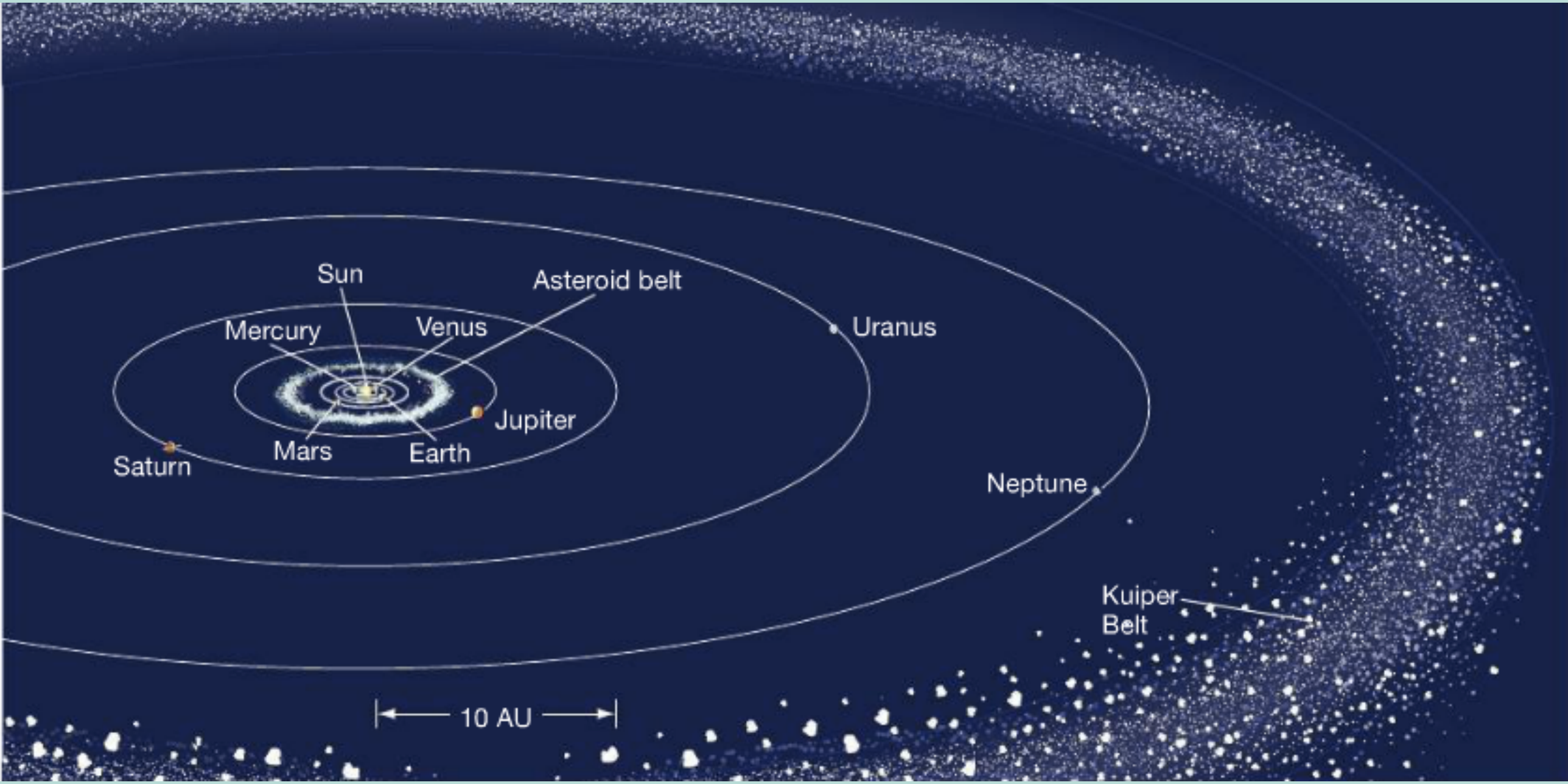
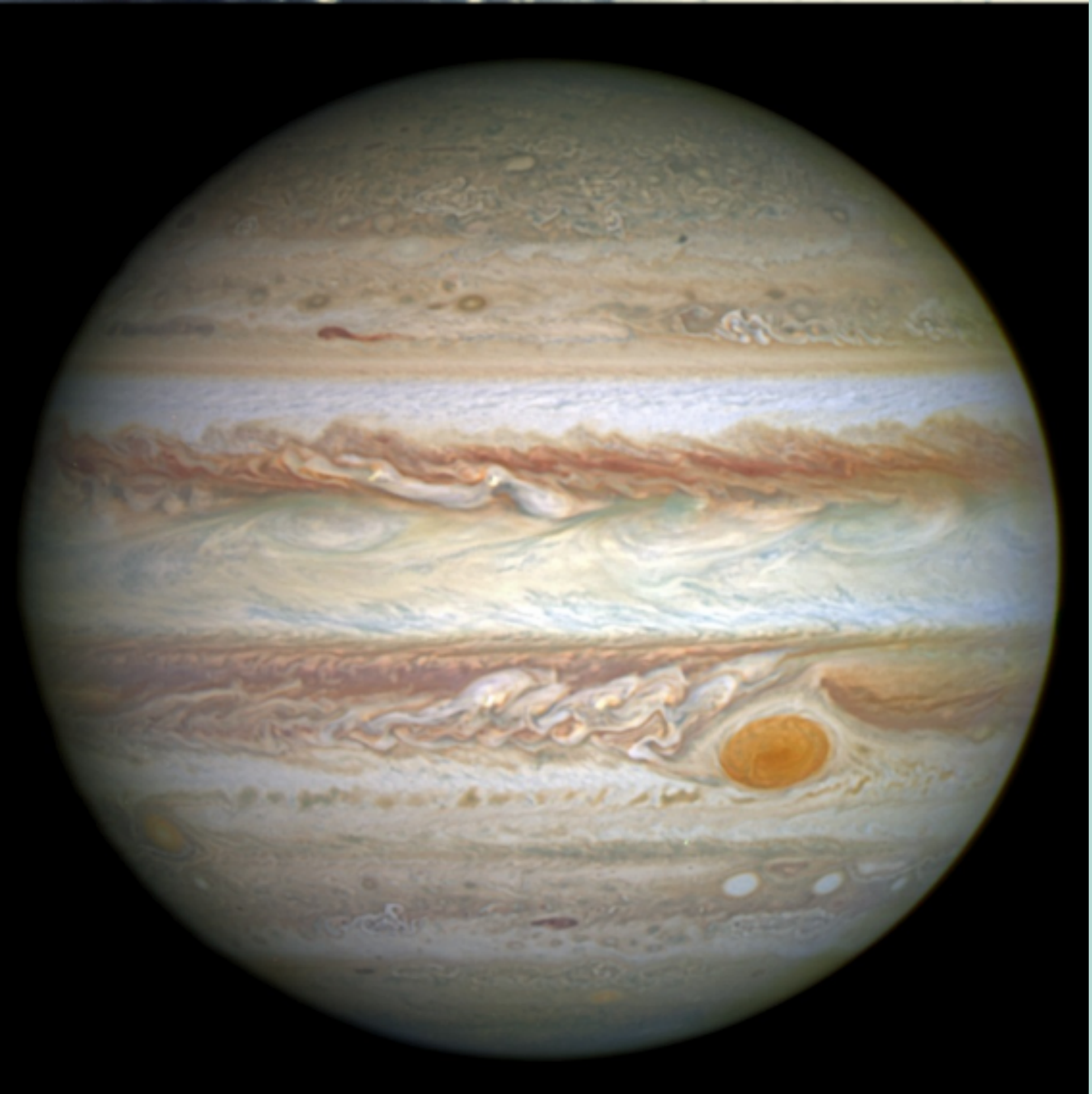
with your host:

