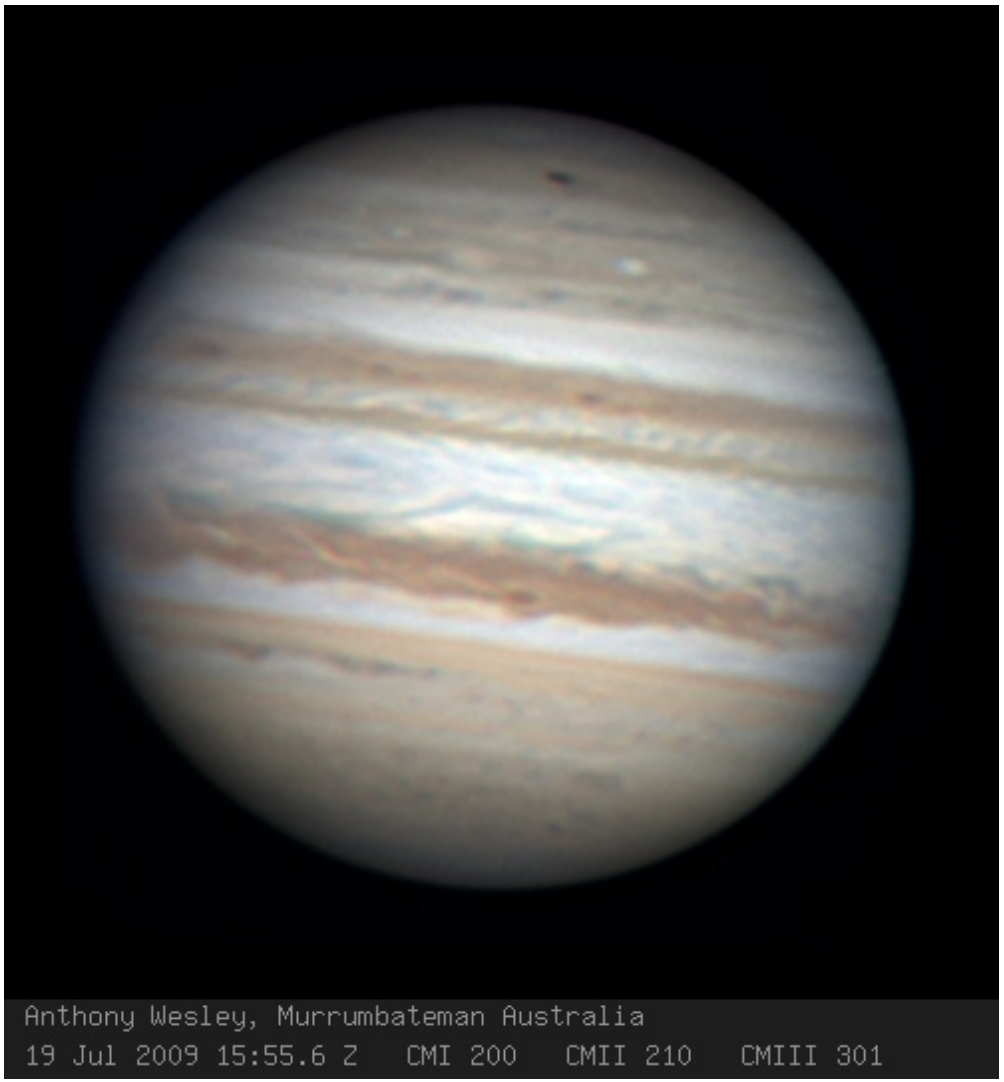
The Composition and Interior of Jupiter



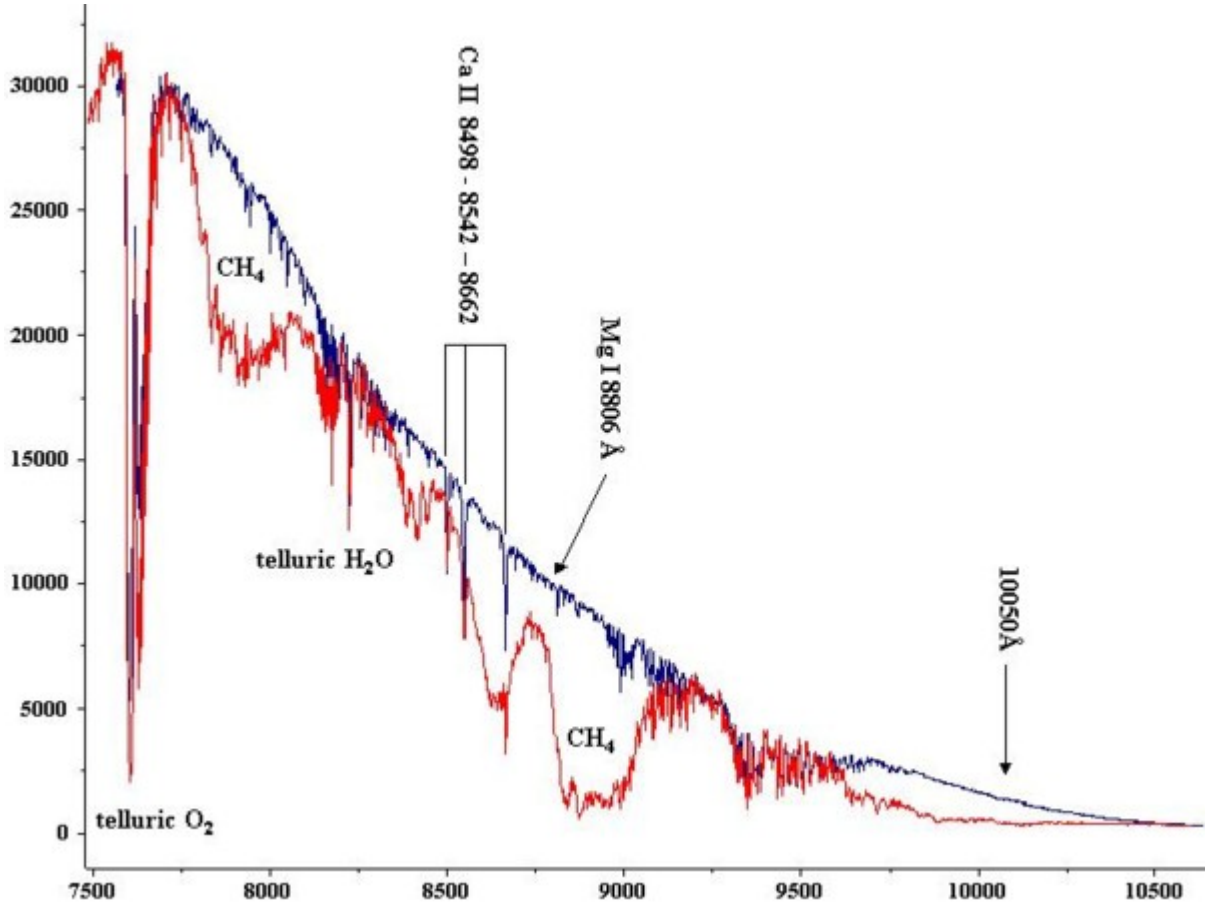
The Chemical Composition of Jupiter and Saturn

The densities of Jupiter and Saturn are about that of water (Jupiter is 1.33 grams/cc, Saturn is 0.69 grams/cc). Basic physics shows that objects with the mass, size, and density of Jupiter and Saturn must be made of very light elements. Specifically, they must be composed nearly completely of hydrogen and helium.

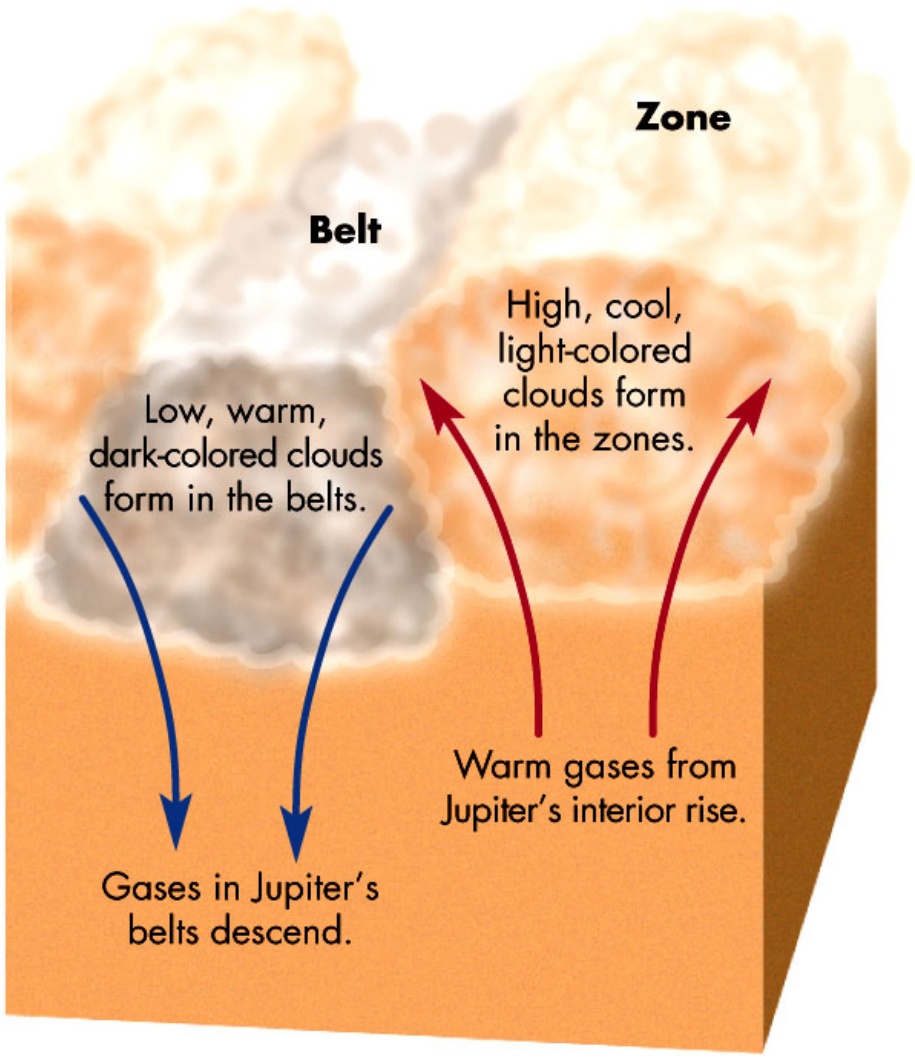
Although we reach this conclusion on the basis of theoretical physics, this conclusion is borne out by all observations. The spectrum of Jupiter shows absorption lines due to hydrogen-rich molecules such as ammonia (NH3), methane (CH4), and water, as well as others hydrocarbons such as acetylene, ethane, and propane. This chemical composition was also verified by the Galileo spacecraft probe, which descended into the atmosphere of Jupiter.

