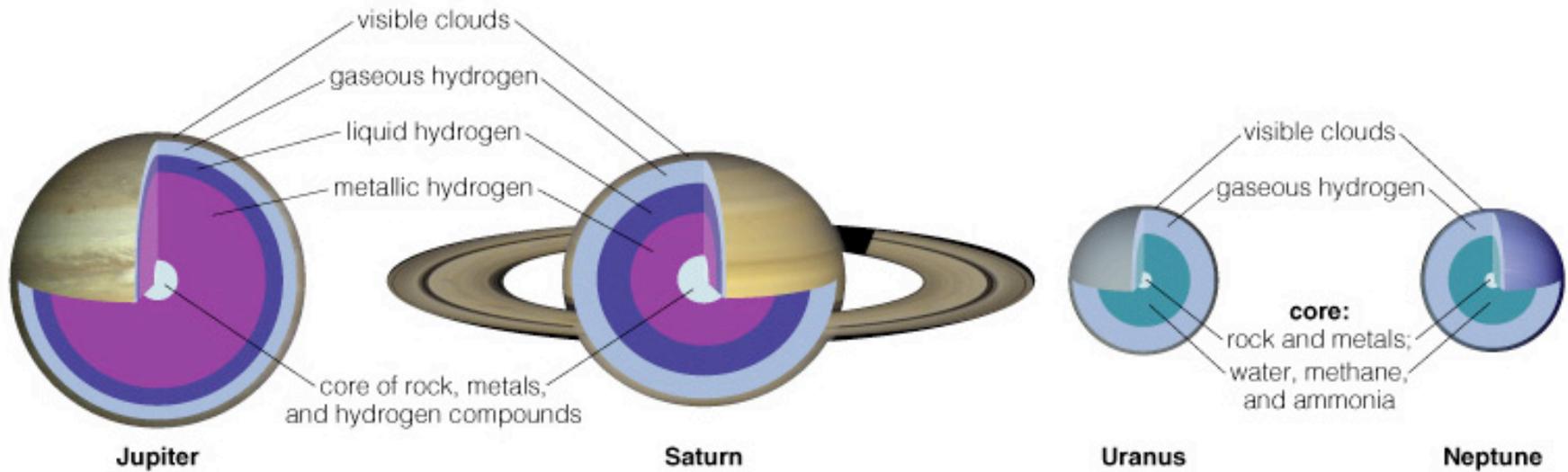
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- Planets get larger as they get more massive
- up to a point...
- Planets more massive than Jupiter are expected to *shrink*.
- There comes a point where gravity wins: adding more mass causes *contraction*.

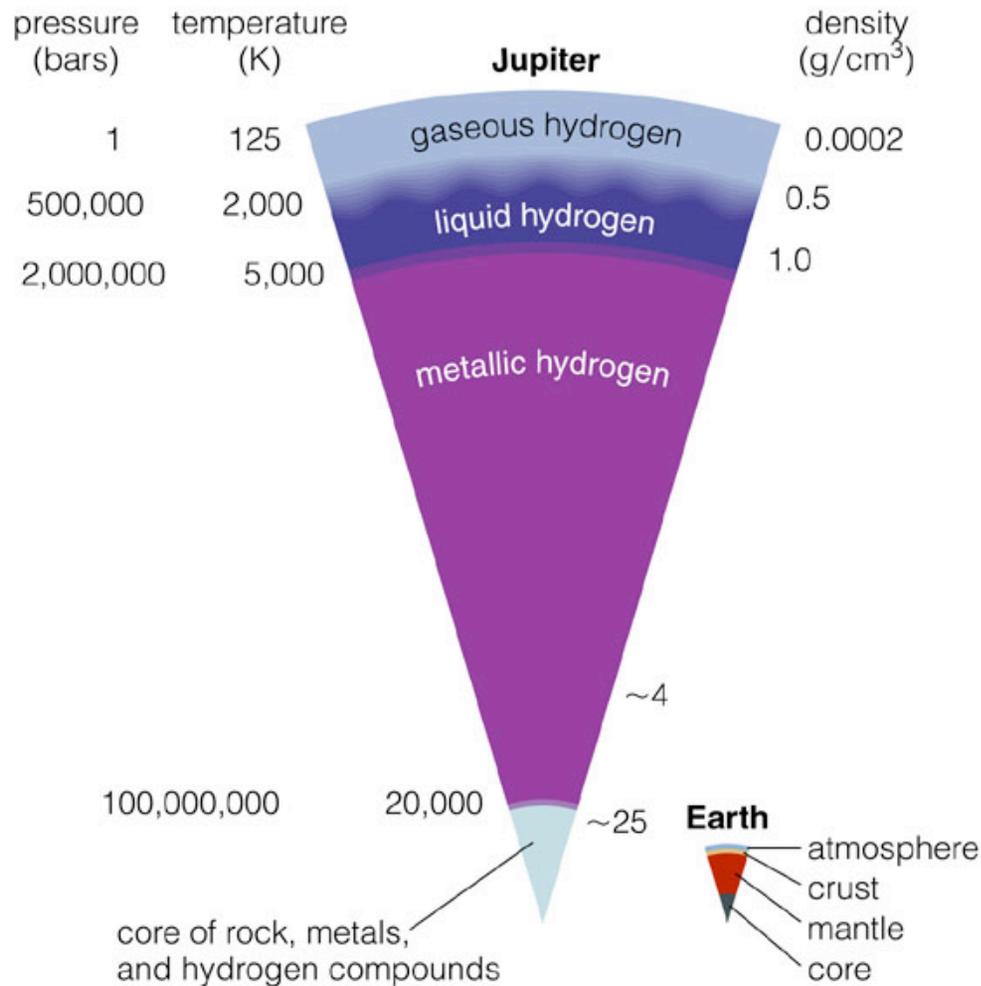
Jovian Planet Composition

- Jupiter and Saturn
 - Mostly H and He gas
 - *these are the most common elements in the Universe*
- Uranus and Neptune
 - Mostly hydrogen compounds: water (H₂O), methane (CH₄), ammonia (NH₃)
 - Some H, He, and rock

Interiors of Jovian Planets

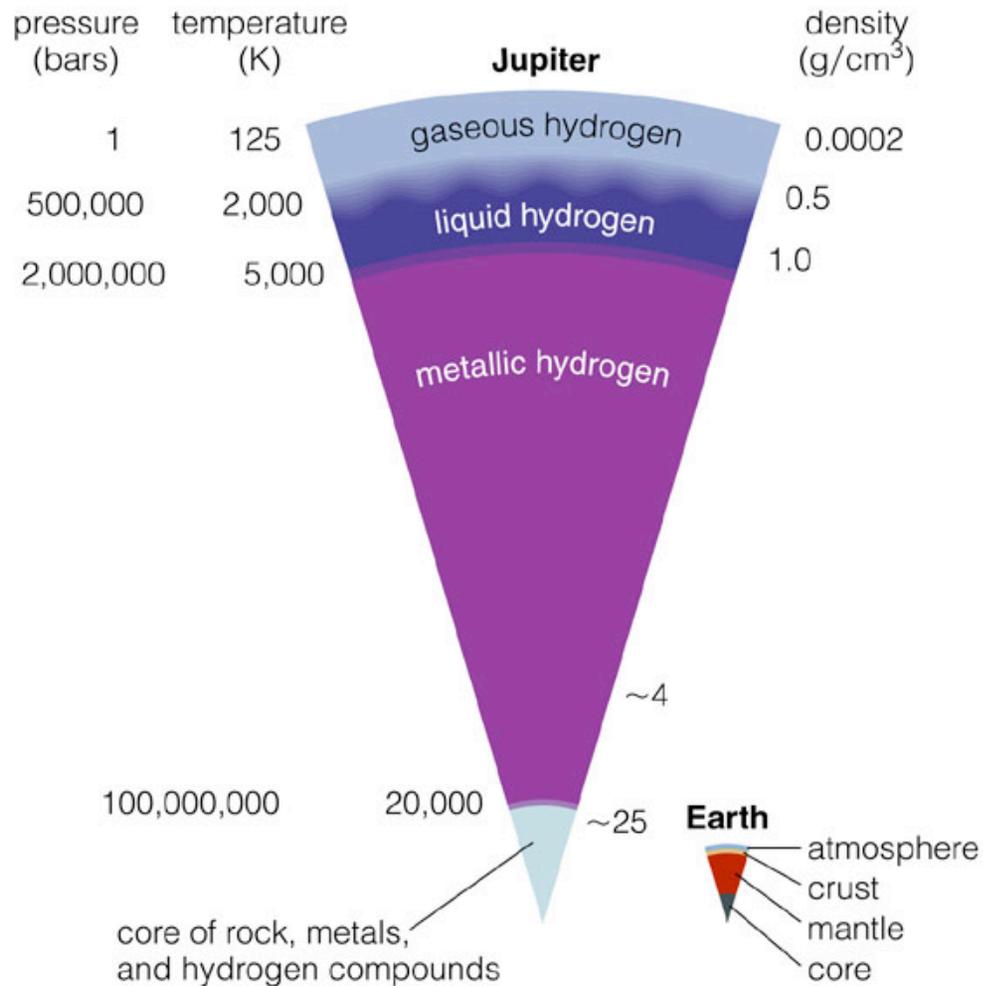


Inside Jupiter



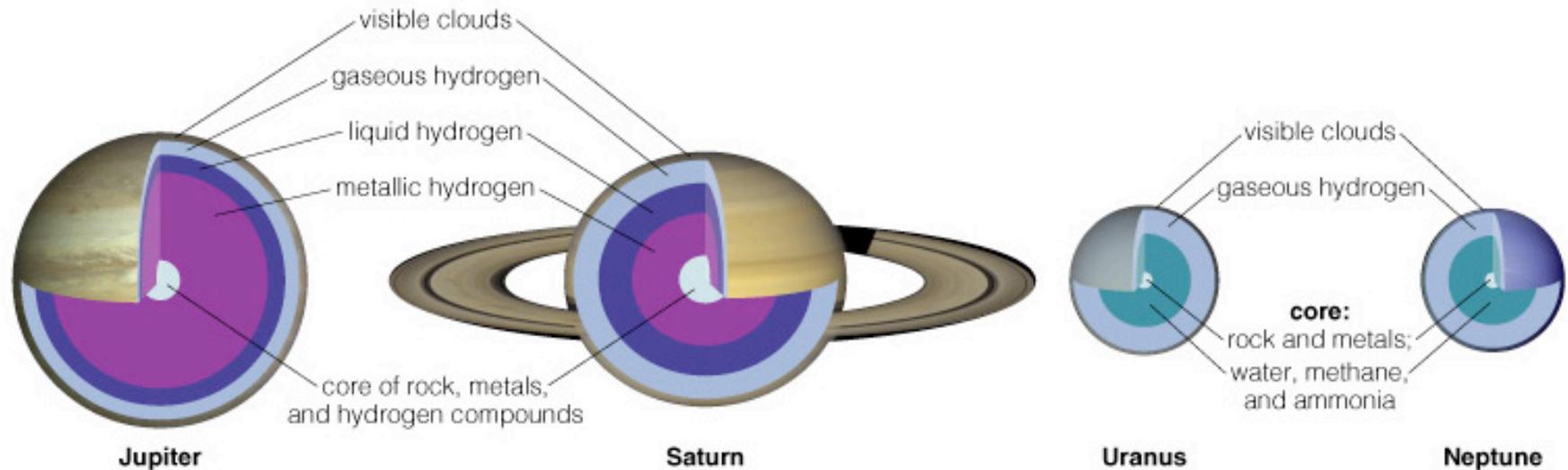
- High pressure inside of Jupiter causes the phase of hydrogen to change with depth.
- Hydrogen acts like a metal at great depths because its electrons move freely.