Lecture 10:
Jupiter

Coop


Sun
Asteroid belt
Mercury
Venus
Uranus
Jupiter
Mars
Earth
Saturn
Neptune
Kuiper
Belt
10 AU



m~ 2 e27 kg
~ 318 m_e

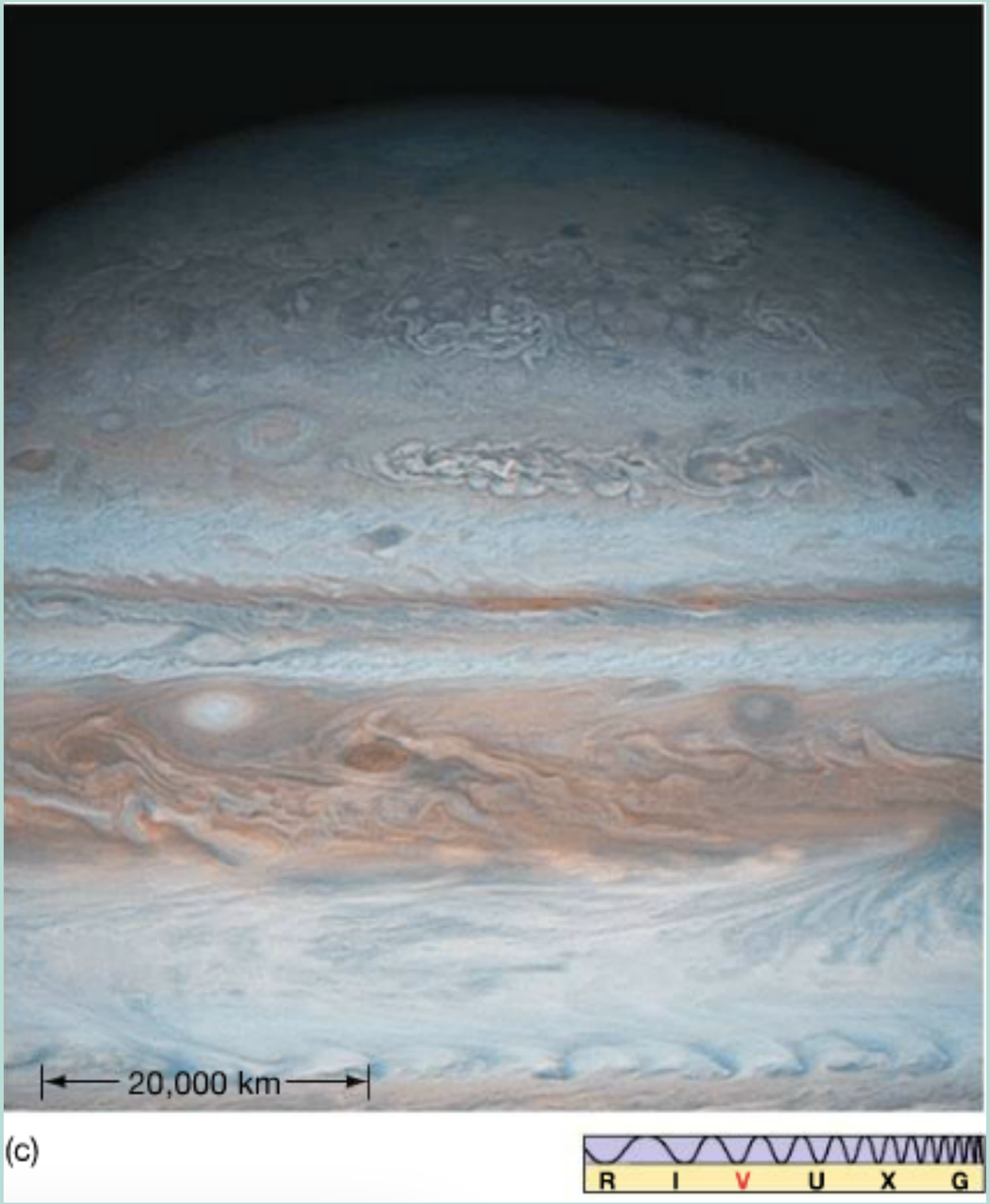
r~ 6.7 e4 km
~ 11 r_e