Read the quotation in the text about the fact that Jupiter and Saturn are nearly completely composed of hydrogen and helium. *In this, they have the same*

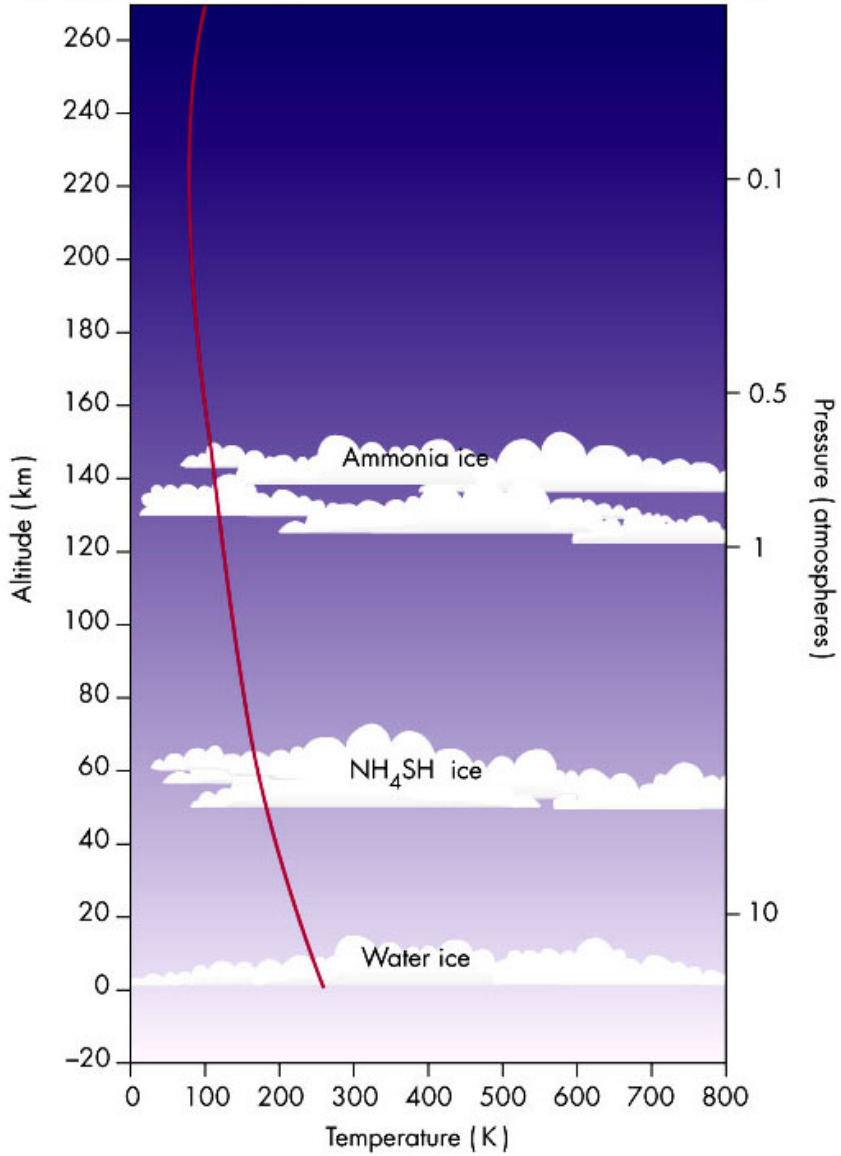
An observational indicator of hydrogen in the atmosphere of Jupiter: absorption lines of hydrogen-bearing molecules in the spectrum of Jupiter