Inside Jupiter



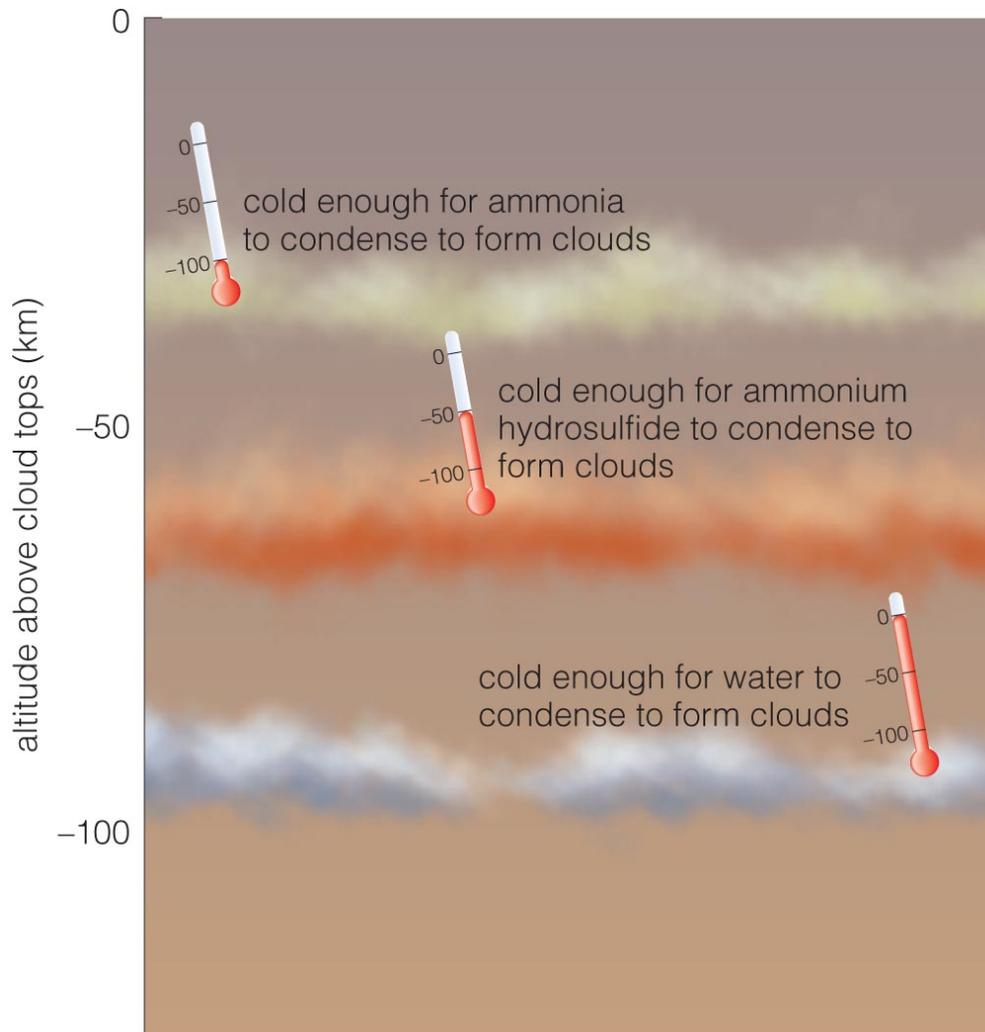
- The core is thought to be made of rock, metals, and hydrogen compounds.
- The core is about the same size as Earth but 10 times as massive.

Comparing Jovian Interiors



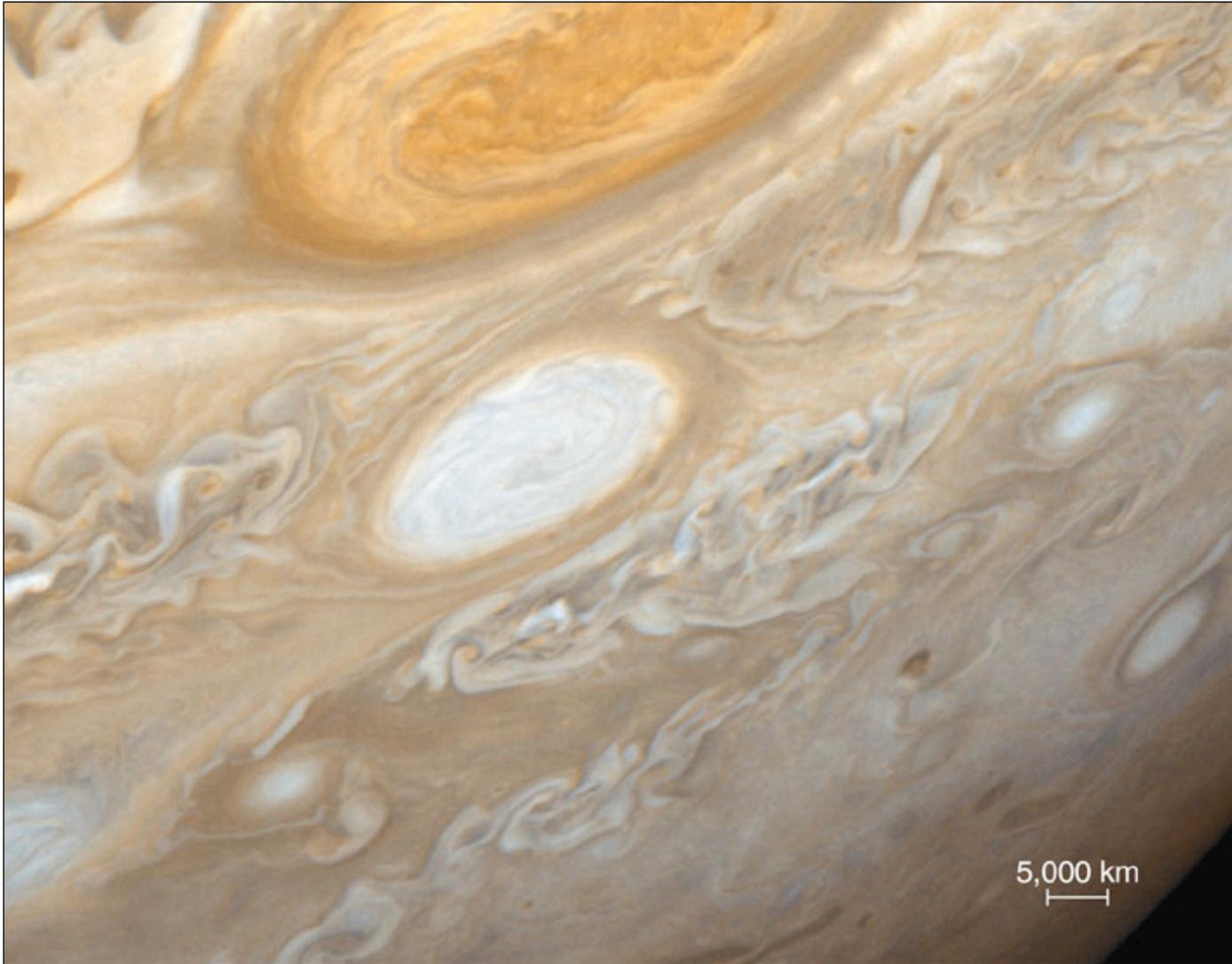
- Models suggest that cores of jovian planets have similar composition.
- Lower pressures inside Uranus and Neptune mean no metallic hydrogen.

Jupiter's Atmosphere

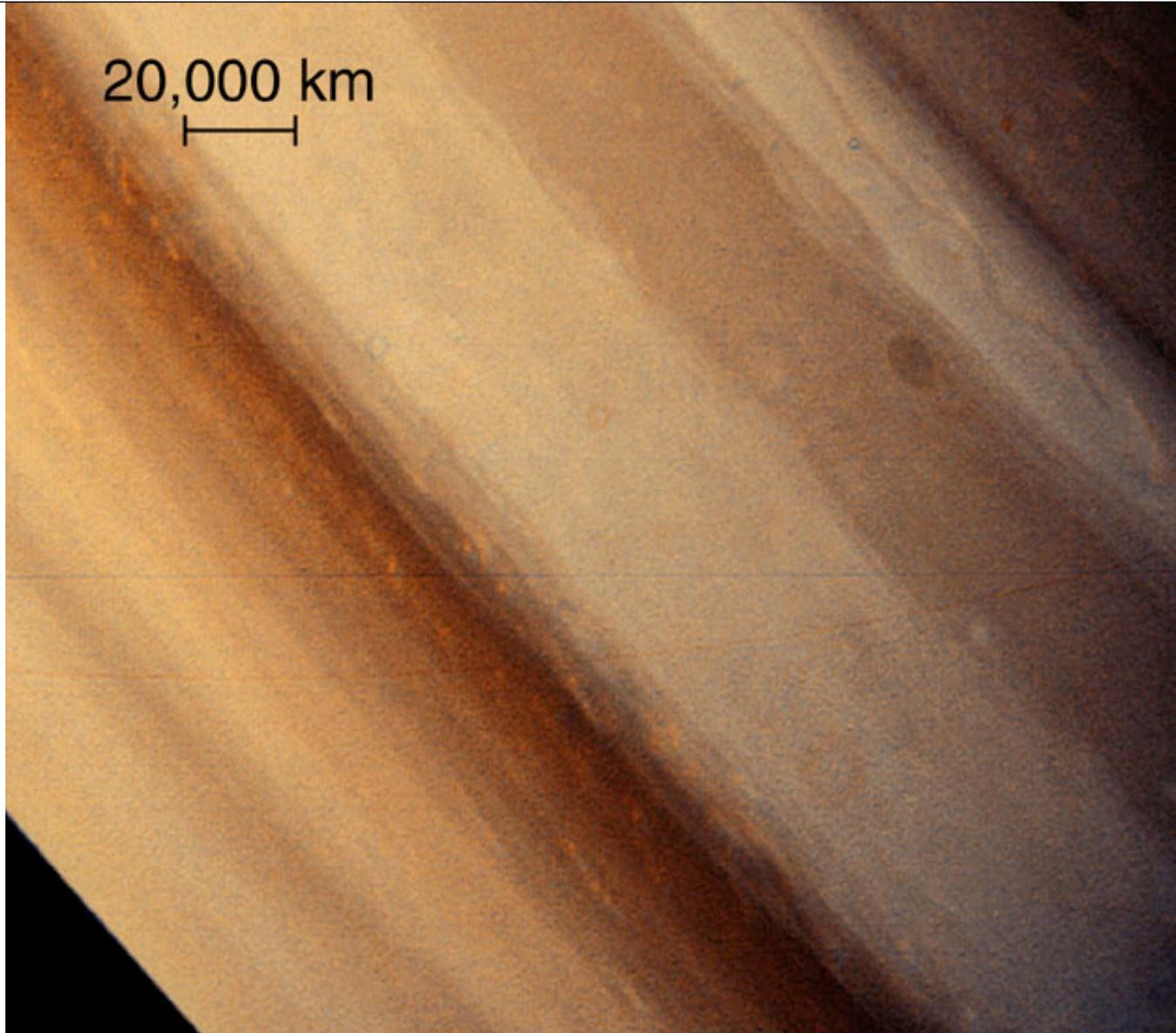


- Hydrogen compounds in Jupiter form clouds.
- Different cloud layers correspond to freezing points of different hydrogen compounds.
- Other jovian planets have similar cloud layers.