d~ 5.2 AU
~ 43 minutes

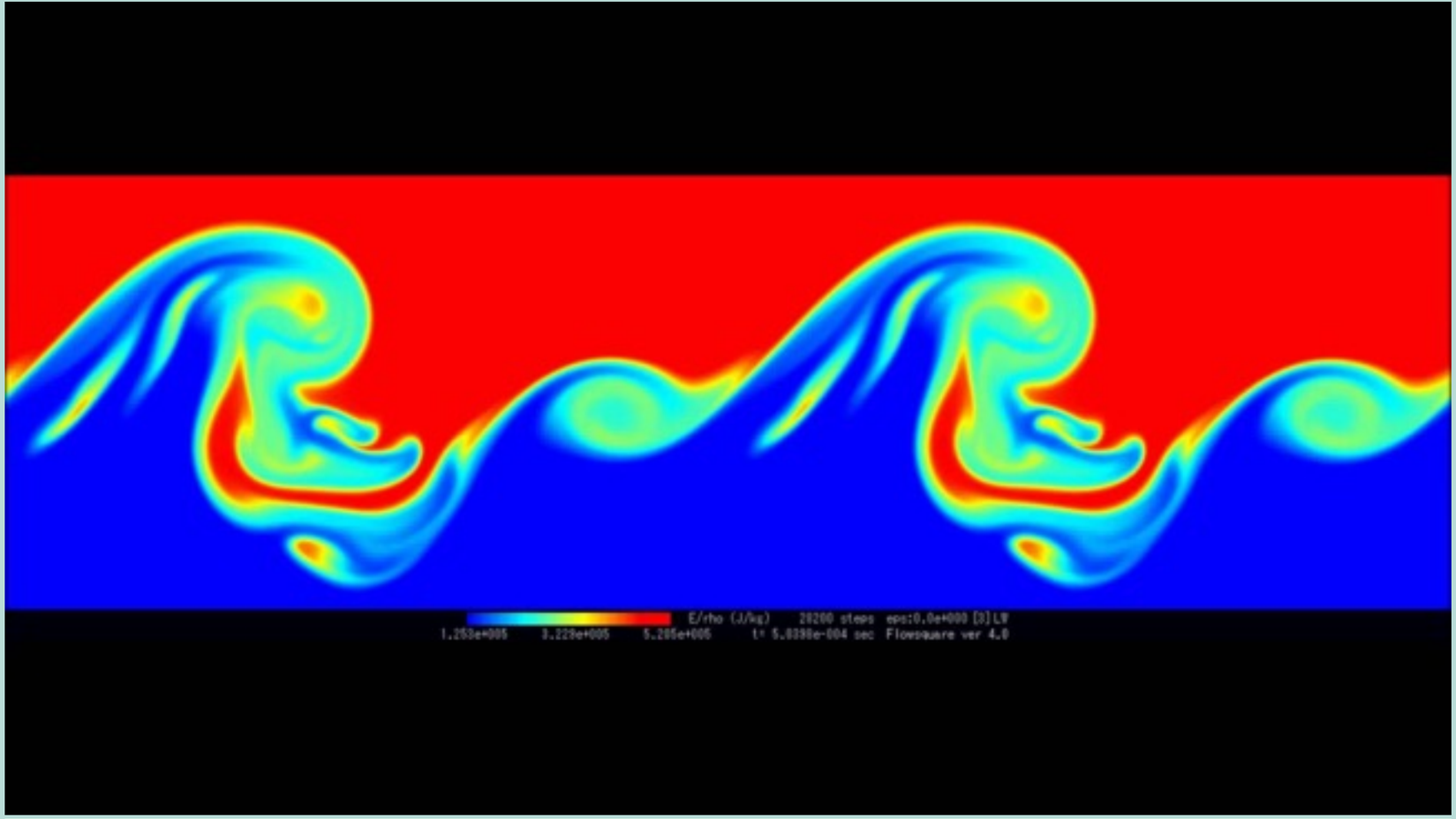
T~ 12 yr

density~
1326 kg/m^3

Cassini Fly-by



Kelvin-Helmholtz

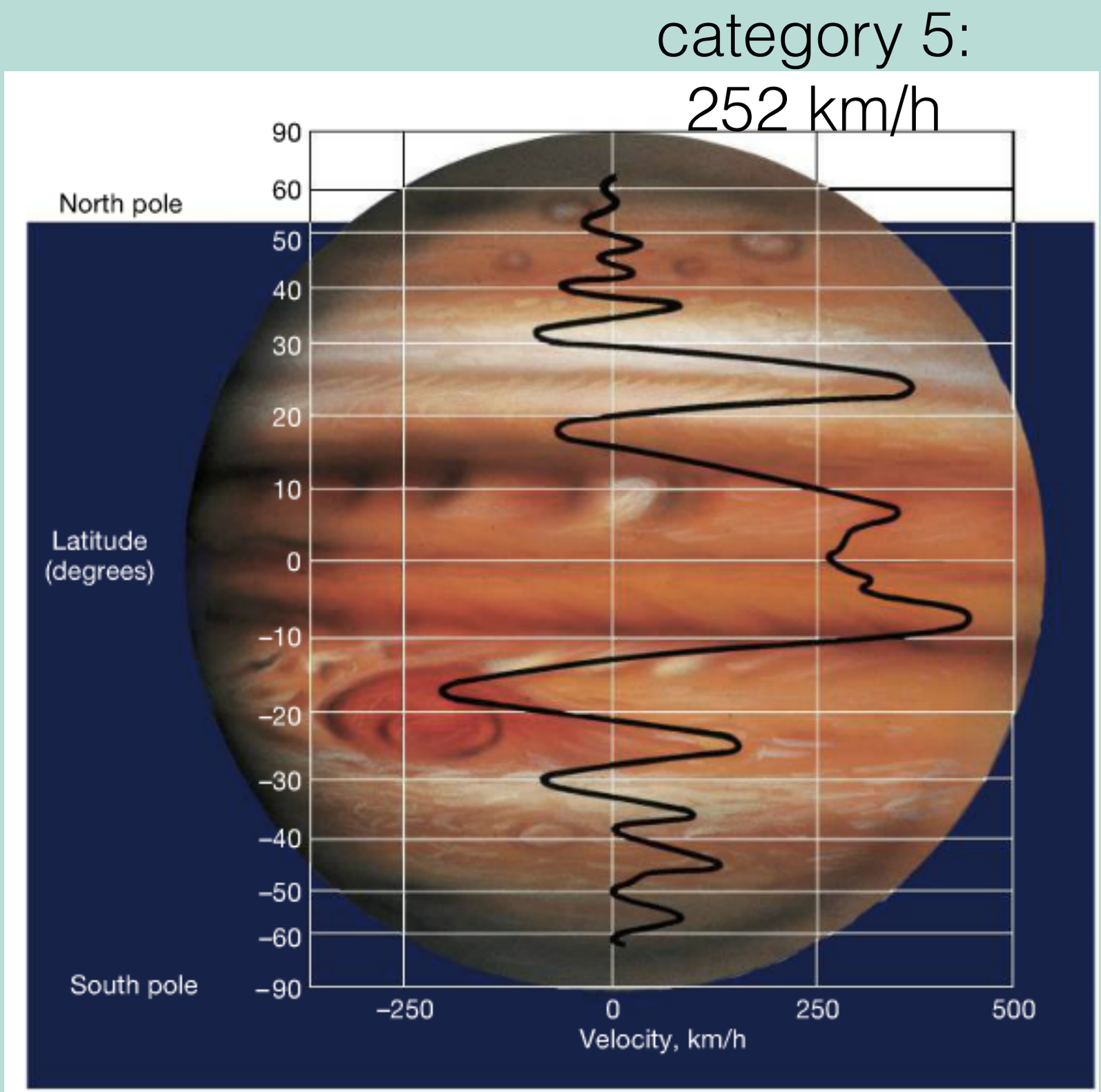


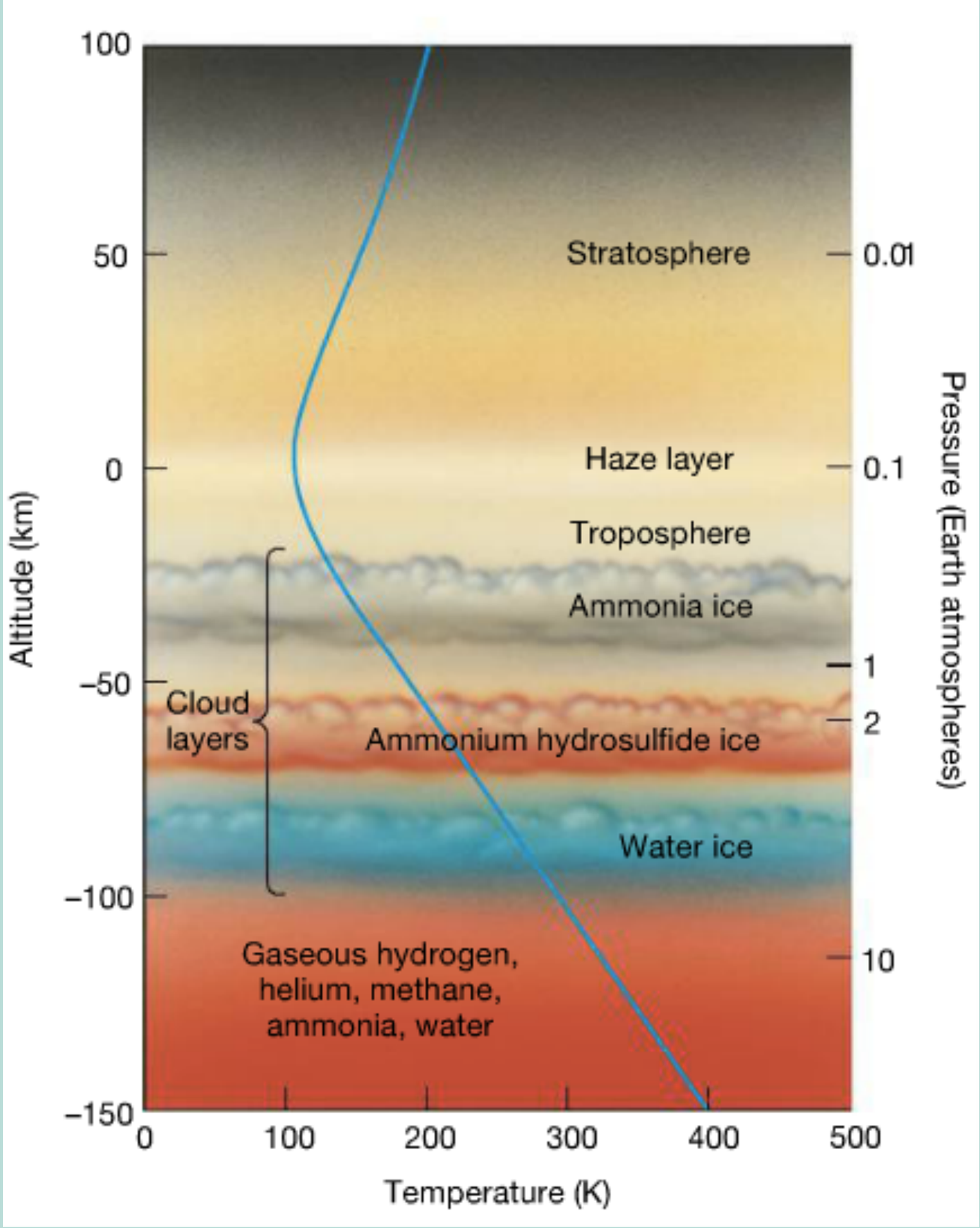
- 50’’ across closest to earth.

- Doppler shift studies show differential rotation

- Better rotation measurements come from radio wave burst periodicity in the magnetosphere (9hr 55min)