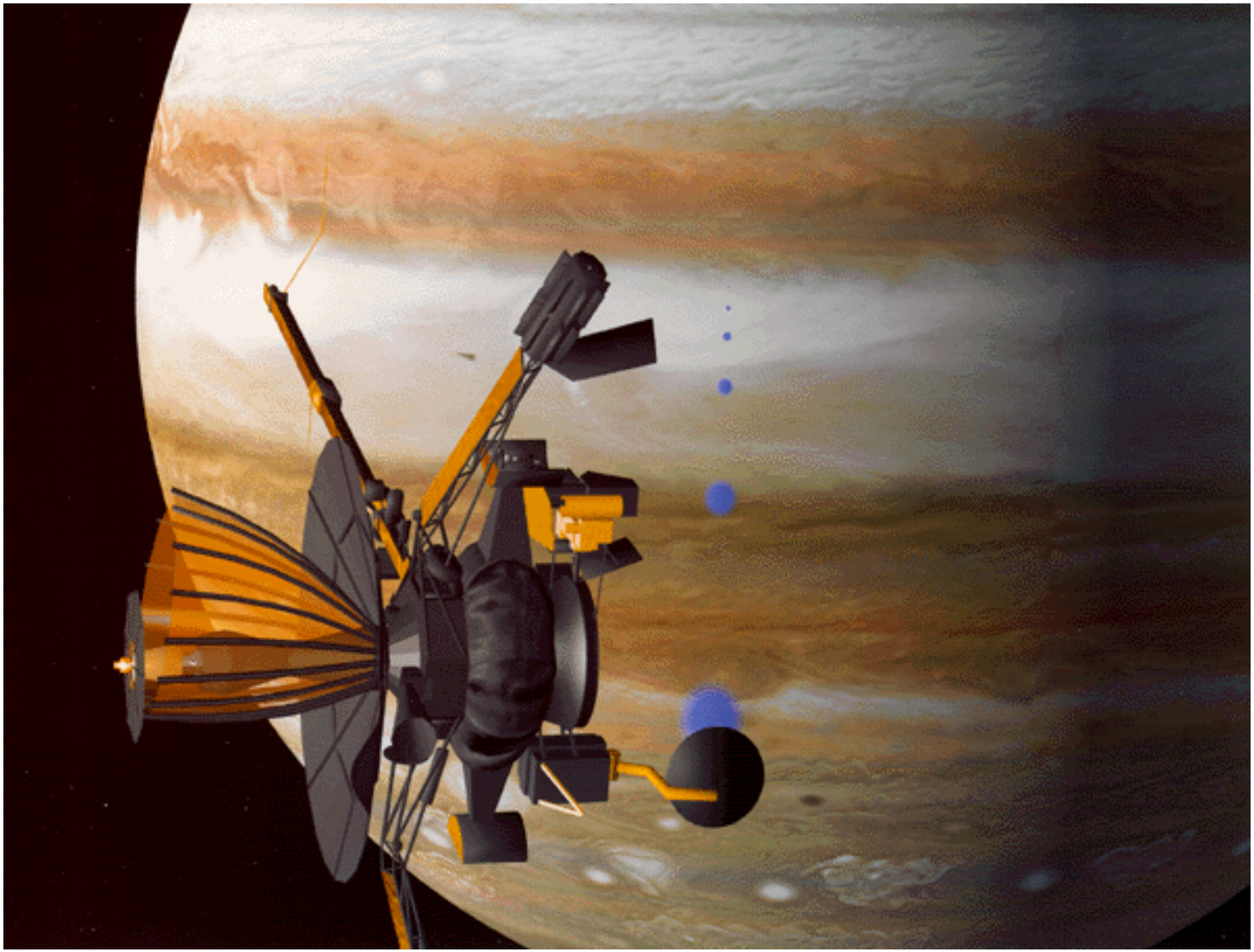
The cloud bands of Jupiter



The atmospheric structure of Jupiter

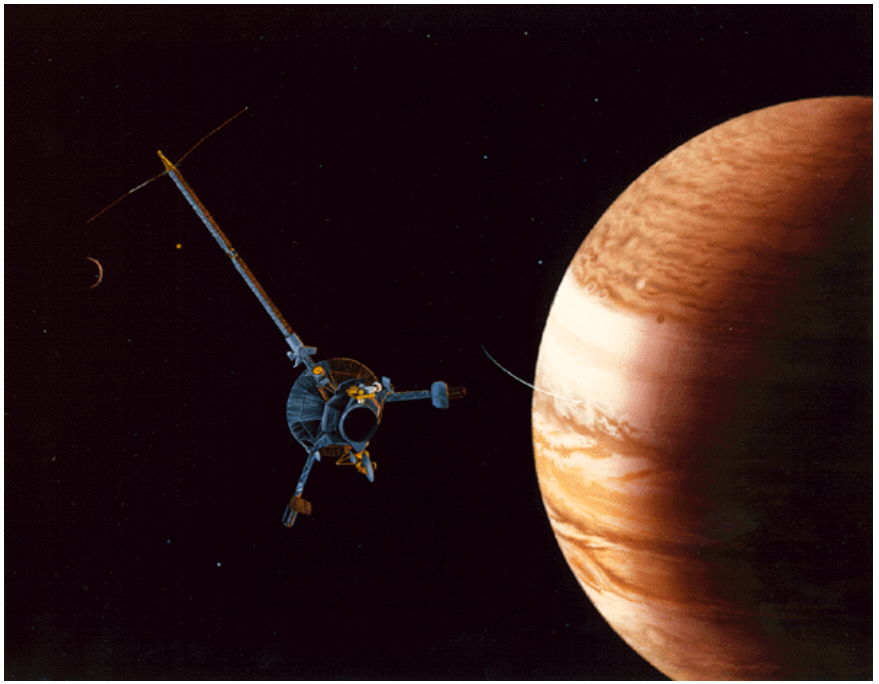


Exploration of Jupiter



The Galileo spacecraft mission

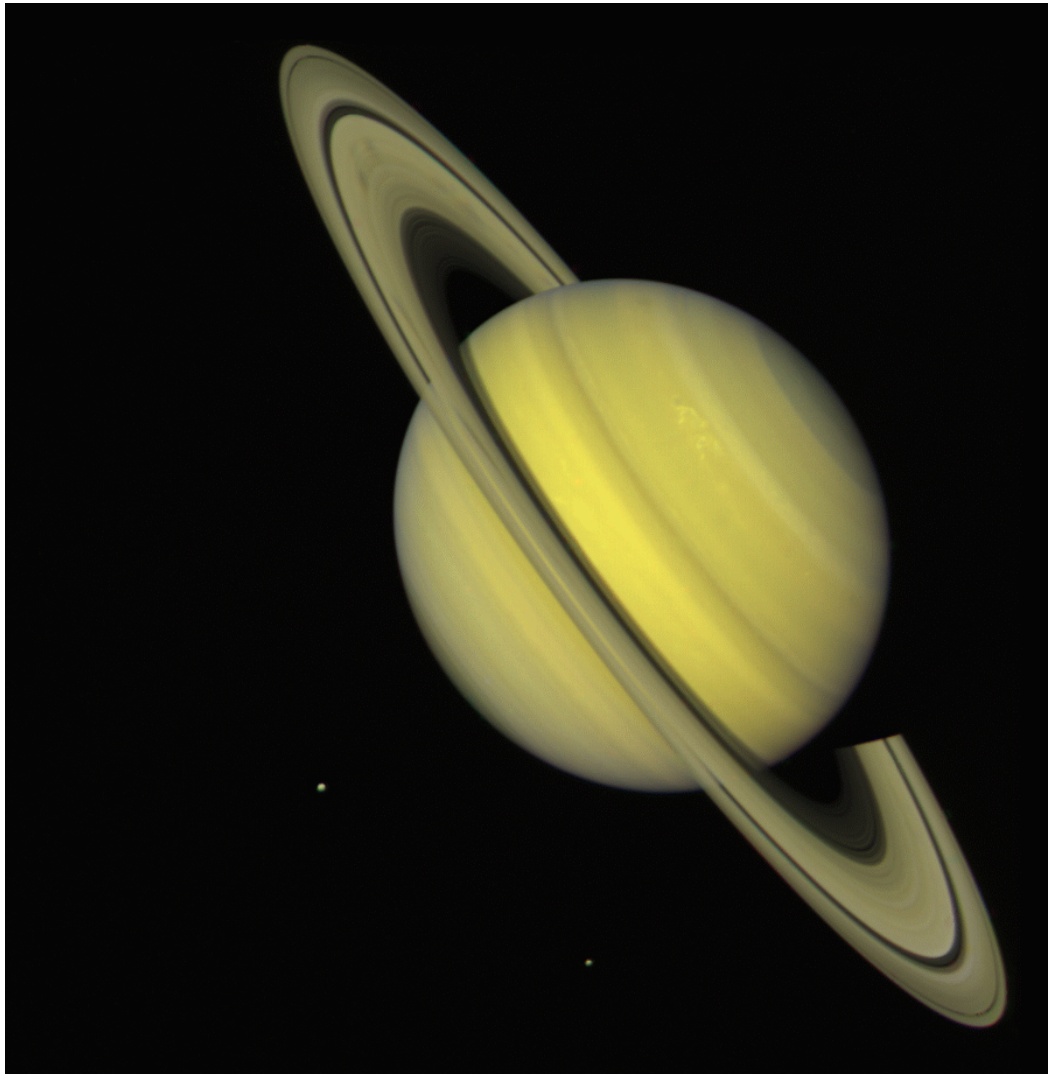
- Launch: October 1989
- Arrival at Jupiter: December 1995
- End of mission (dive into Jupiter): September 2003



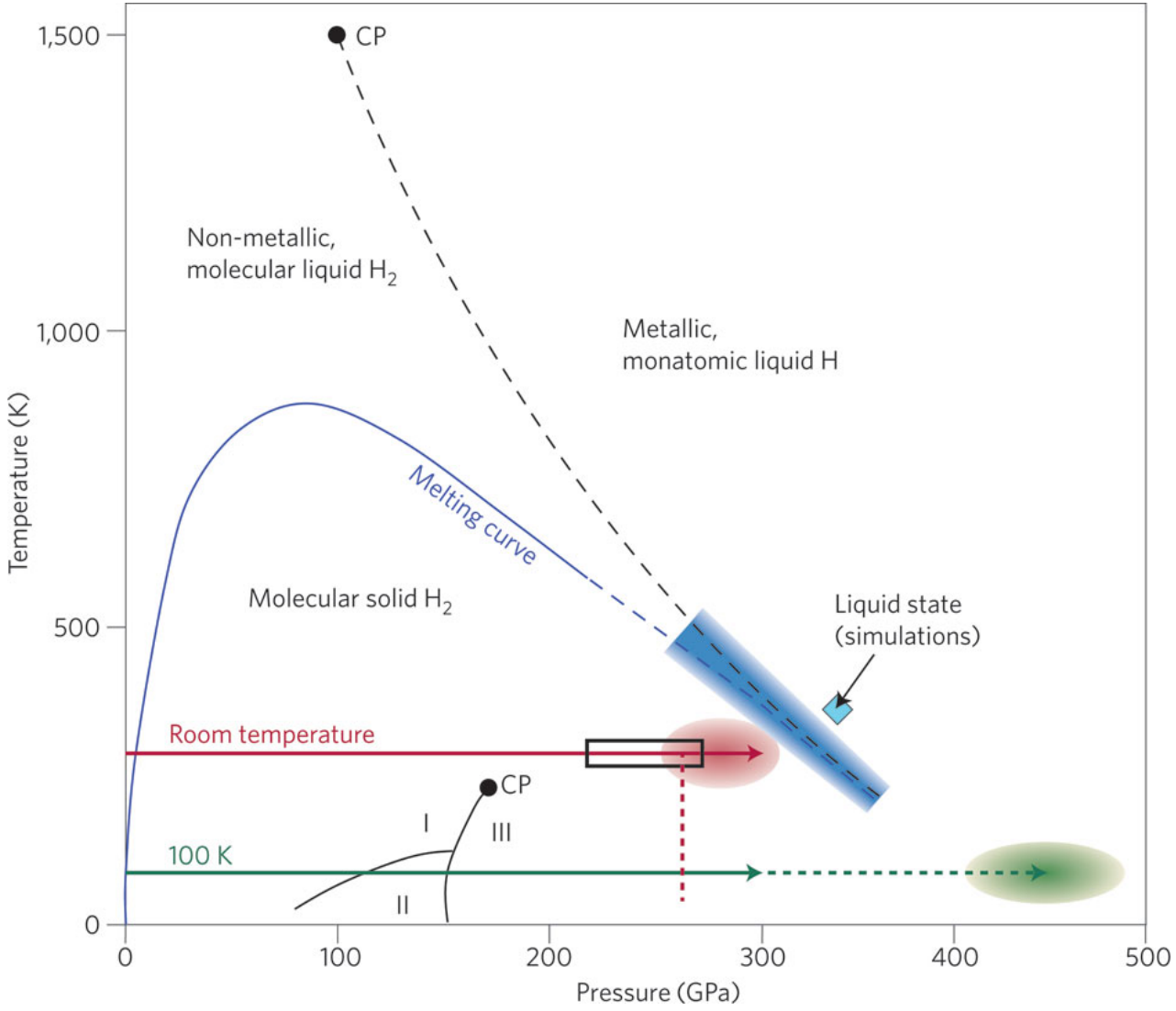
The Galileo Probe

The Galileo Probe

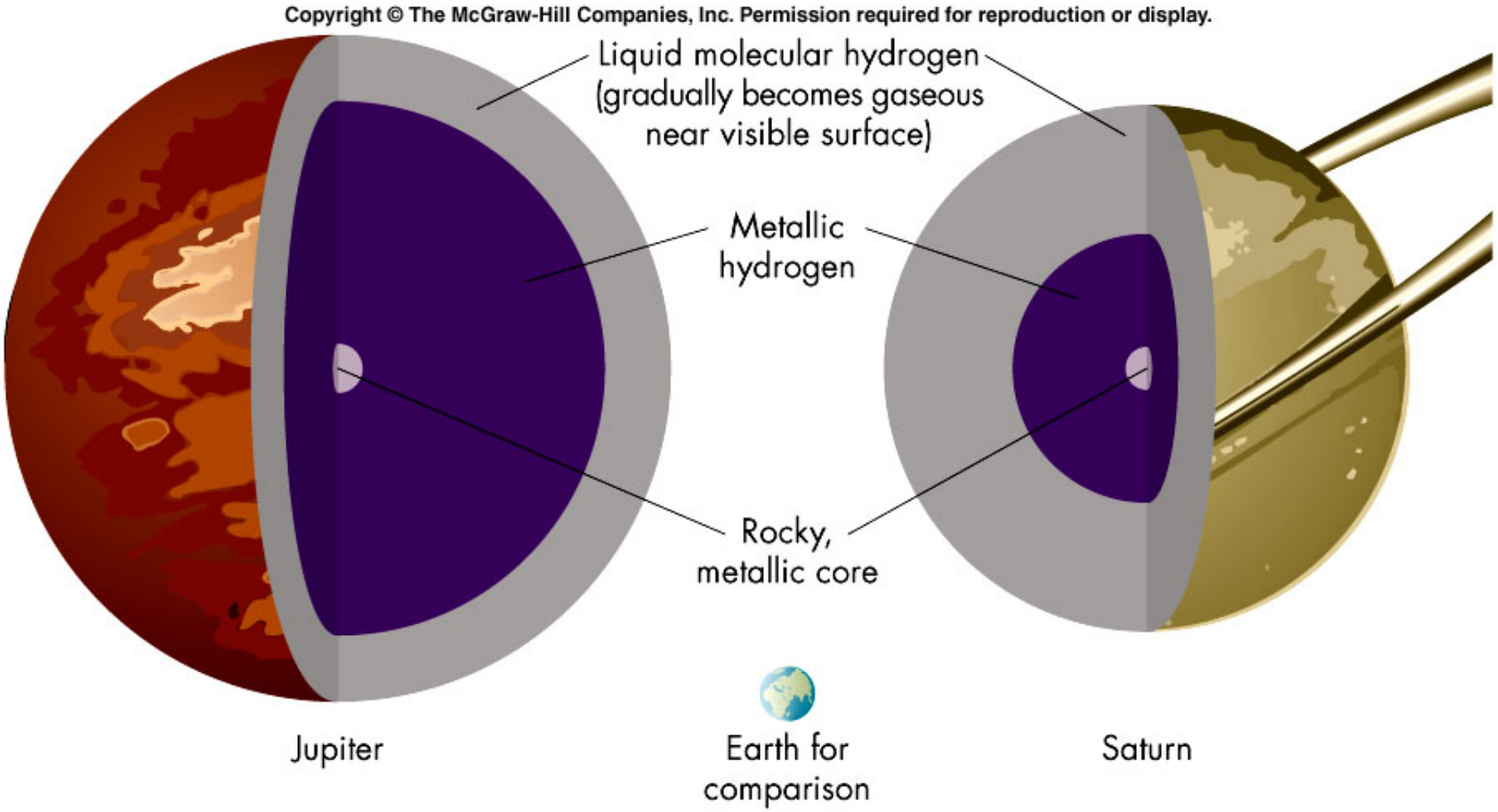
Given that Jupiter and Saturn are balls of hydrogen, what can we say about their internal structure?