Jupiter's Colors



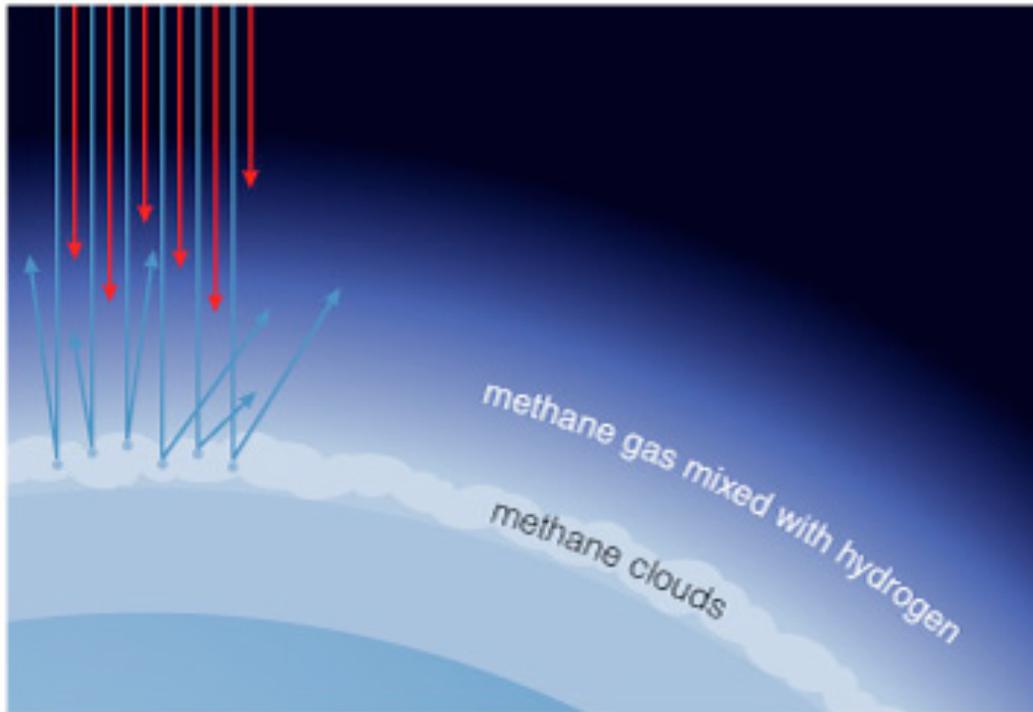
- Ammonium sulfide clouds (NH_4SH) reflect red/brown.
- Ammonia, the highest, coldest layer, reflects white.



Saturn's Colors

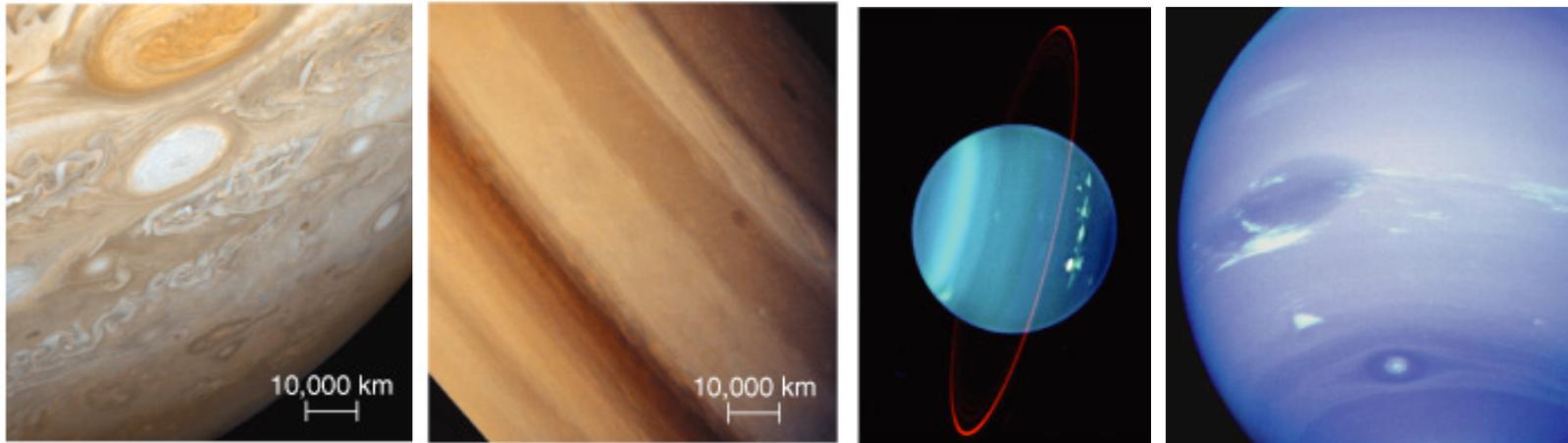
- Saturn's layers are similar but are deeper in and farther from the Sun — more subdued.

Methane on Uranus and Neptune



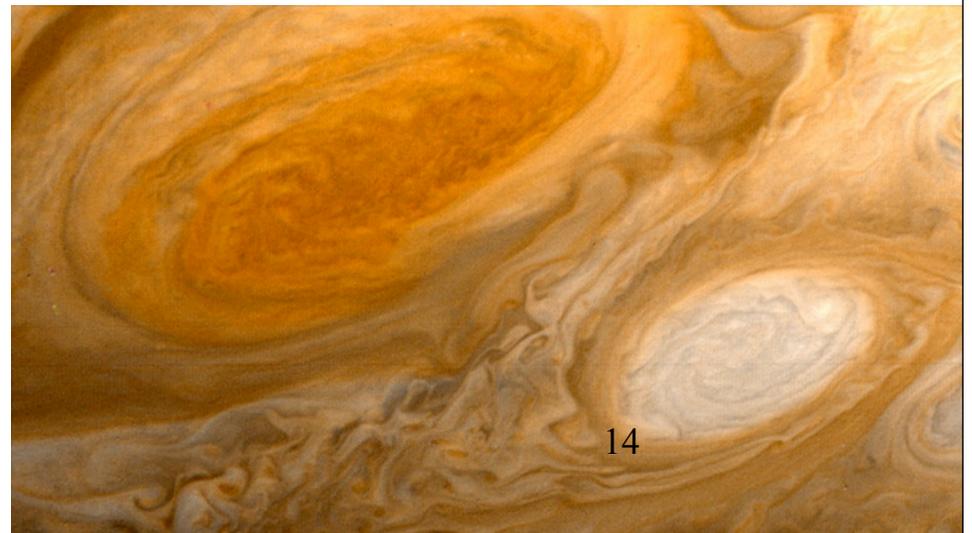
- Methane gas on Neptune and Uranus absorbs red light but transmits blue light.
- Blue light reflects off methane clouds, making those planets look blue.

Weather on Jovian Planets



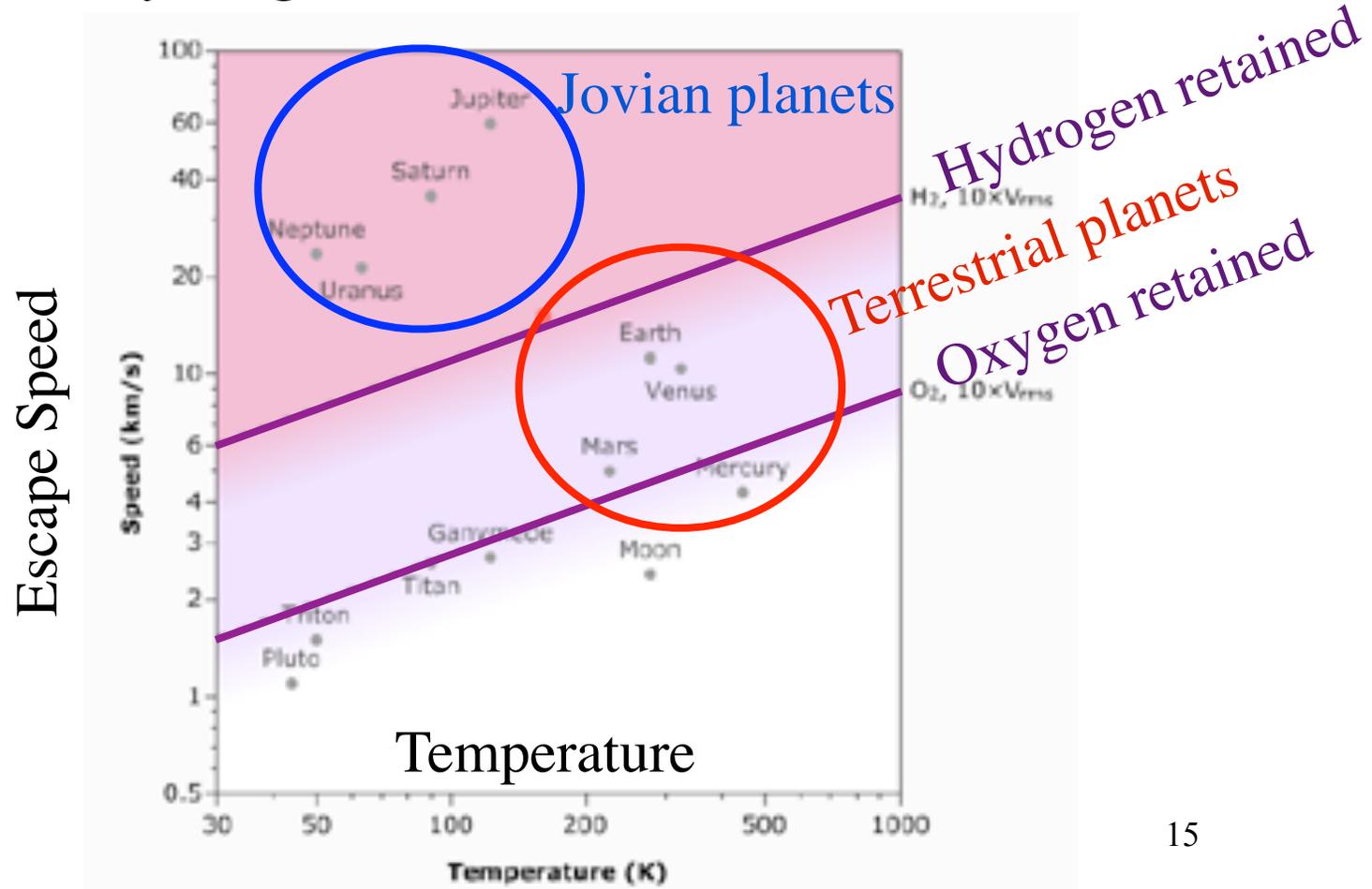
- All the jovian planets have strong winds and storms.

The great red spot on Jupiter is a storm larger than Earth that has persisted for centuries.