Rotational Velocities





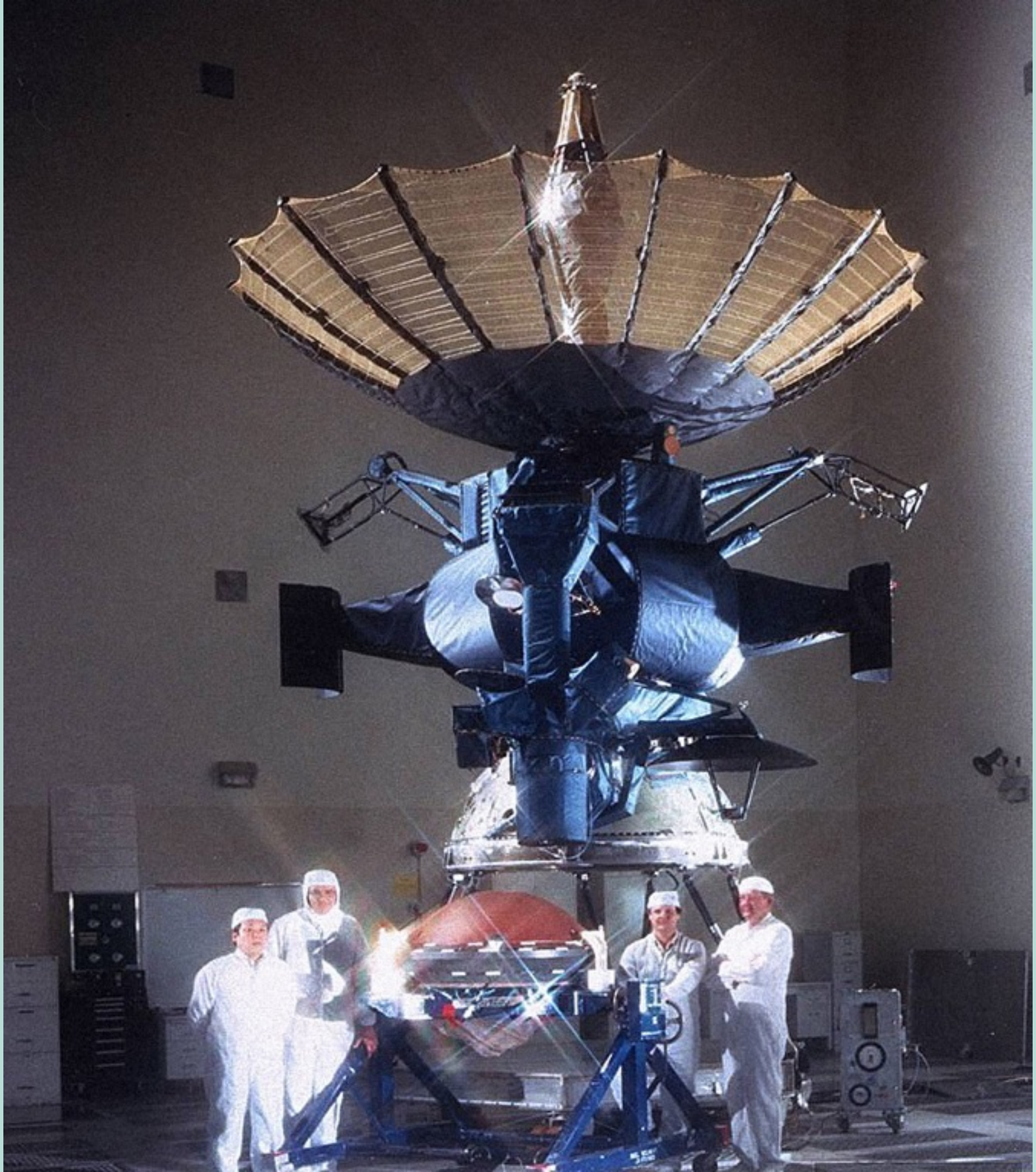
Jovian Atmosphere

Composition: 86.1% Hydrogen, 13.8% Helium

Trace Methane (CH_4) Ammonia (NH_3) and water vapor

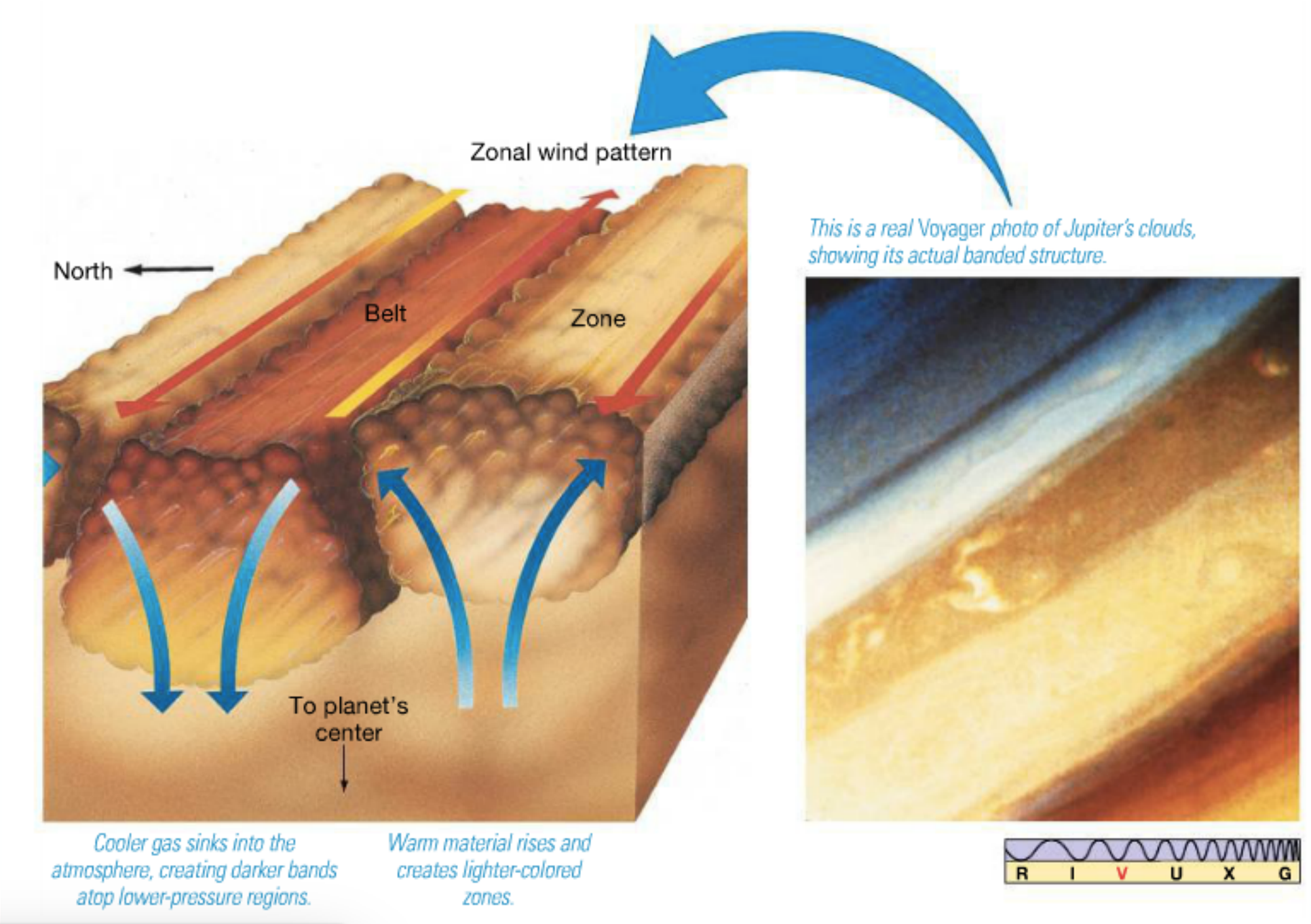
? What's the escape velocity ?