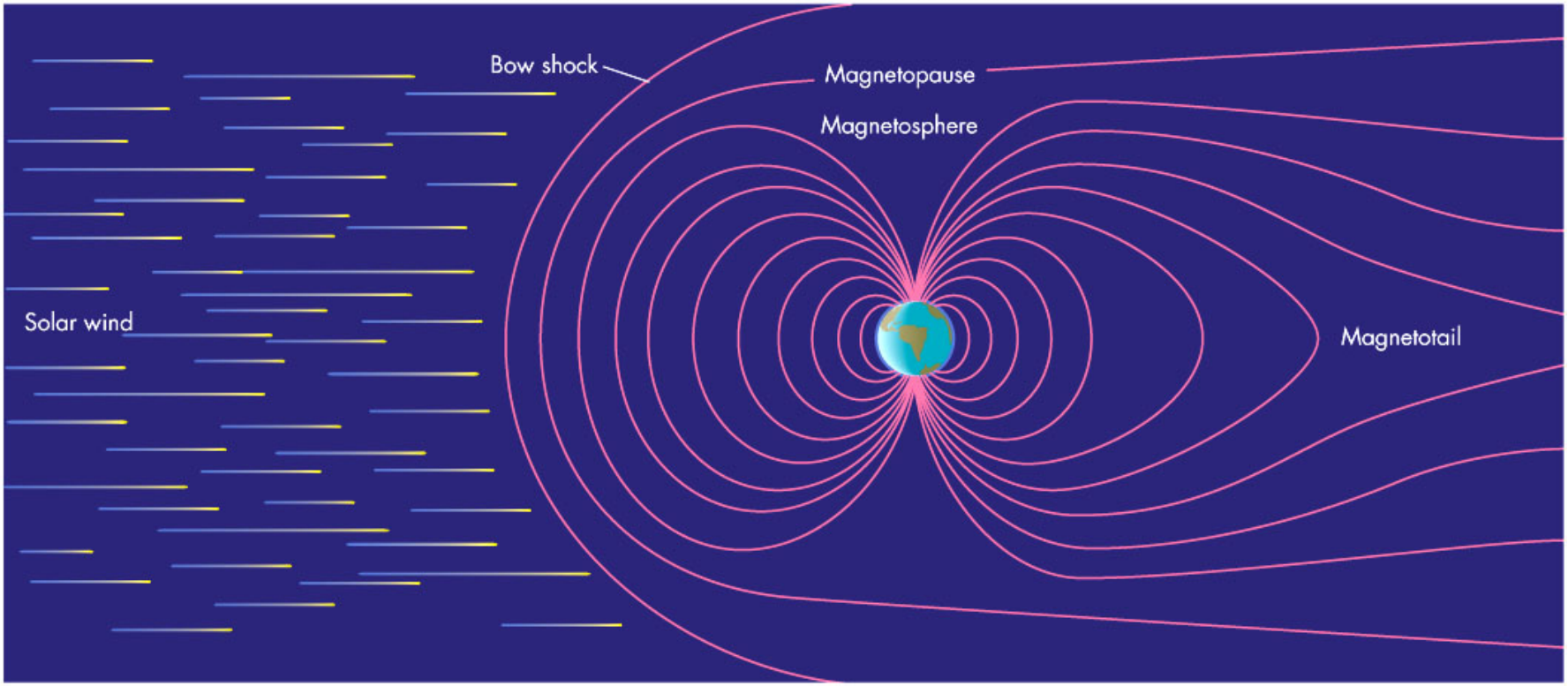
At high enough pressures, hydrogen can be come a liquid, and even a liquid metal



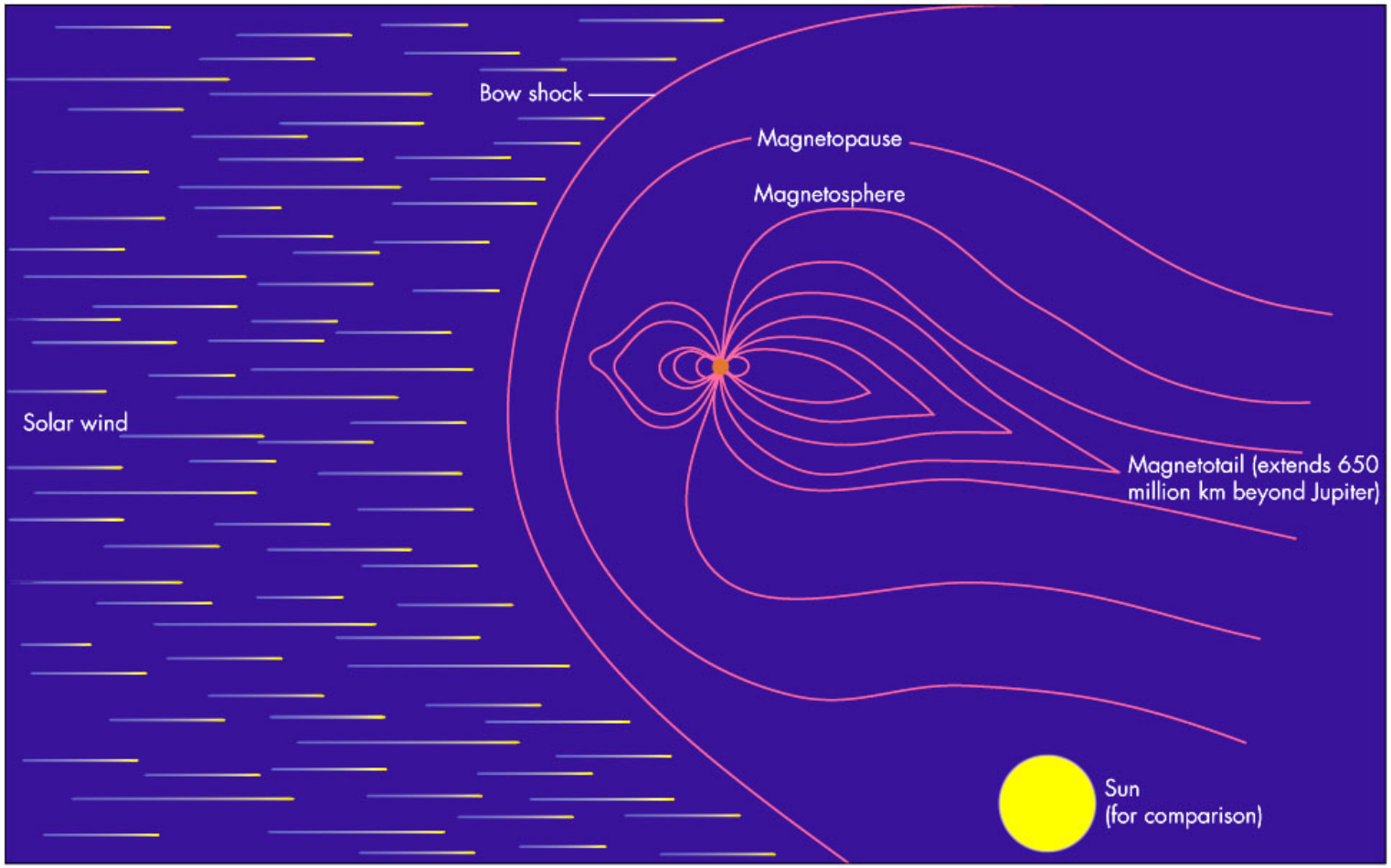
The interior structure of Jupiter (and Saturn)



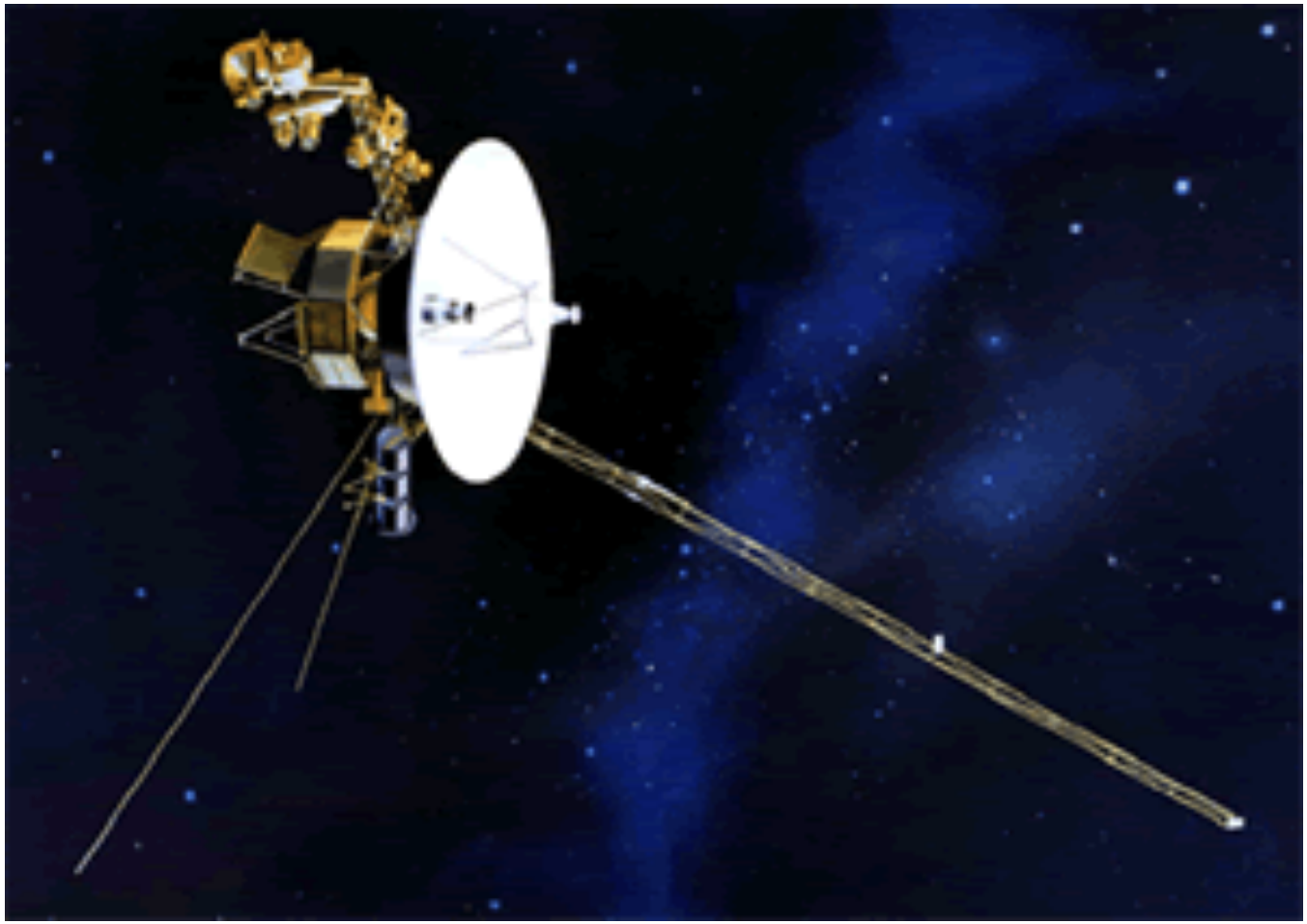
Magnetospheres 1: the Earth and the Van Allen Belts