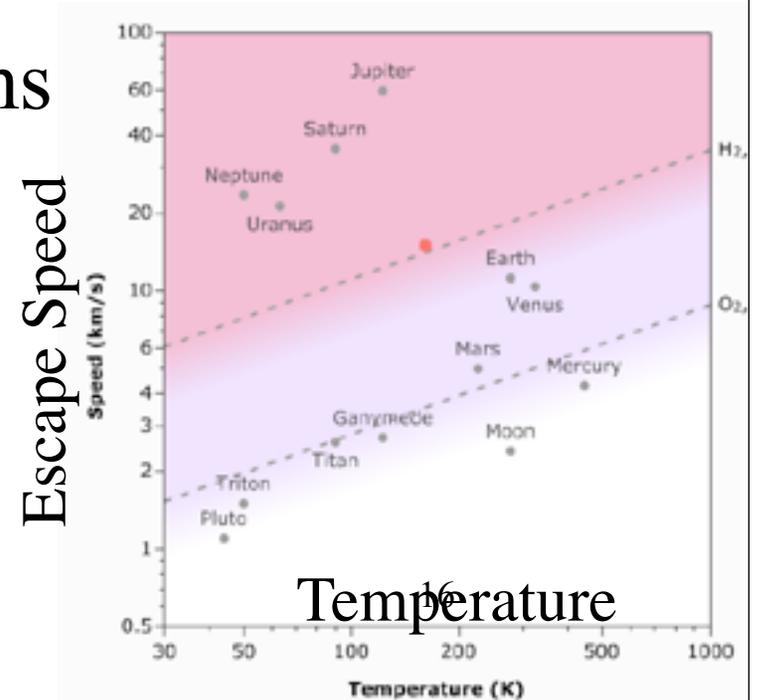
Jovian planets are

- Big
 - massive and cold, they can retain light elements like hydrogen and helium



Jovian planets are

- Big
 - massive and cold, they can retain light elements like hydrogen and helium
 - their composition is like that of the stars
 - the smaller terrestrial planets are the abnormal planets in terms of composition
- Like miniature solar systems
 - moons
 - rings



Big Moons of Jupiter

Jupiter's inner big moon, Io, is smaller than Mercury but has active volcanos. What could supply the energy?

A. Tidal squeezing by Jupiter

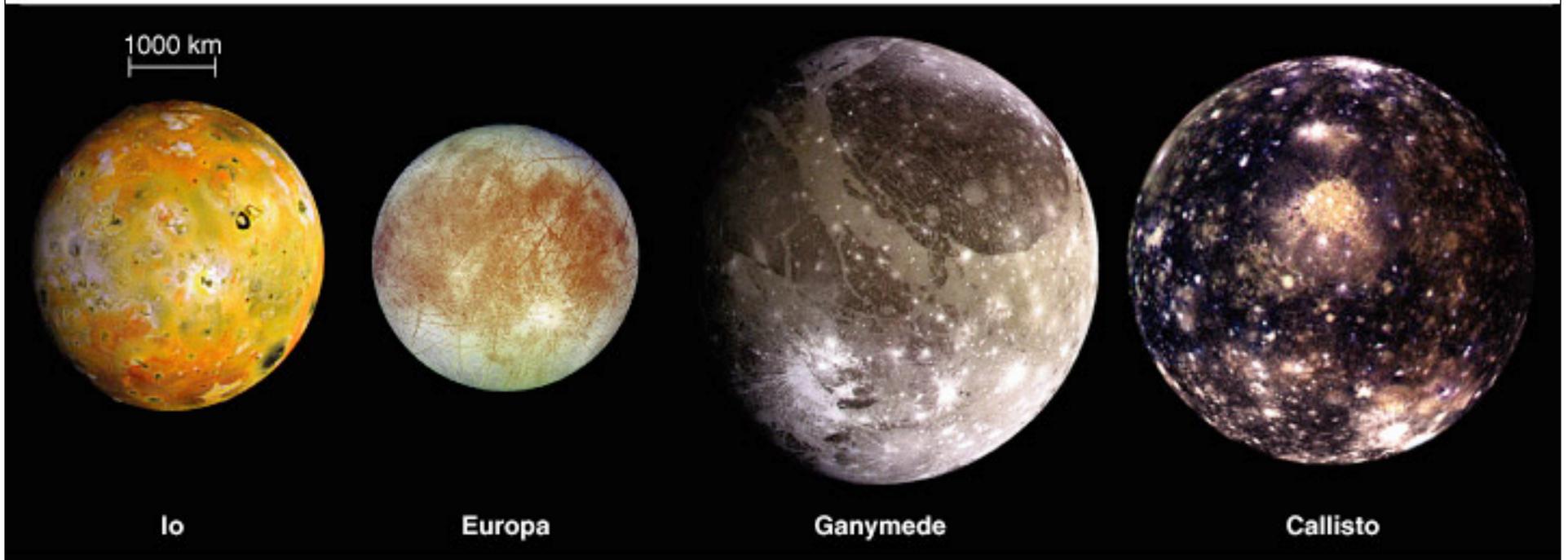
B. Radiation from Jupiter

C. Heat from the formation of Io

D. Radioactive elements inside Io

E. I don't know

The moons of the Jovian planets



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Galilean moons of Jupiter
("Medici stars")

Sizes of Moons

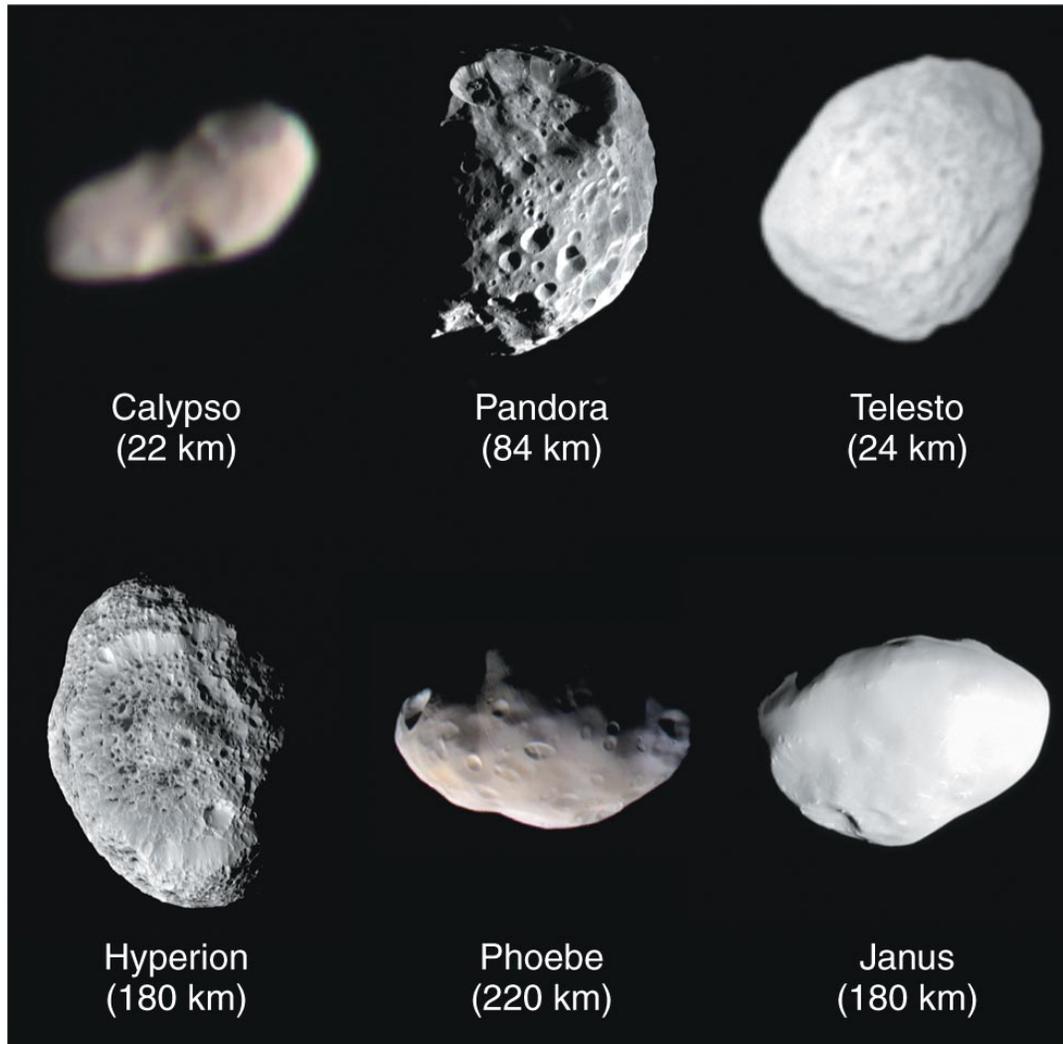
- Small moons (< 300 km)
 - No geological activity
- Medium-sized moons (300–1,500 km)
 - Geological activity in past
- Large moons ($> 1,500$ km)
 - Ongoing geological activity



Medium and Large Moons

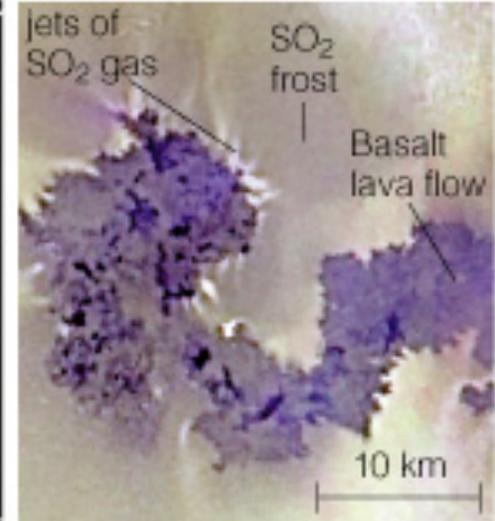
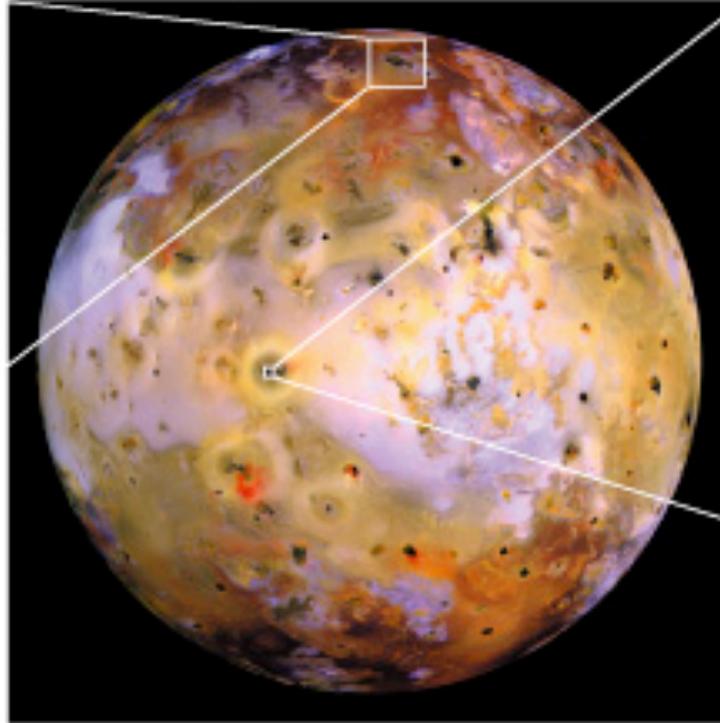
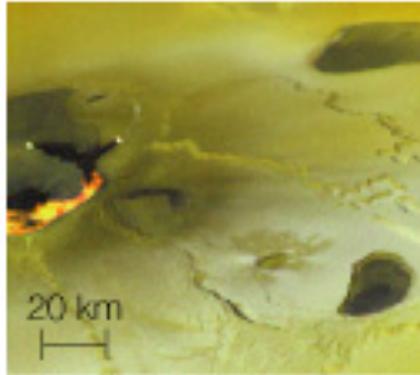
- Enough self-gravity to be spherical
- Have substantial amounts of ice - as important as rock to overall composition
- Formed in orbit around jovian planets
- Circular orbits mostly in the same direction as planet rotation

Small Moons



- Far more numerous than the medium and large moons
- Not enough gravity to be spherical: “potato-shaped”