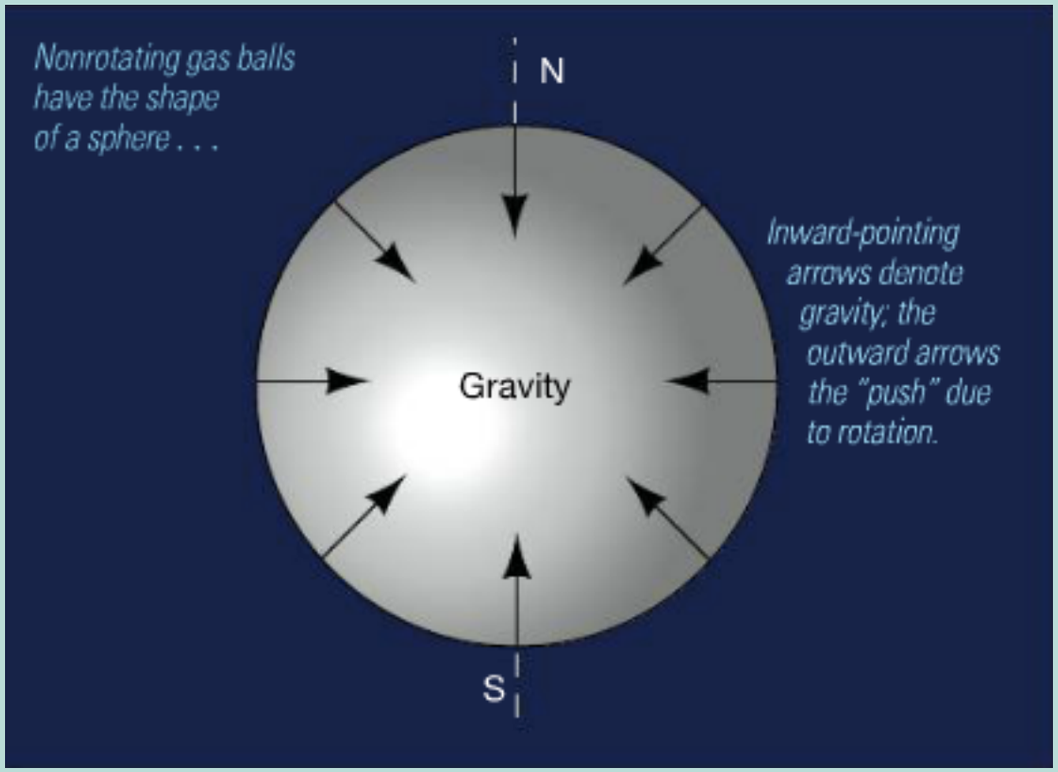
Galileo (1989-2003)