Magnetospheres 2: the magnetosphere of Jupiter



University of Iowa connection…plasma waves and radio waves with the Voyager spacecraft



Sounds from the Voyager encounter with the Jovian bow shock

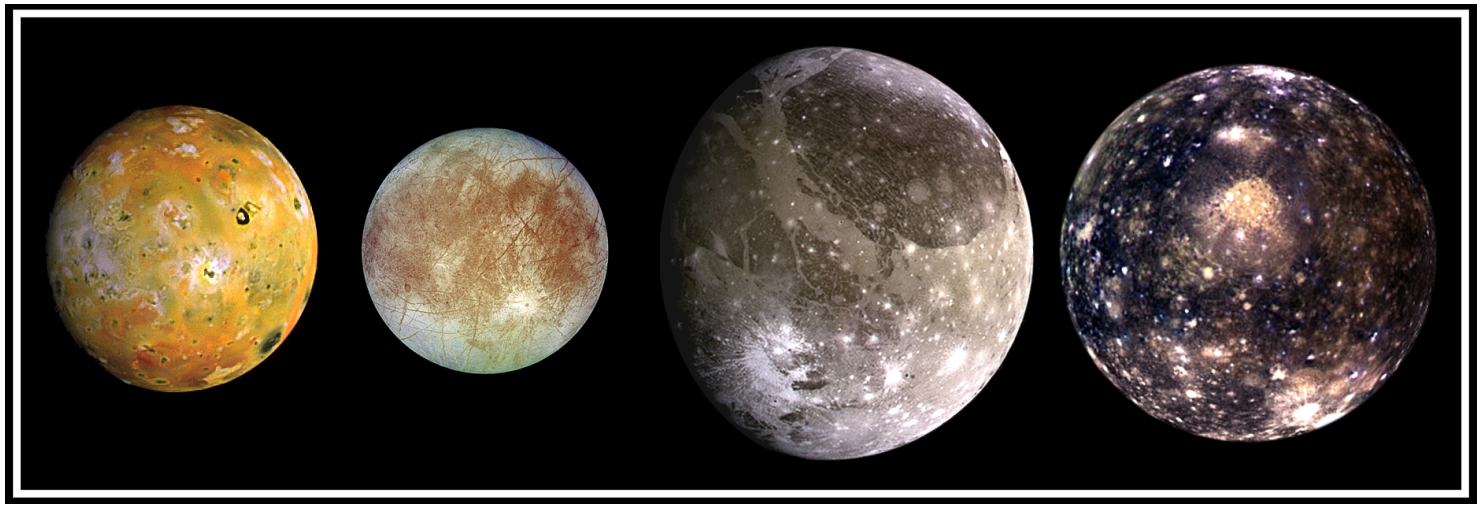
University of Iowa space plasma waves

In earlier lectures we saw how much we learned from studies of the Earth's moon (the Moon). It is the key to understanding the solar system

How much can we learn from the moons (or satellites) of the other planets?

Of the three solar system objects most interesting from the viewpoint of exobiology (existence of life in outer space), two are satellites of planets. Or possibly 3 of 4. The only one we have discussed is the planet Mars

Satellites in the solar system are an example of the fact that Nature always has surprises for us. The famous film *2001 A Space Odyssey* was insufficiently imaginative concerning the Galilean satellites of Jupiter



Why we knew so little about the Galilean satellites prior to the space age…. From Earth, they subtend a very small angle

During our observing session, the angular diameter of Saturn was 19 arcseconds (remember what an arcsecond is).

At that time, the angular diameter of the moon Titan (the star off to the left that night) was 0.84 arcseconds, smaller than the "seeing disk" due to the Earth's atmosphere.

The "top 7" moons in the solar system

Satellite	Planet	Diameter (km)	Mass (relative to Moon)
Ganymede	Jupiter	5262	2.03
Titan	Saturn	5150	1.83
Callisto	Jupiter	4820	1.46
Io	Jupiter	3640	1.21
Moon	Earth	3476	1.00
Europa	Jupiter	3122	0.66
Triton	Neptune	2700	0.29

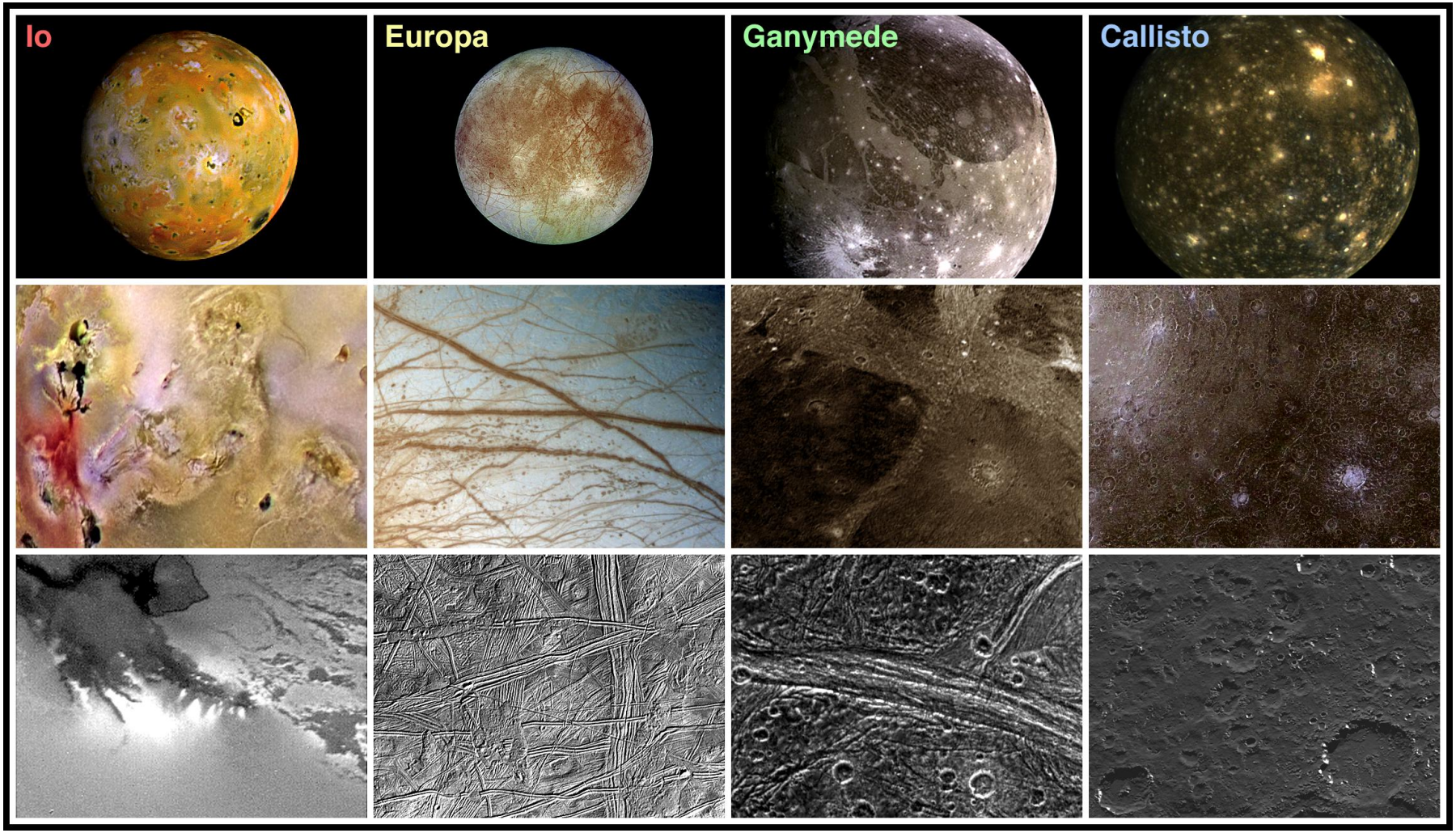
Let's start with the moons of Jupiter (especially the Galilean satellites)

Virtually nothing was known about the Moons of Jupiter prior to the arrival of spacecraft in the 1970s