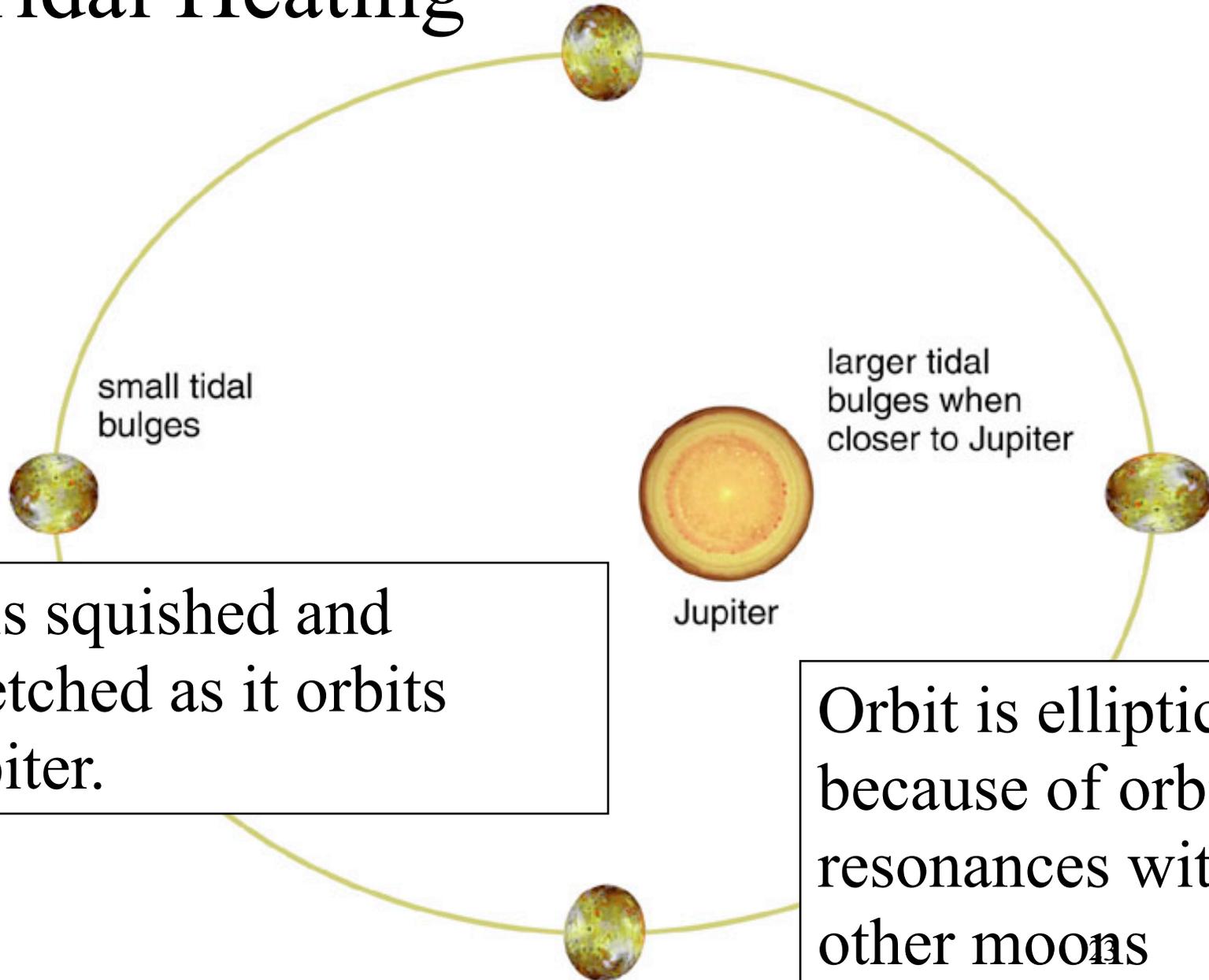
Some interesting cases:



Io

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

Tidal Heating

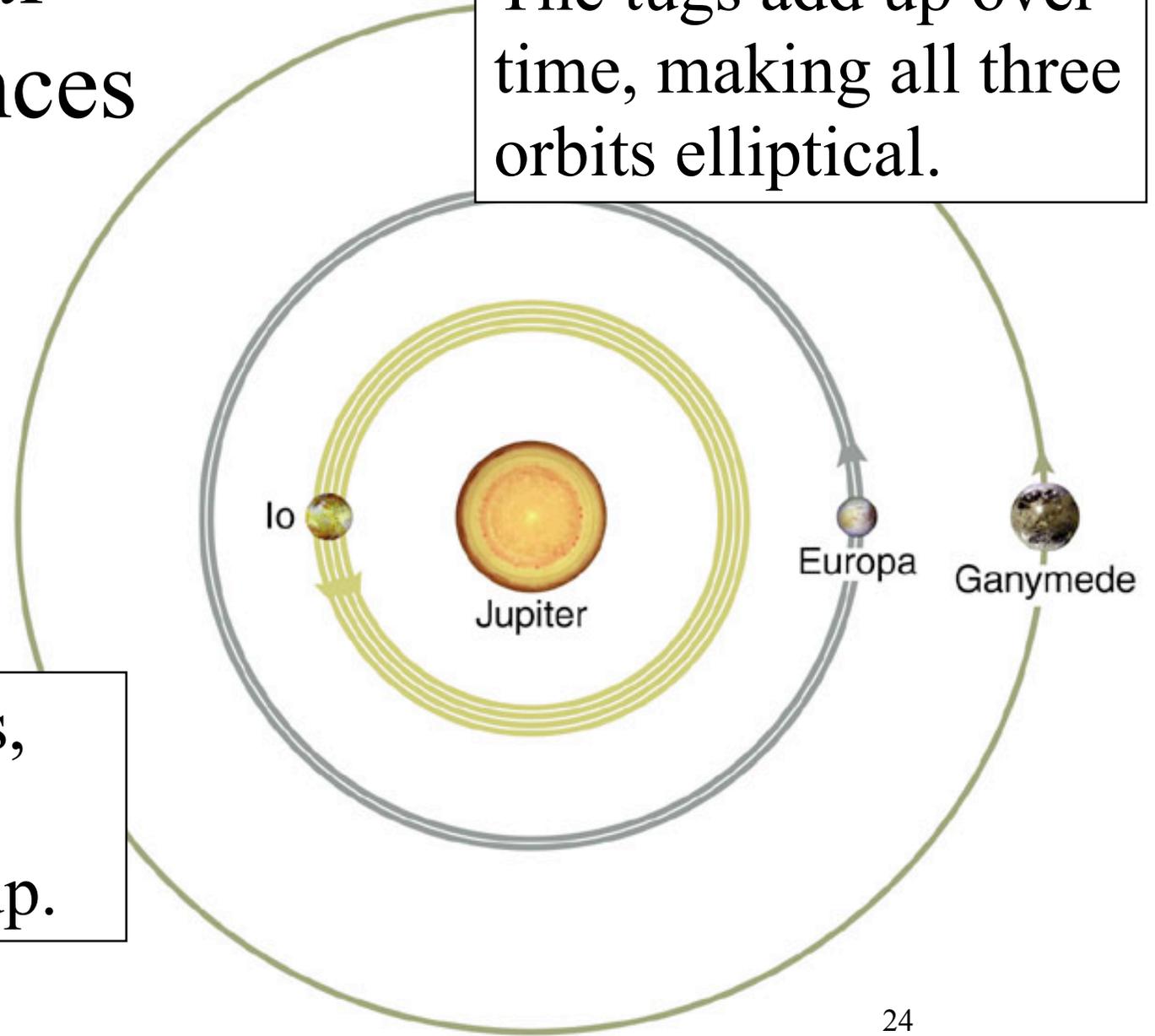


Io is squished and stretched as it orbits Jupiter.

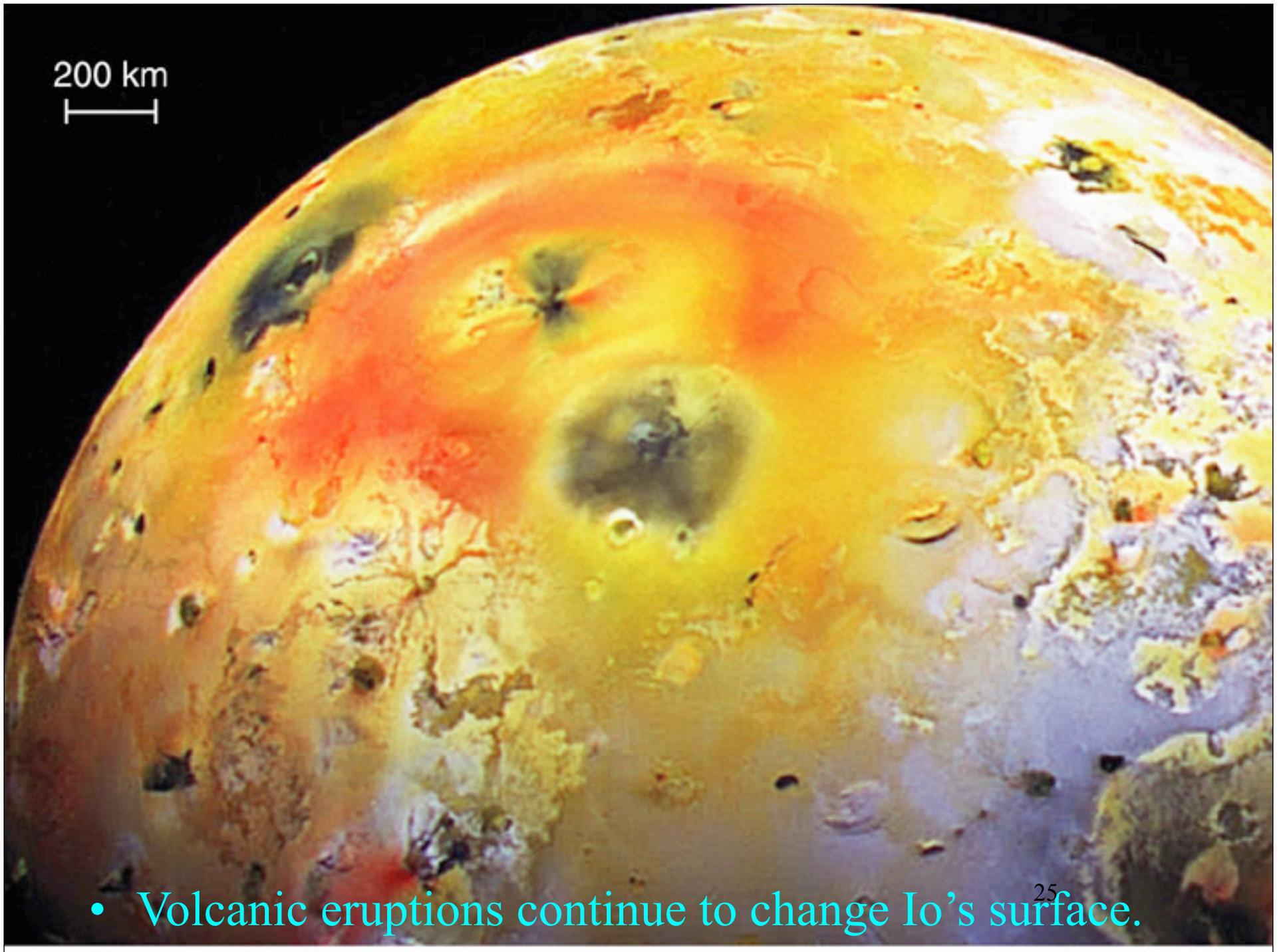
Orbit is elliptical because of orbital resonances with other moons

Orbital Resonances

The tugs add up over time, making all three orbits elliptical.