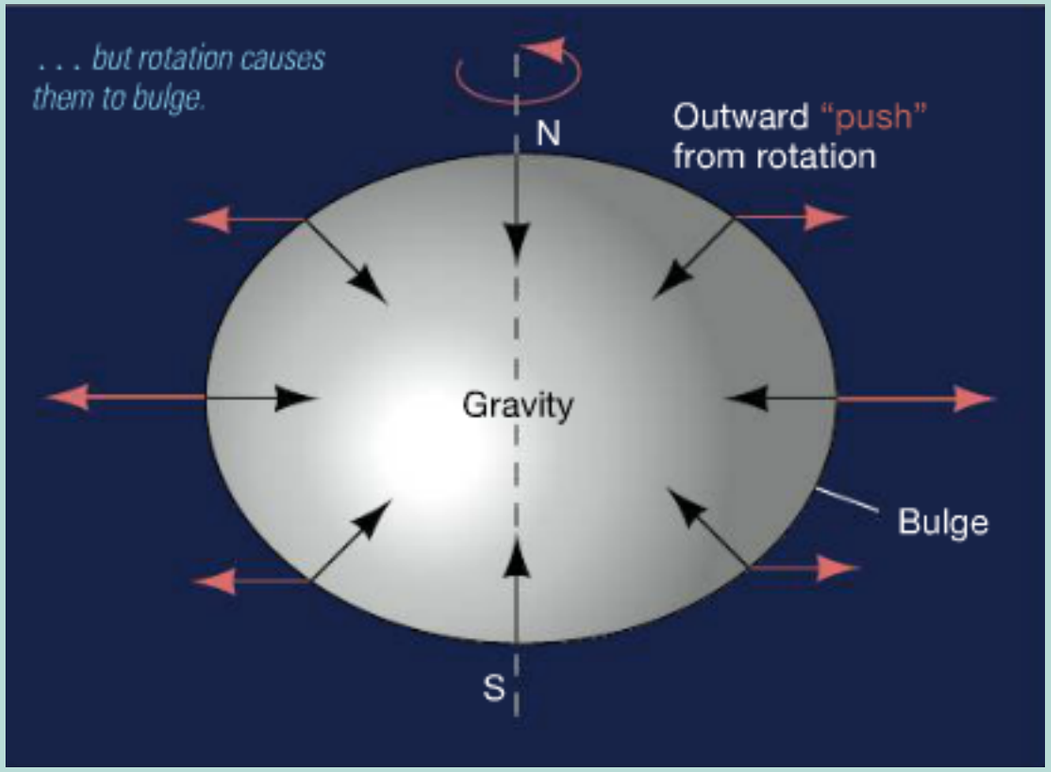


Galileo's Entry Point

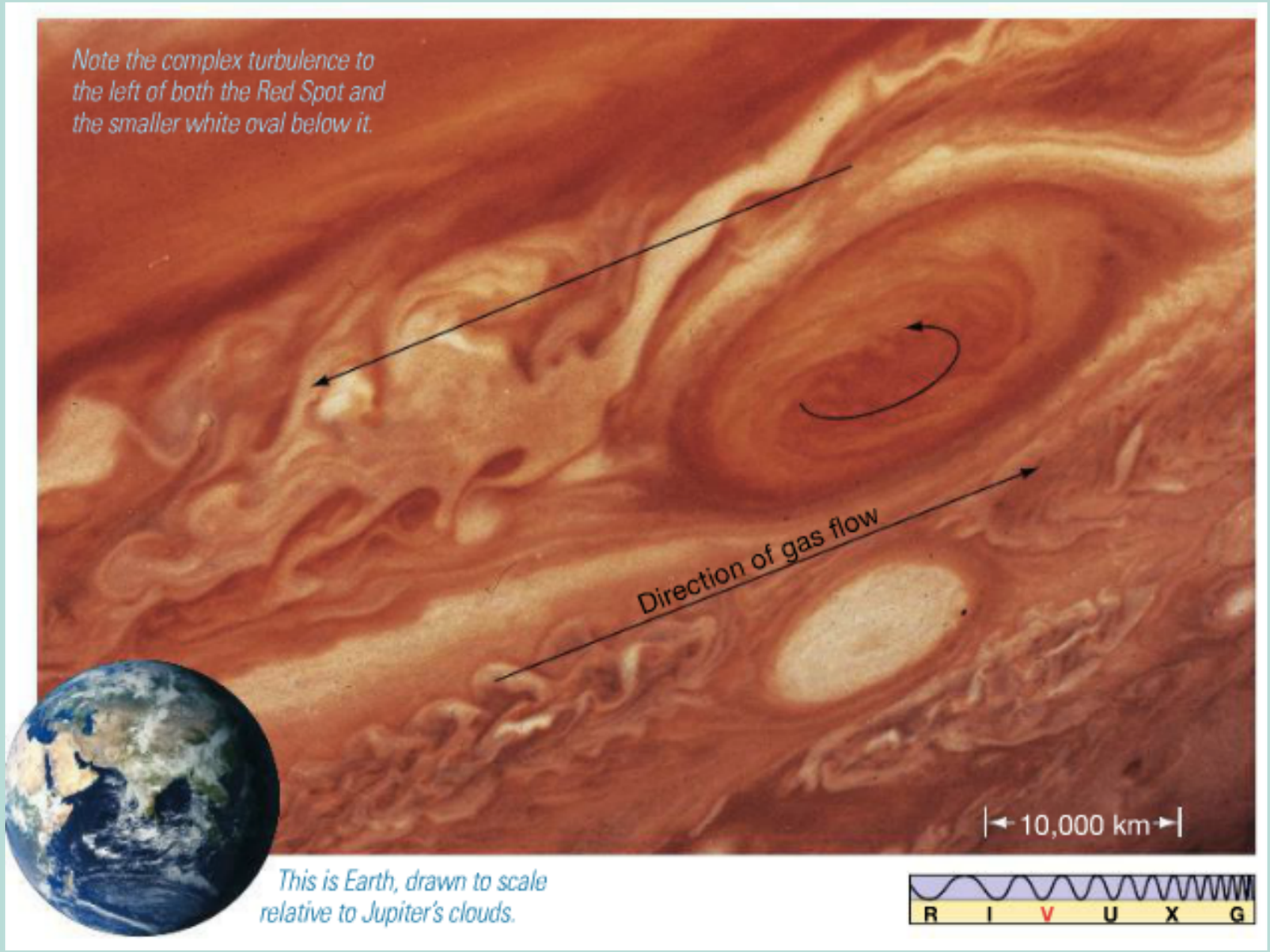
Zonal Flow


Zonal wind pattern
North
Belt
Zone
To planet's center
This is a real Voyager photo of Jupiter's clouds, showing its actual banded structure.
Cooler gas sinks into the atmosphere, creating darker bands atop lower-pressure regions.
Warm material rises and creates lighter-colored zones.
R I V U X G