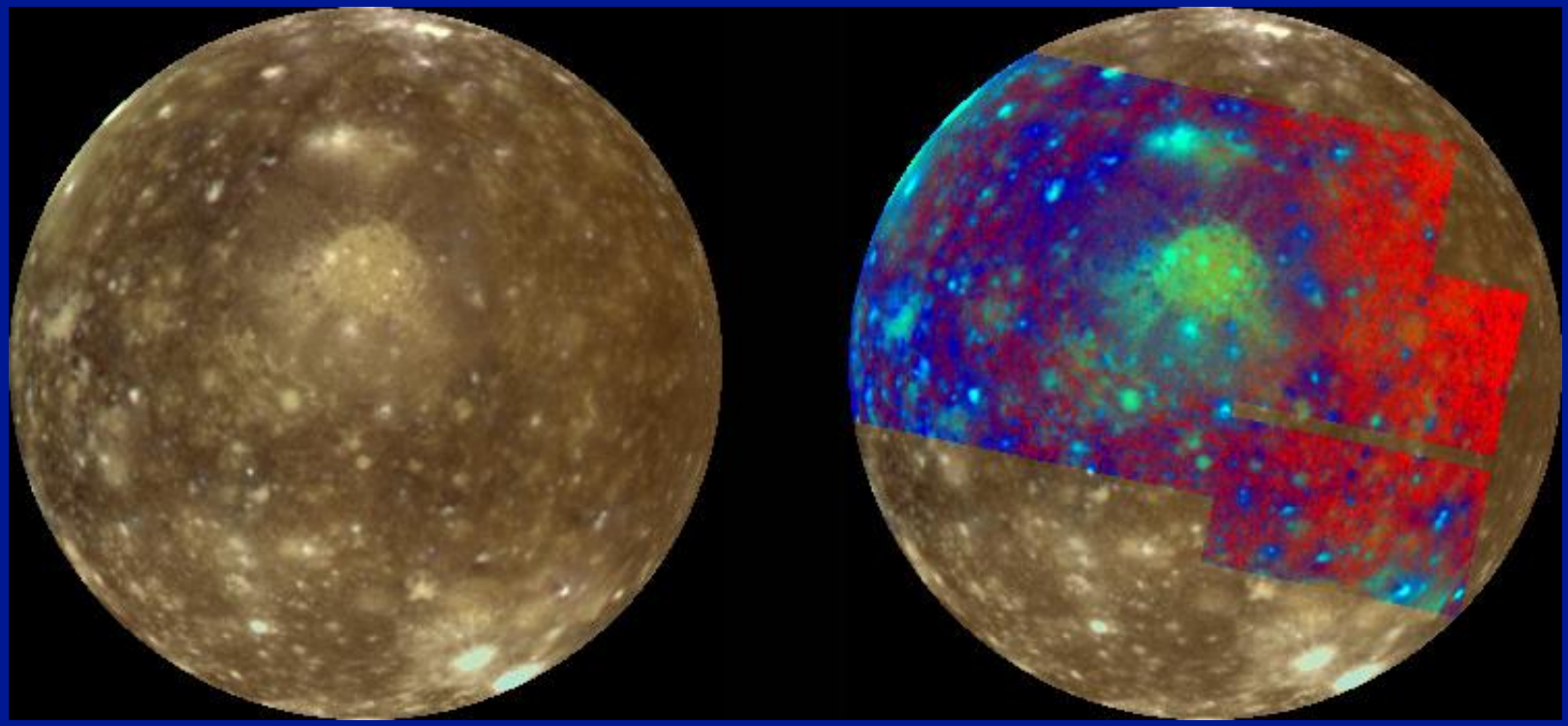
- Io
- Europa
- Ganymede
- Callisto
- 8 others known before space age
- A total of 63 now known (mostly tiny)

The Galilean satellites of Jupiter

The Galilean satellites of Jupiter (cont)



Callisto: most distant of Galilean satellites



Distance from Jupiter = 1883 thousand km; diameter = 4820km

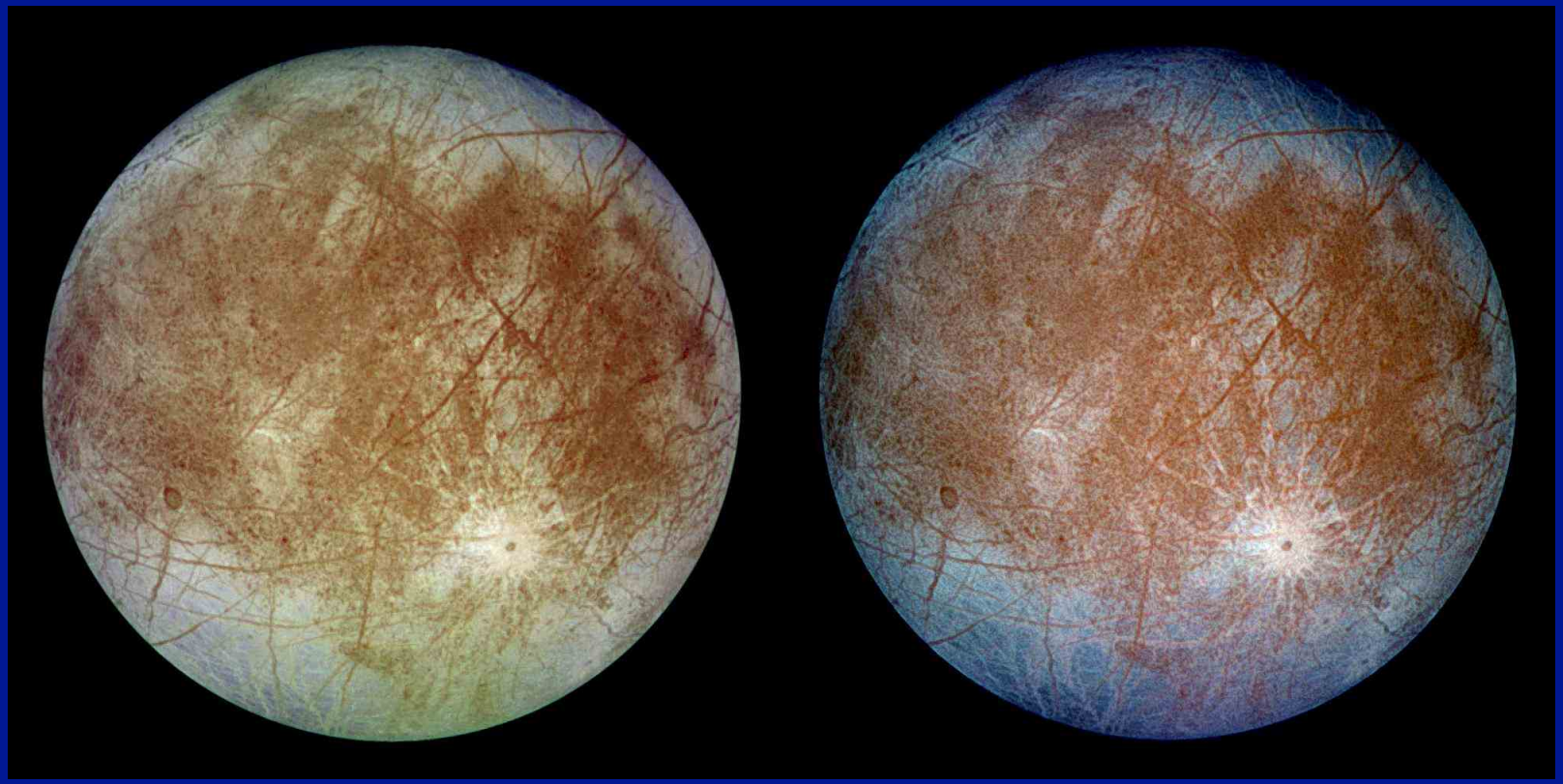
Ganymede: largest moon in solar system

Distance from Jupiter = 1080 thousand km,
diameter = 5262

Ganymede has a magnetic field…interior with conducting water

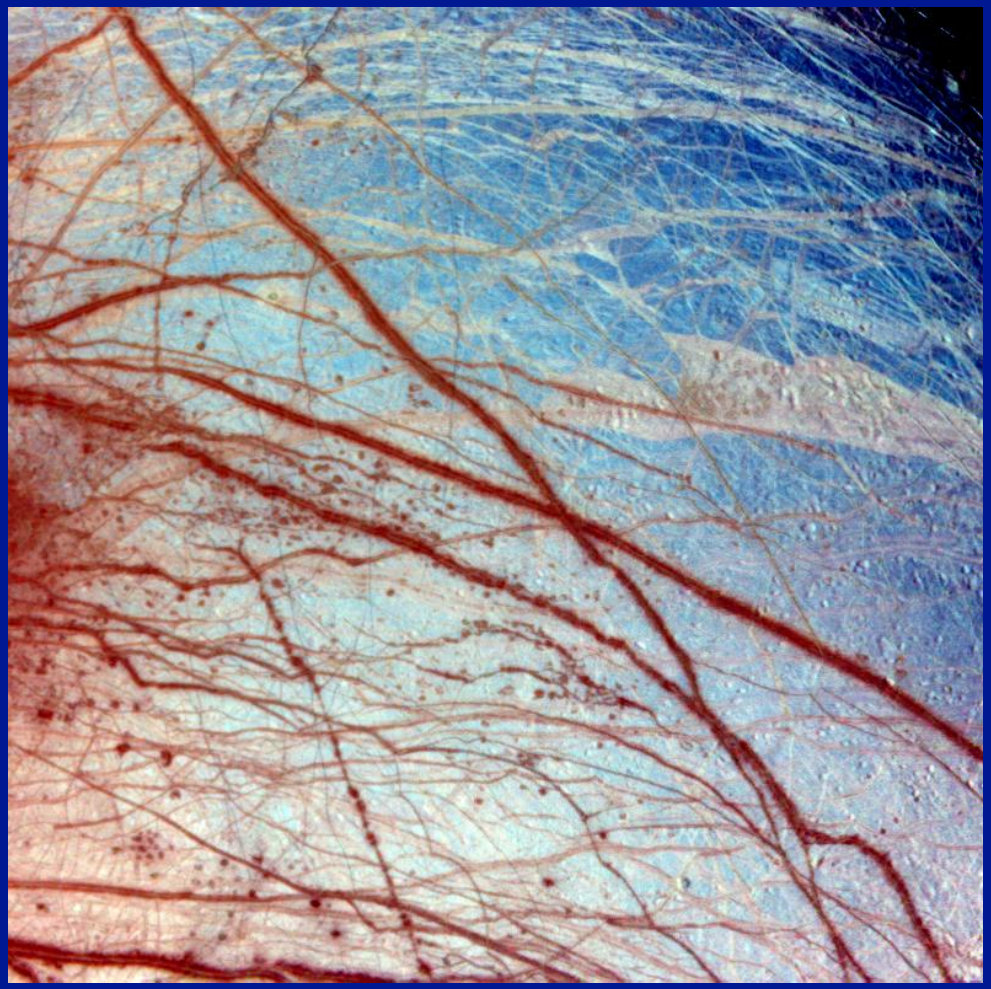
U. of Iowa instrument detects radio waves during a flyby of Ganymede