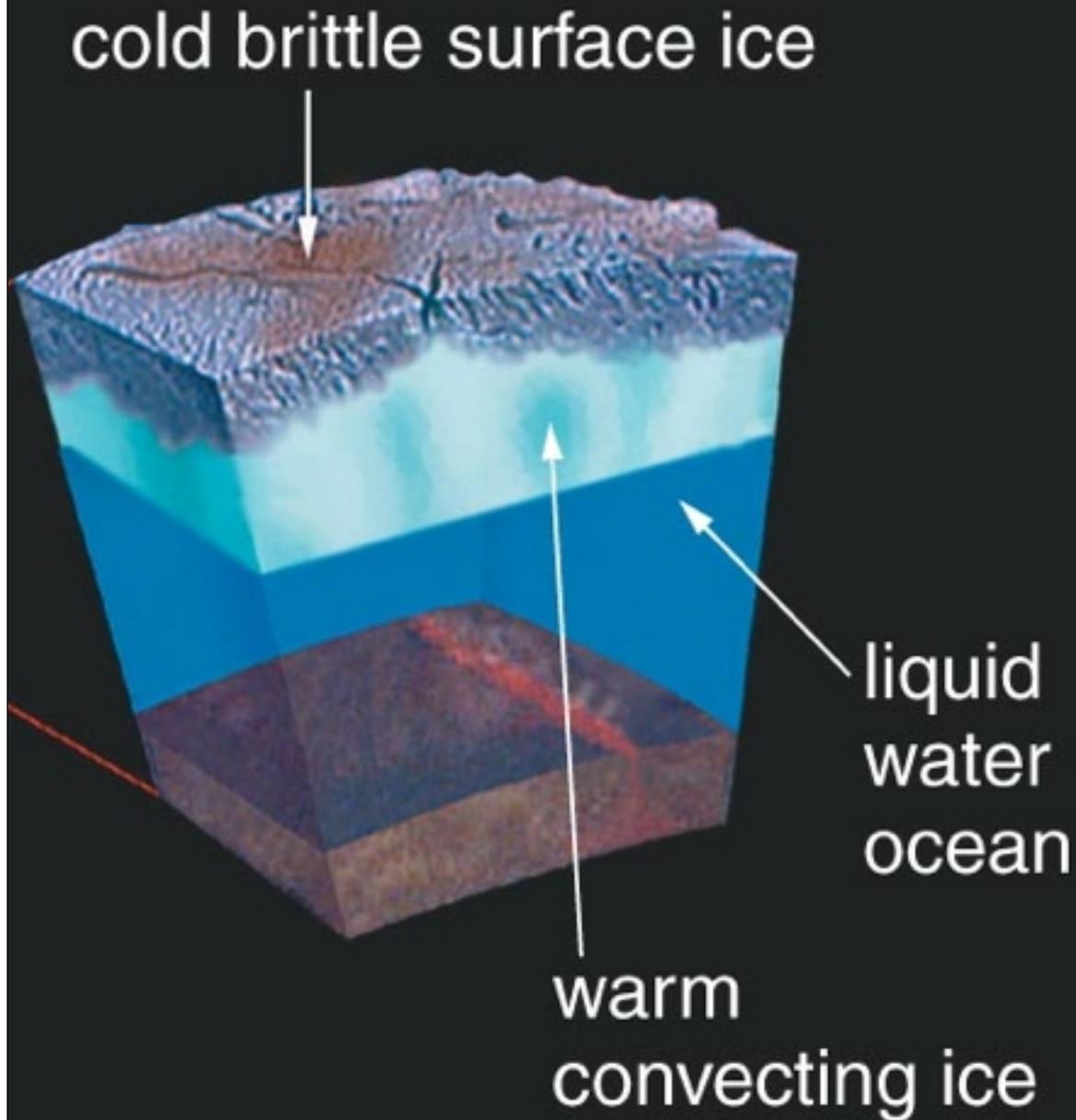


Every 7 days, these three moons line up.



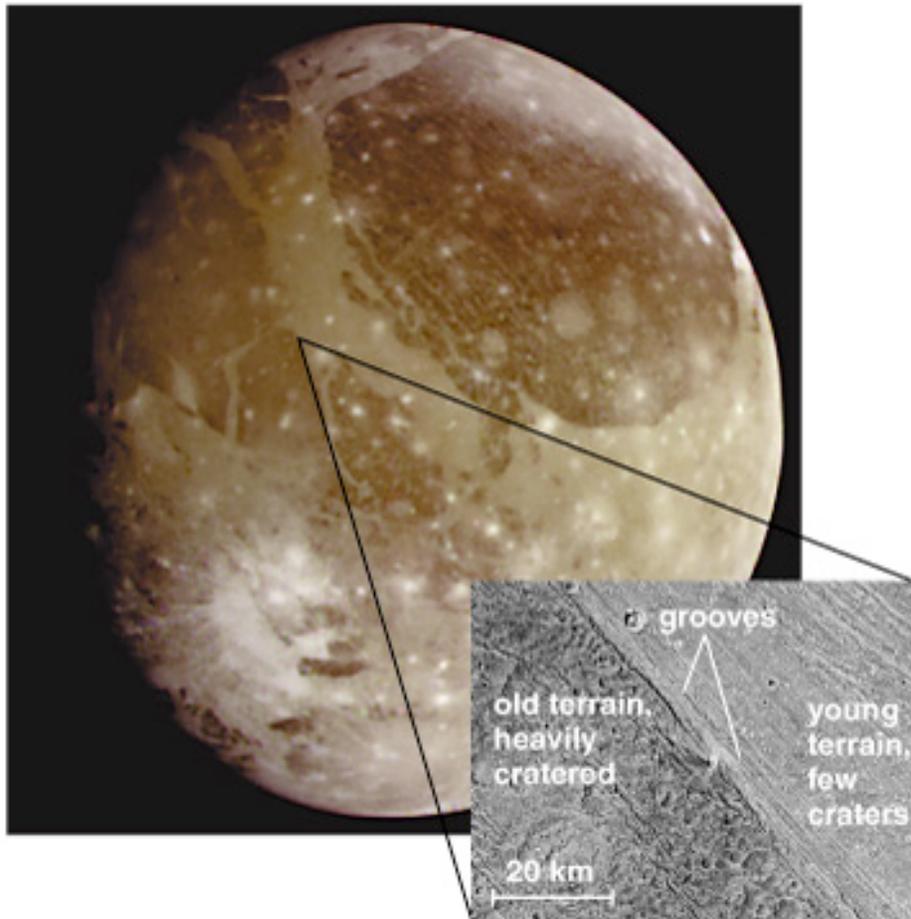
- Volcanic eruptions continue to change Io's surface.

Europa



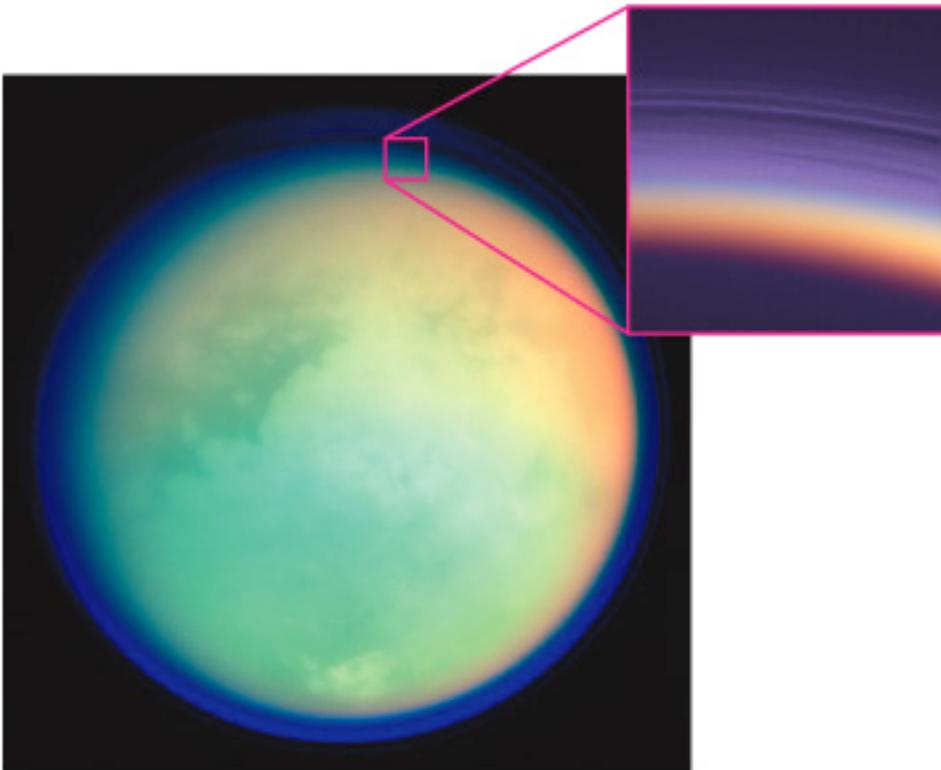
- Icy surface
 - cracks driven by some “geological” activity
- Liquid ocean beneath?
 - popular spot to speculate about the potential for life

Ganymede



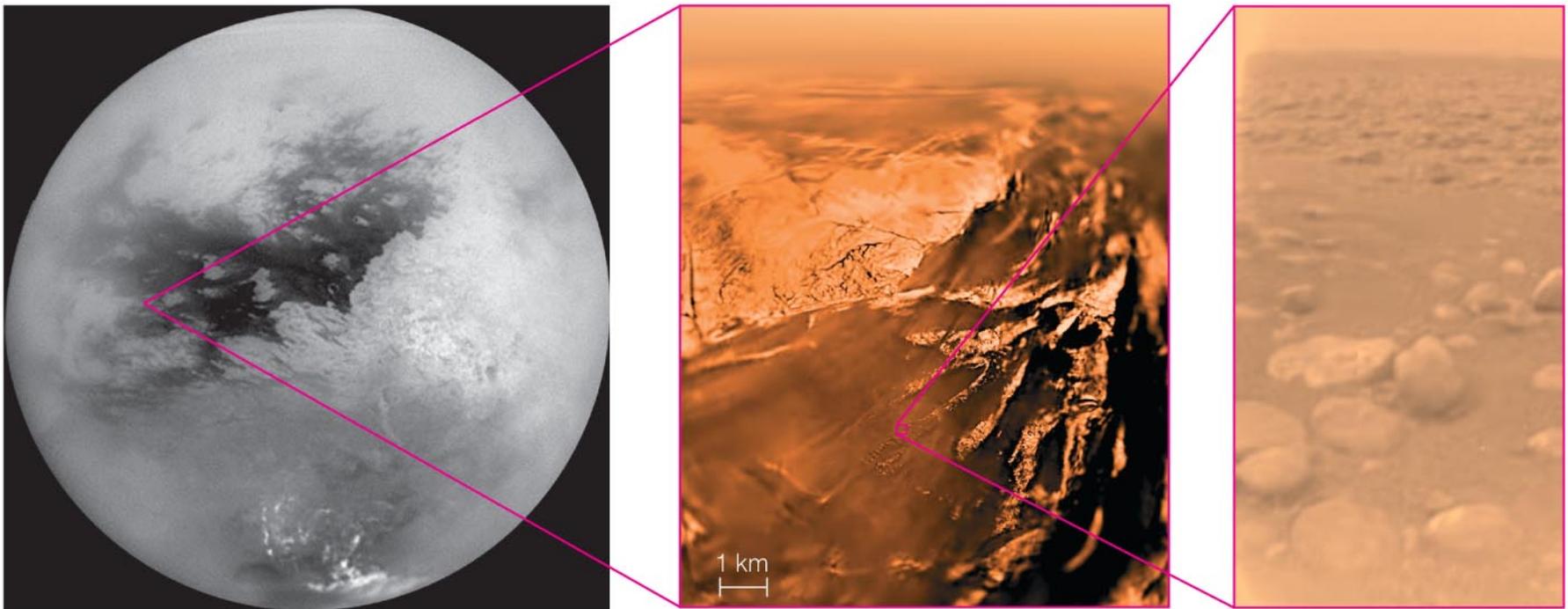
- Largest moon in the solar system
- Clear evidence of geological activity
- Tidal heating plus heat from radioactive decay?