Europa and the origins of life in the universe



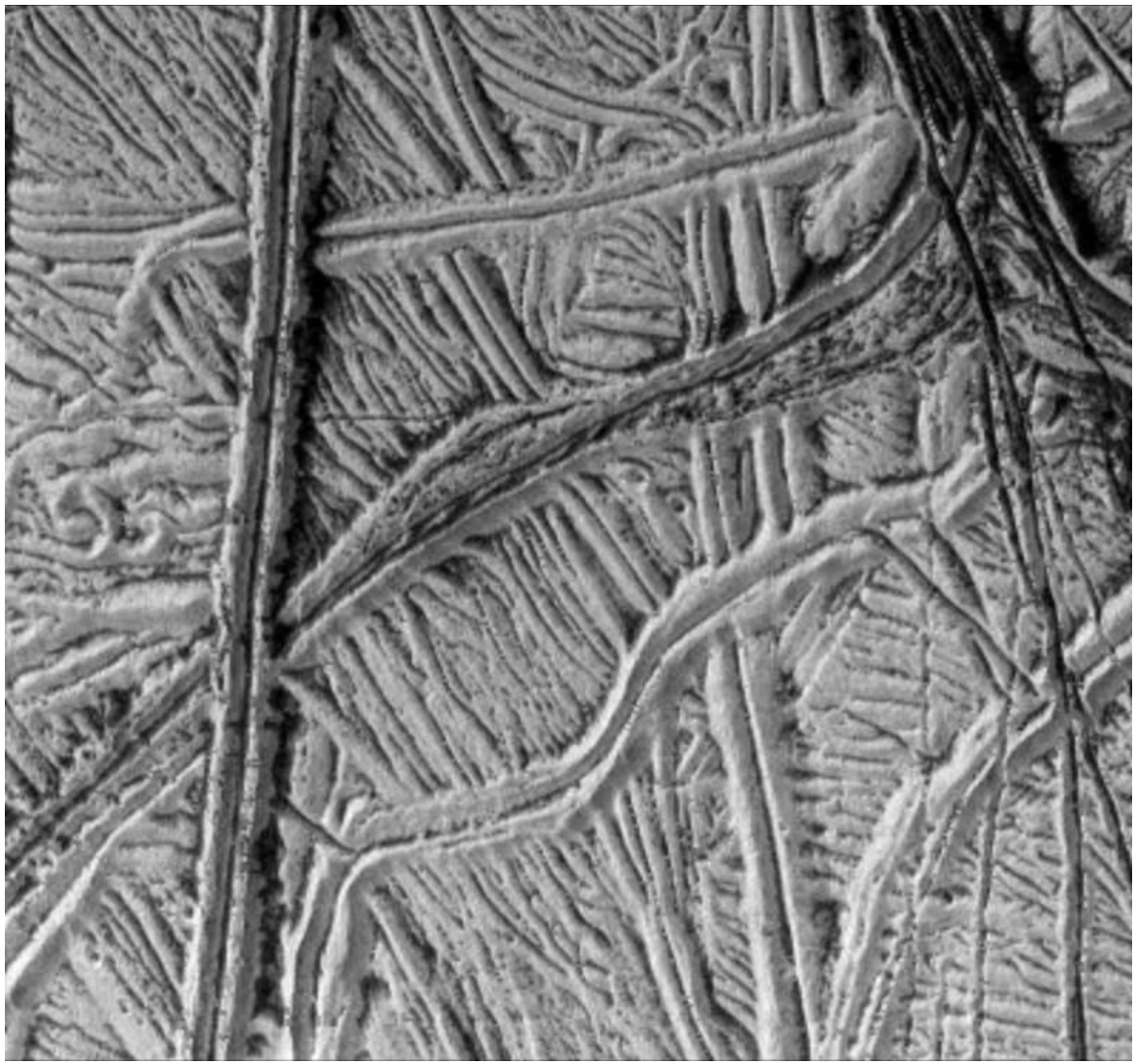
Distance from Jupiter = 671 thousand km,
diameter = 3122 km