Saturn's large moon Titan



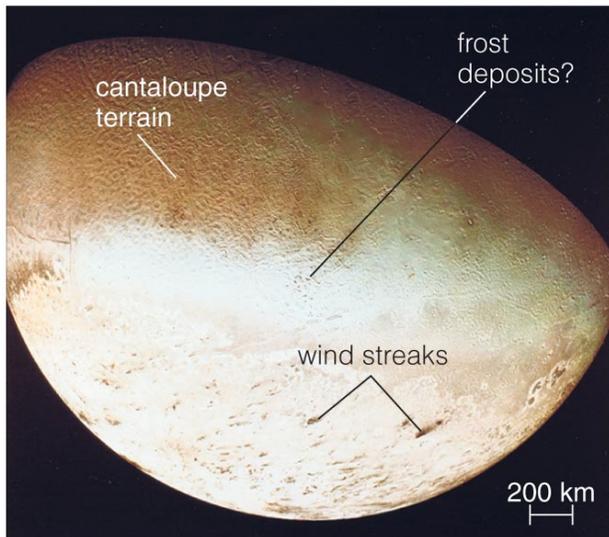
- Titan is the only moon in the solar system which has a thick atmosphere.
- It consists mostly of nitrogen with some argon, methane, and ethane.

Titan's Surface

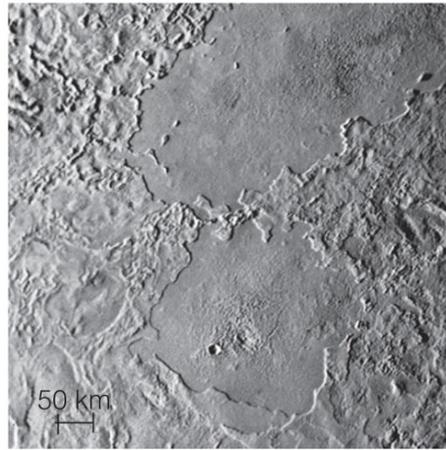


- The *Huygens* probe provided a first look at Titan's surface in early 2005.
- It had liquid methane, “rocks” made of ice.

Neptune's Moon Triton



Triton's southern hemisphere as seen by *Voyager 2*.



This close-up shows lava-filled impact basins similar to the lunar maria, but the lava was water or slush rather than molten rock.

- Similar to Pluto, but larger
- Evidence for past geological activity
- orbits retrograde
 - unique for such a large moon

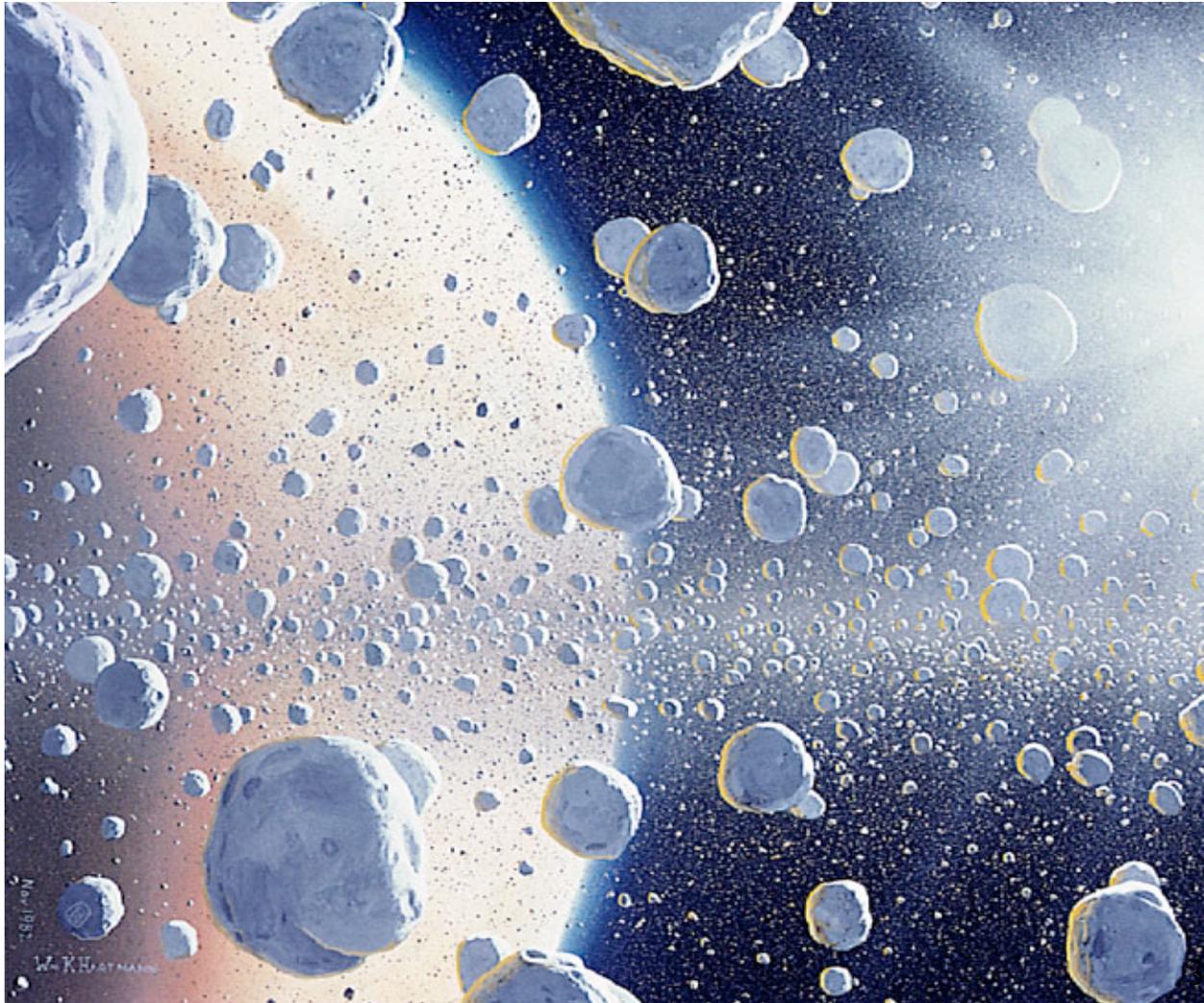
Saturn's rings



What are Saturn's rings like?

- They are made up of numerous, small, icy particles.
- They orbit over Saturn's equator.
- They are very thin.

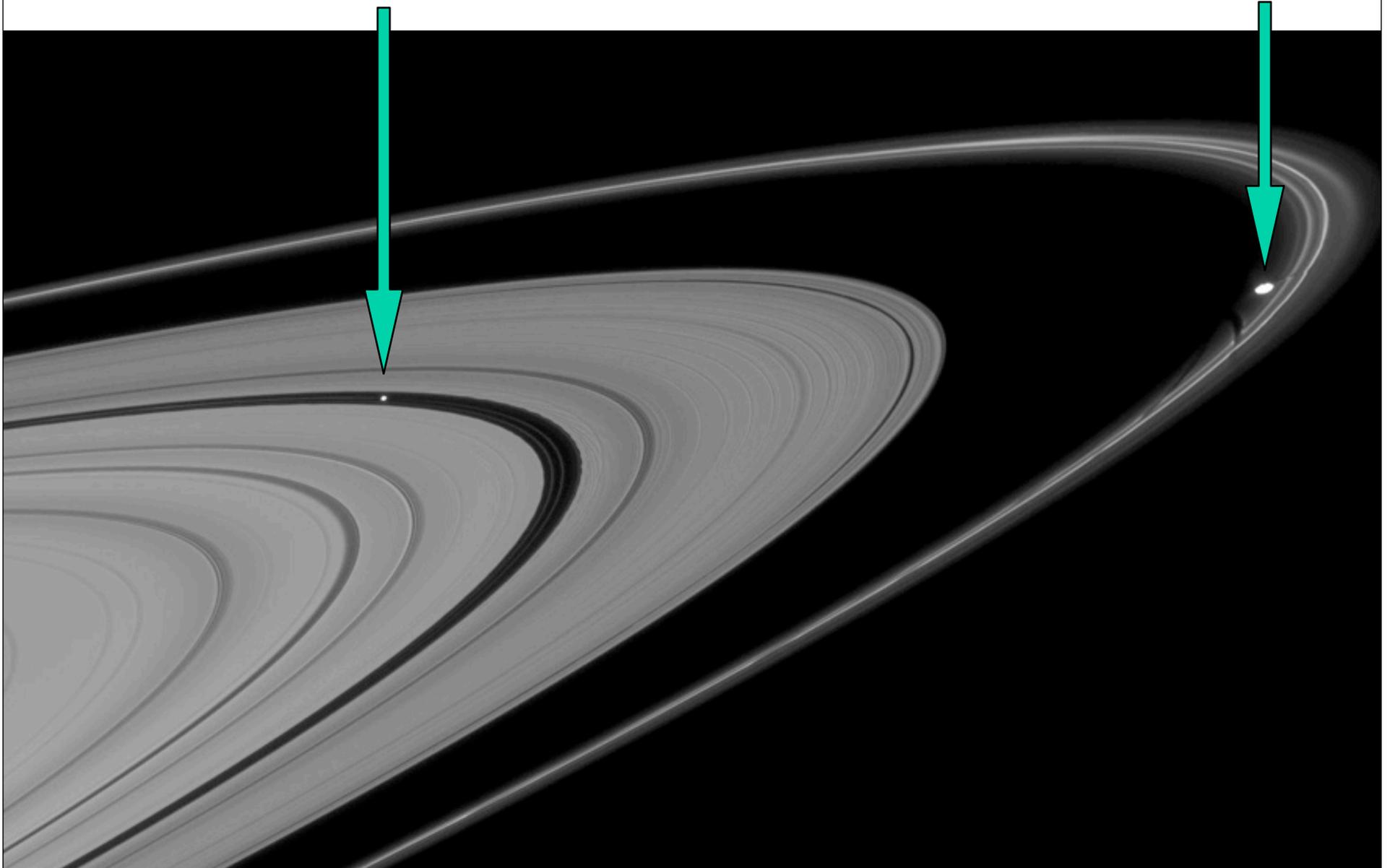
Artist's Conception of Ring



Elaborate structure in rings controlled by the gravity of “shepherd” moons

Pan

Prometheus



Newly discovered outer ring



Co-discovered by our own Professor Doug Hamilton!

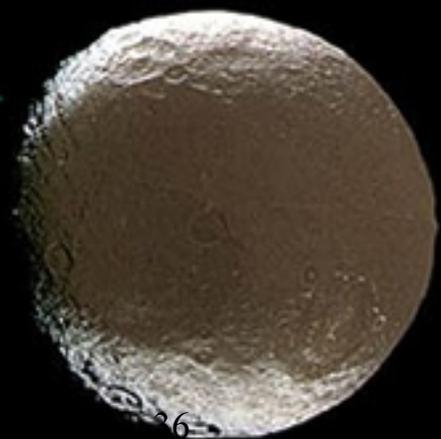
Saturn

Phoebe

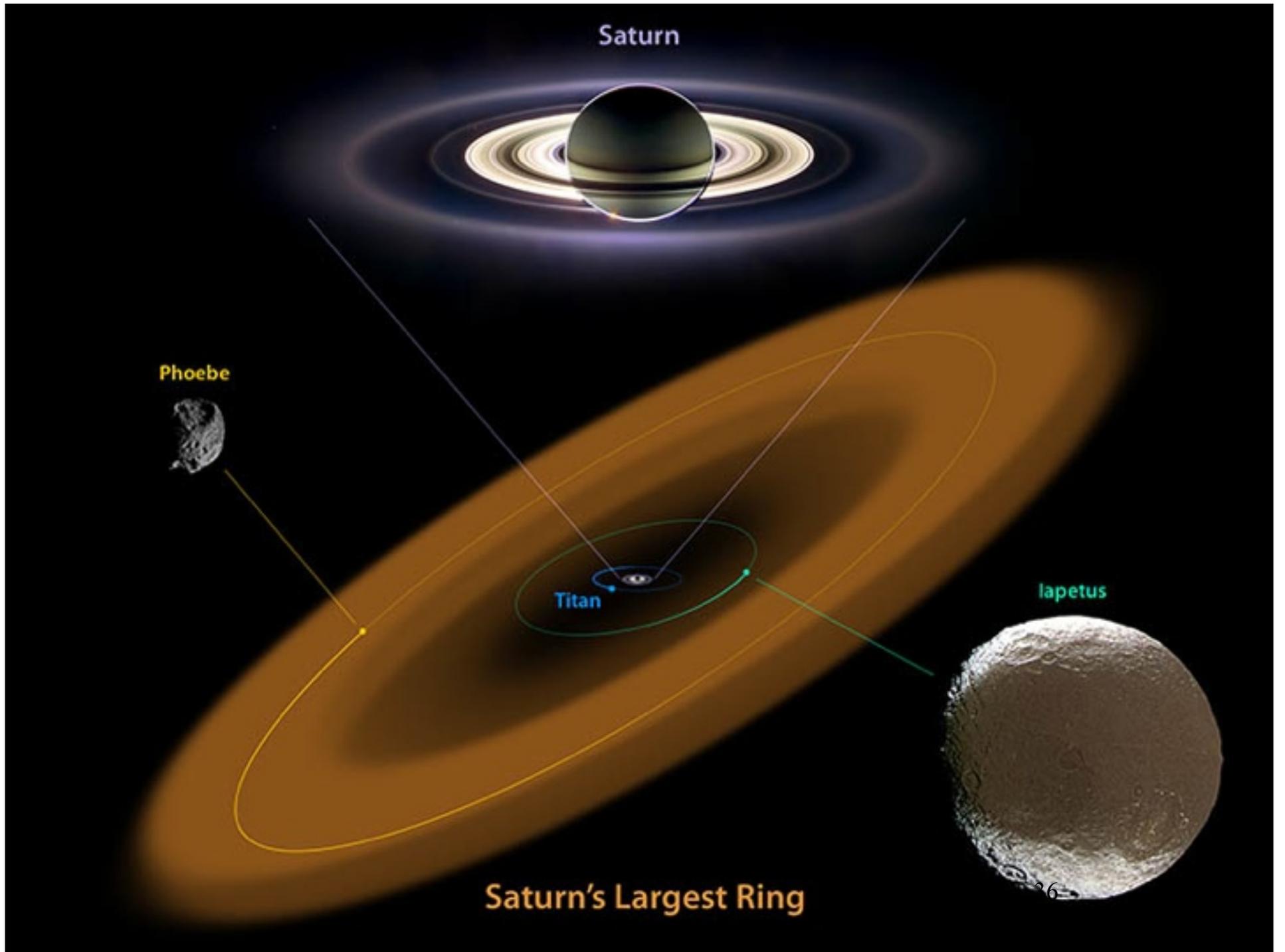


Titan

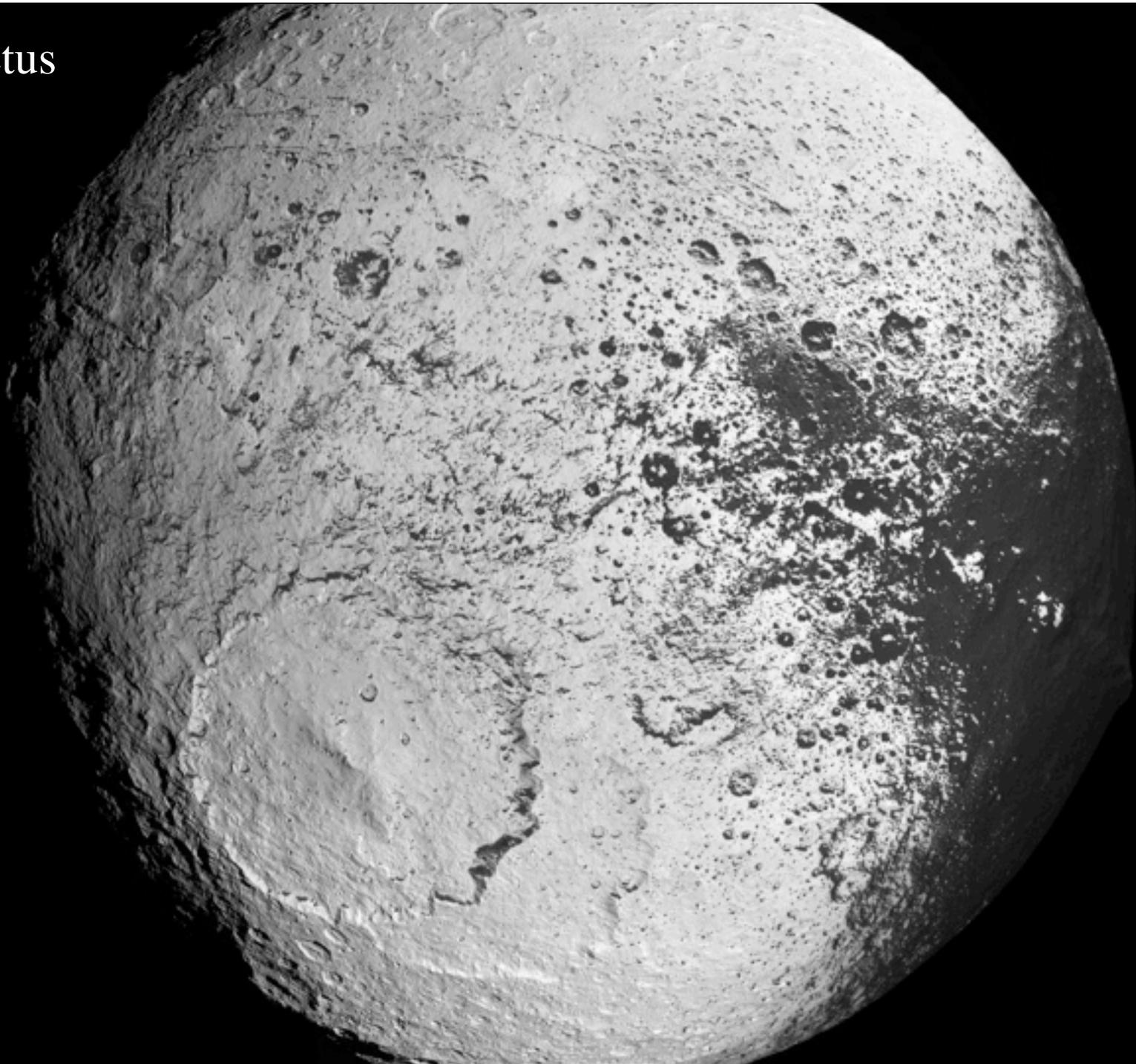
Iapetus



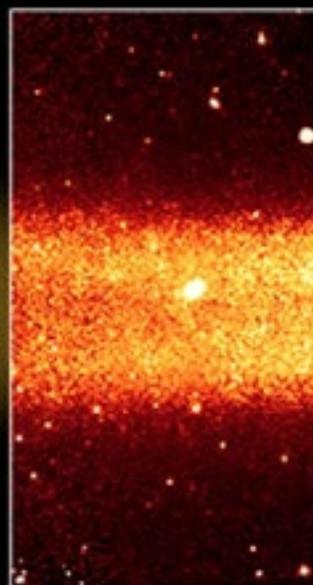
Saturn's Largest Ring



Iapetus



actual data

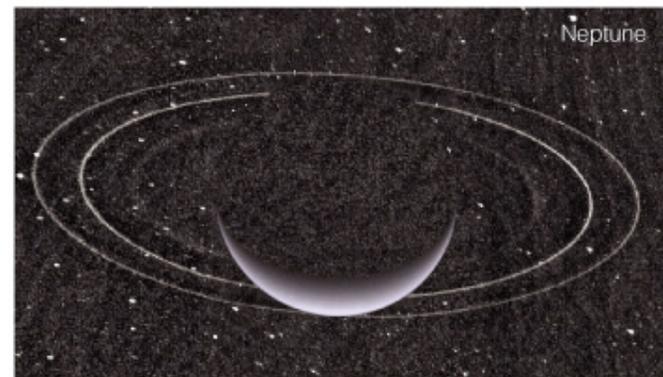
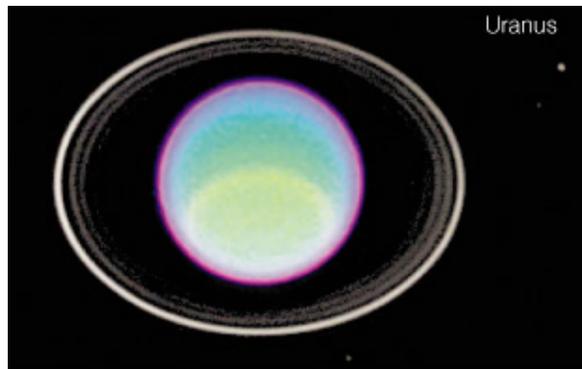
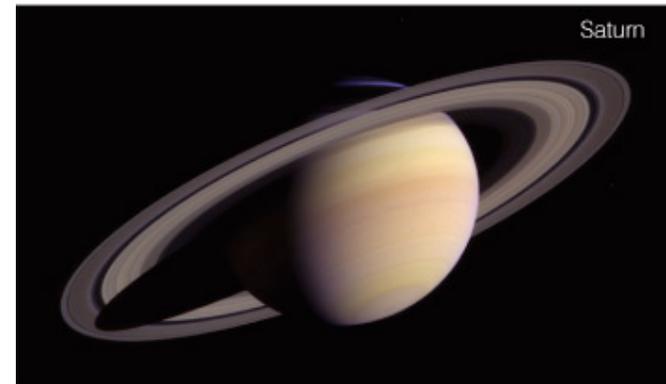
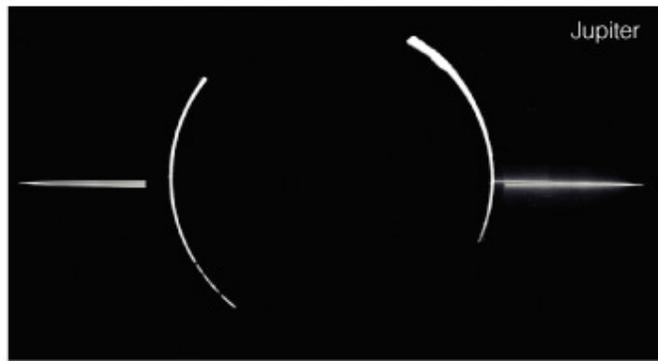


Dust Ring

Saturn



Jovian Ring Systems



- All four jovian planets have ring systems.
- Others have smaller, darker ring particles than does Saturn.
- Rings and moons ubiquitous around Jovian planets
 - like small solar systems.