Cracks in the ice crust of Europa

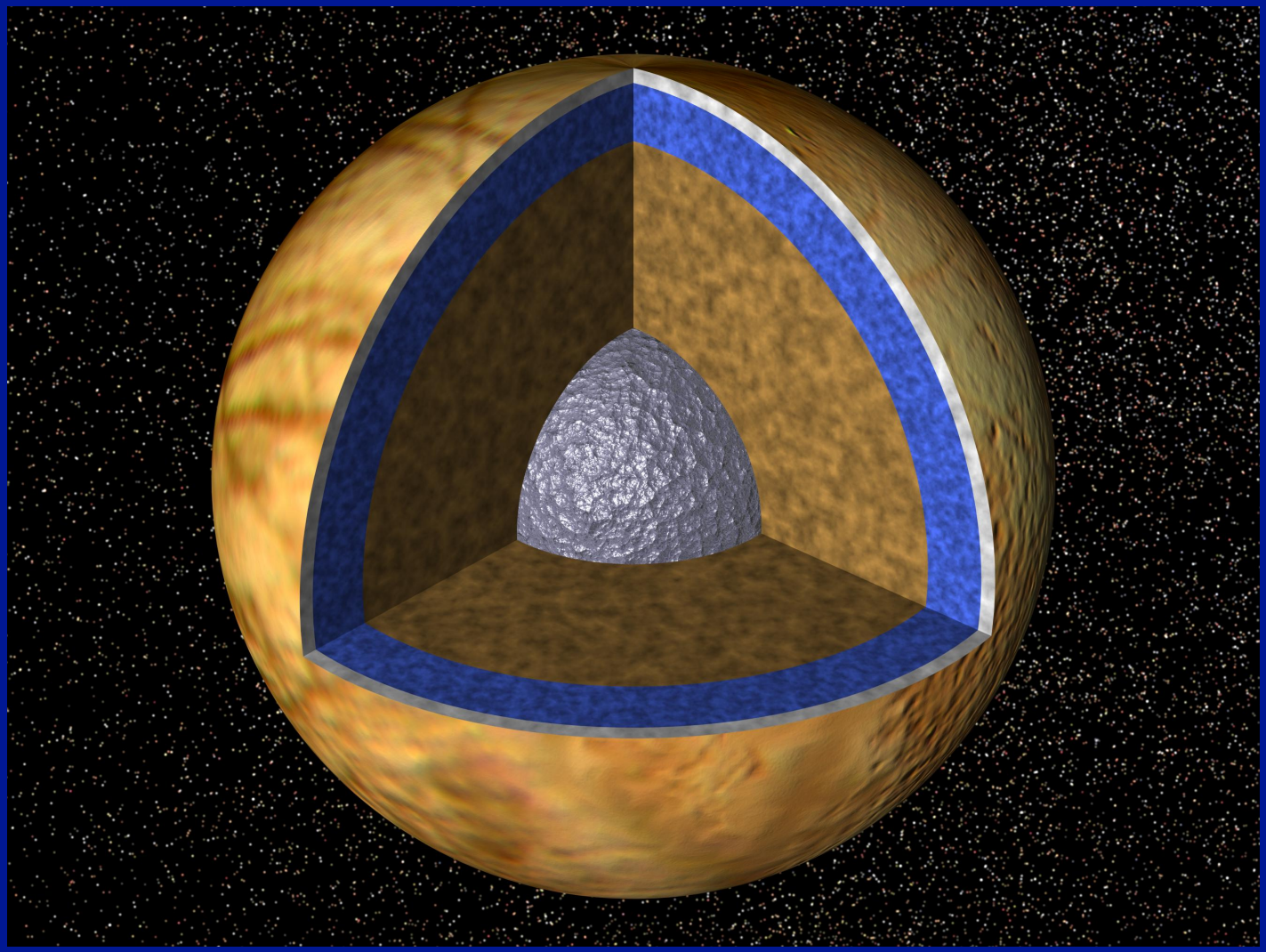


Evidence of water flows from the interior

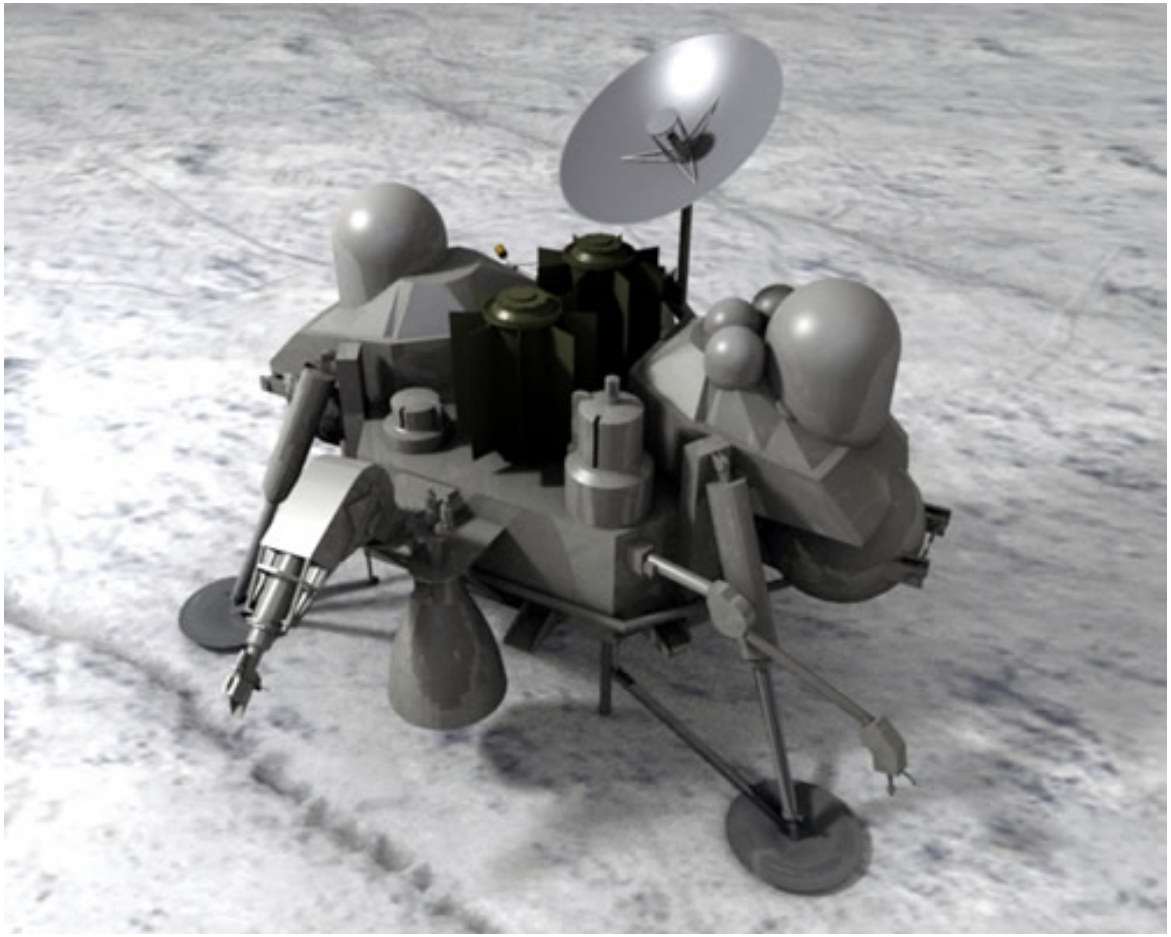
Views of the cracks from Galileo



Speculations on interior structure of Europa



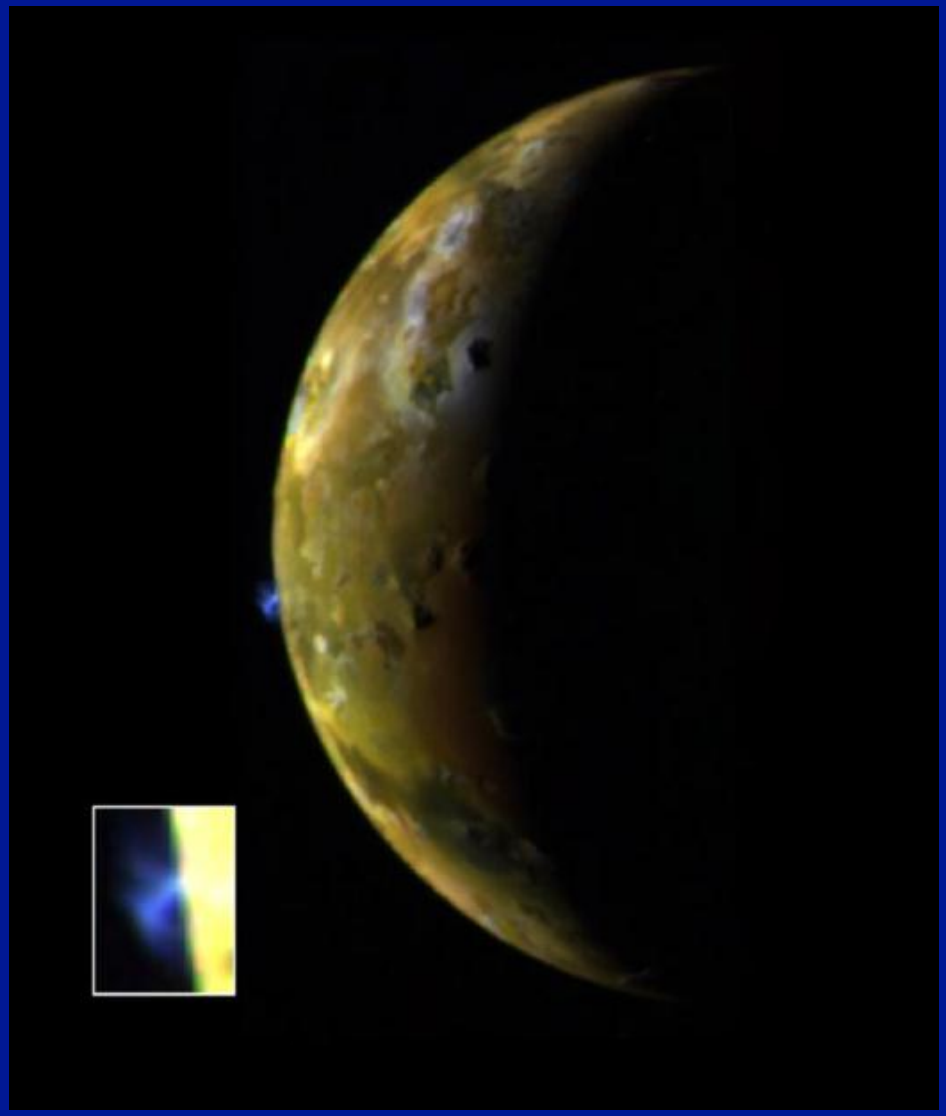
A future Europa Lander could tell us much about the possible subsurface ocean of Europa



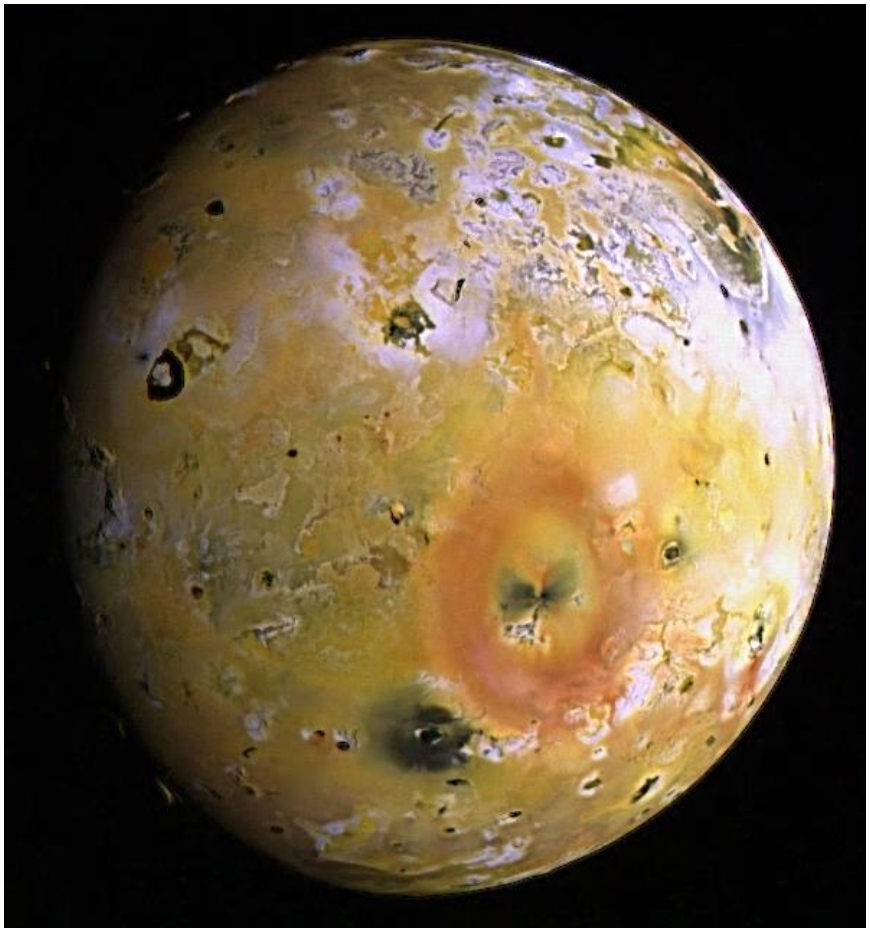
Speculations on Europa of 4.5 Gyr ago

Io … world of rapid changes

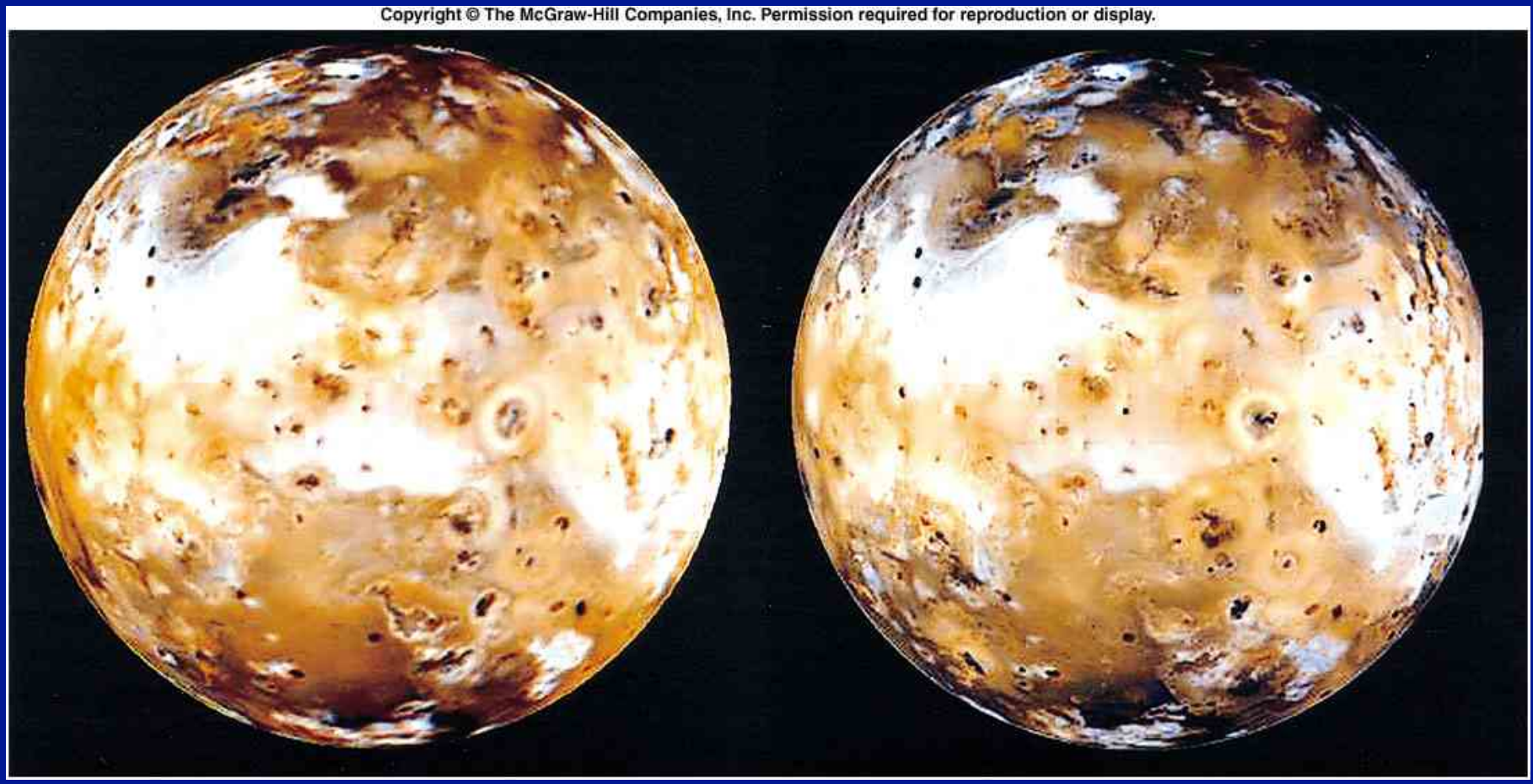
Distance from Jupiter = 422 thousand kilometers, diameter = 3640 km



Io



Changes on Io: 1979-1999



The lesson from study of the Galilean satellites: the primary geophysical process is tidal flexing or squeezing due to the strong tides of Jupiter. The tides aren't strong enough to disrupt these satellites, but they do control their geology