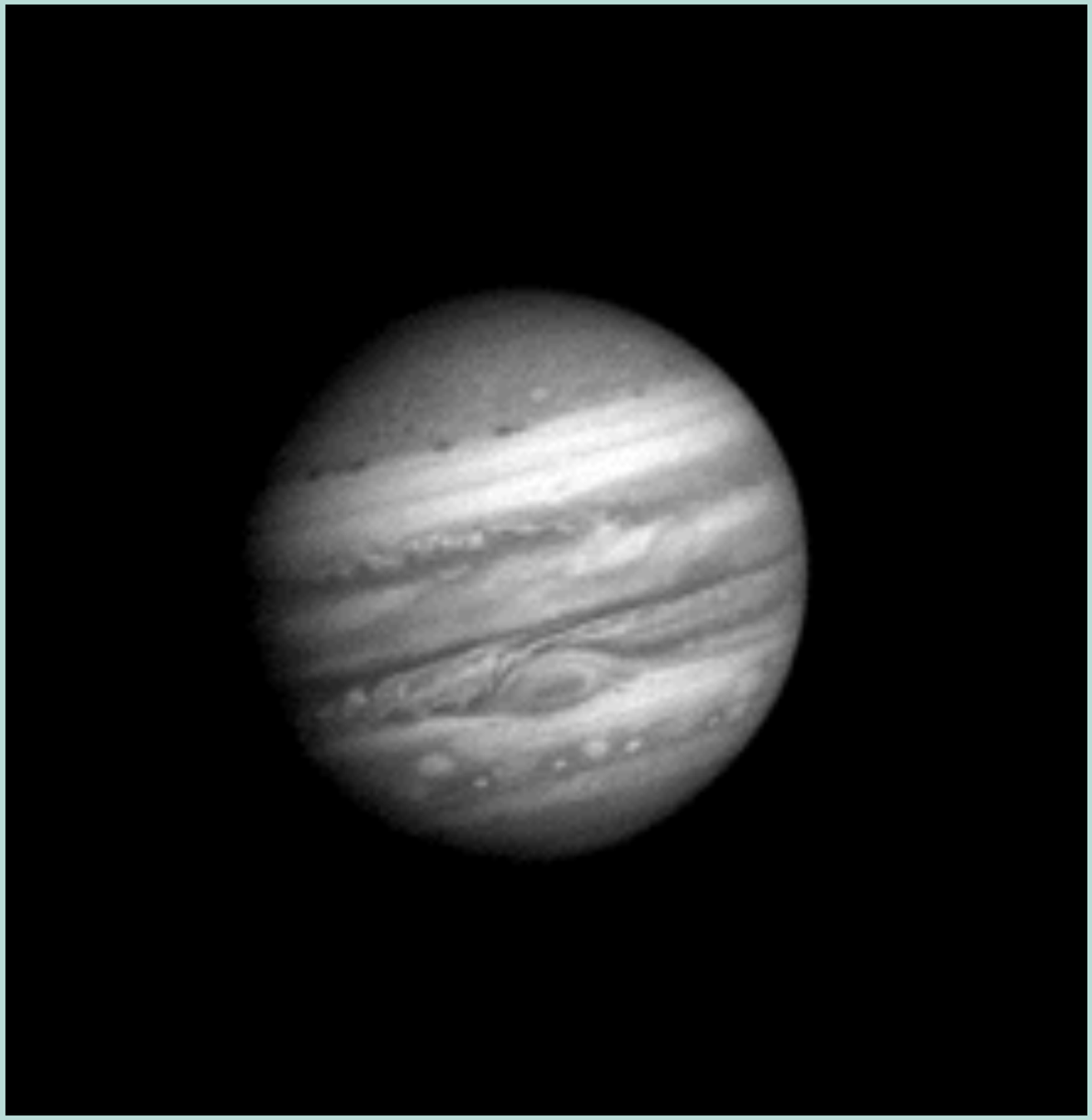

Nonrotating gas balls have the shape of a sphere . . .
N
Inward-pointing arrows denote gravity; the outward arrows the "push" due to rotation.
Gravity
S


. . . but rotation causes them to bulge.
N
Outward "push" from rotation
Gravity
Bulge
S

The Great Red Spot

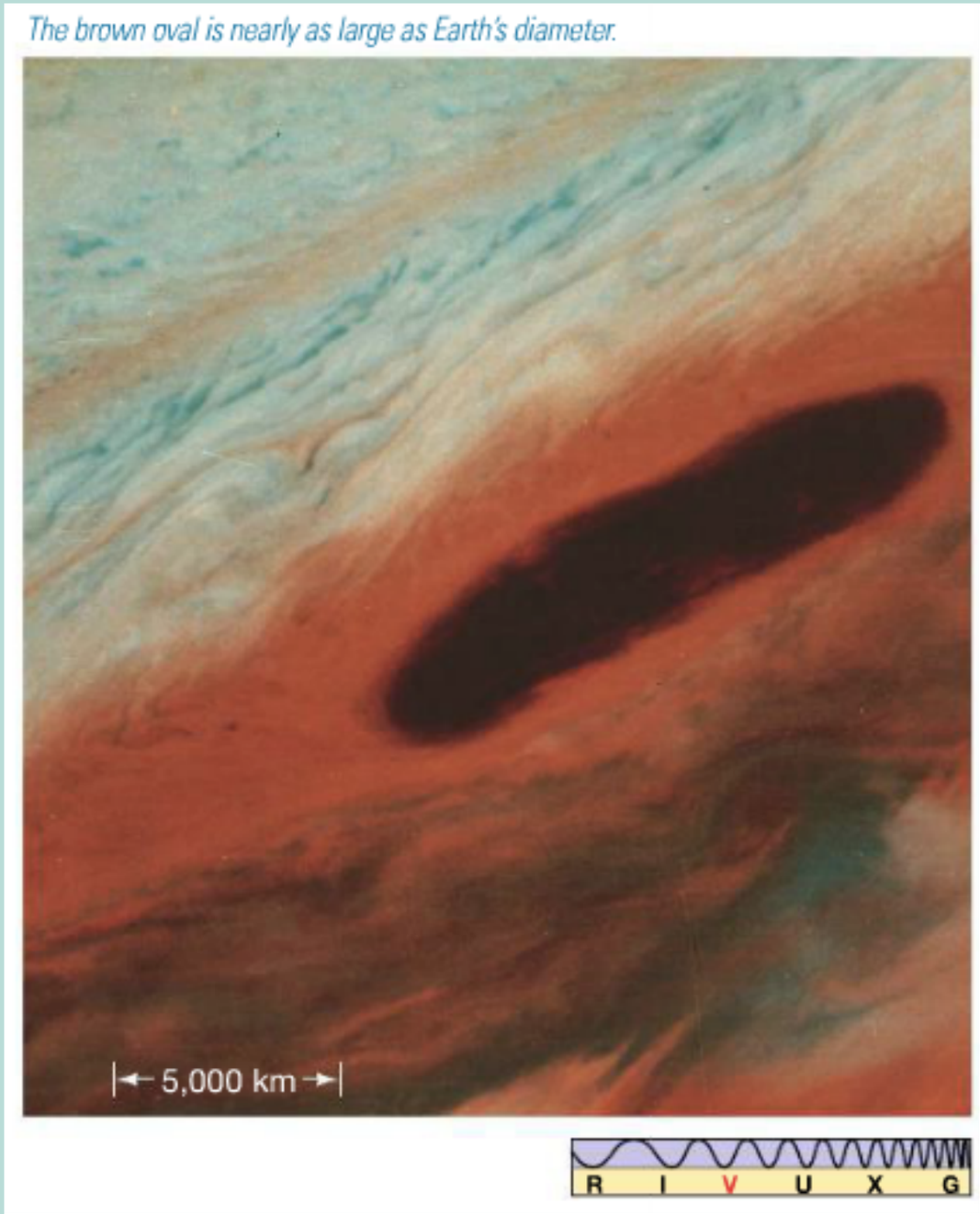


- First noticed by Robert Hooke (~350 years ago!)
- Twice the size of the Earth
- 430 km/h



Red Spot Turbulence

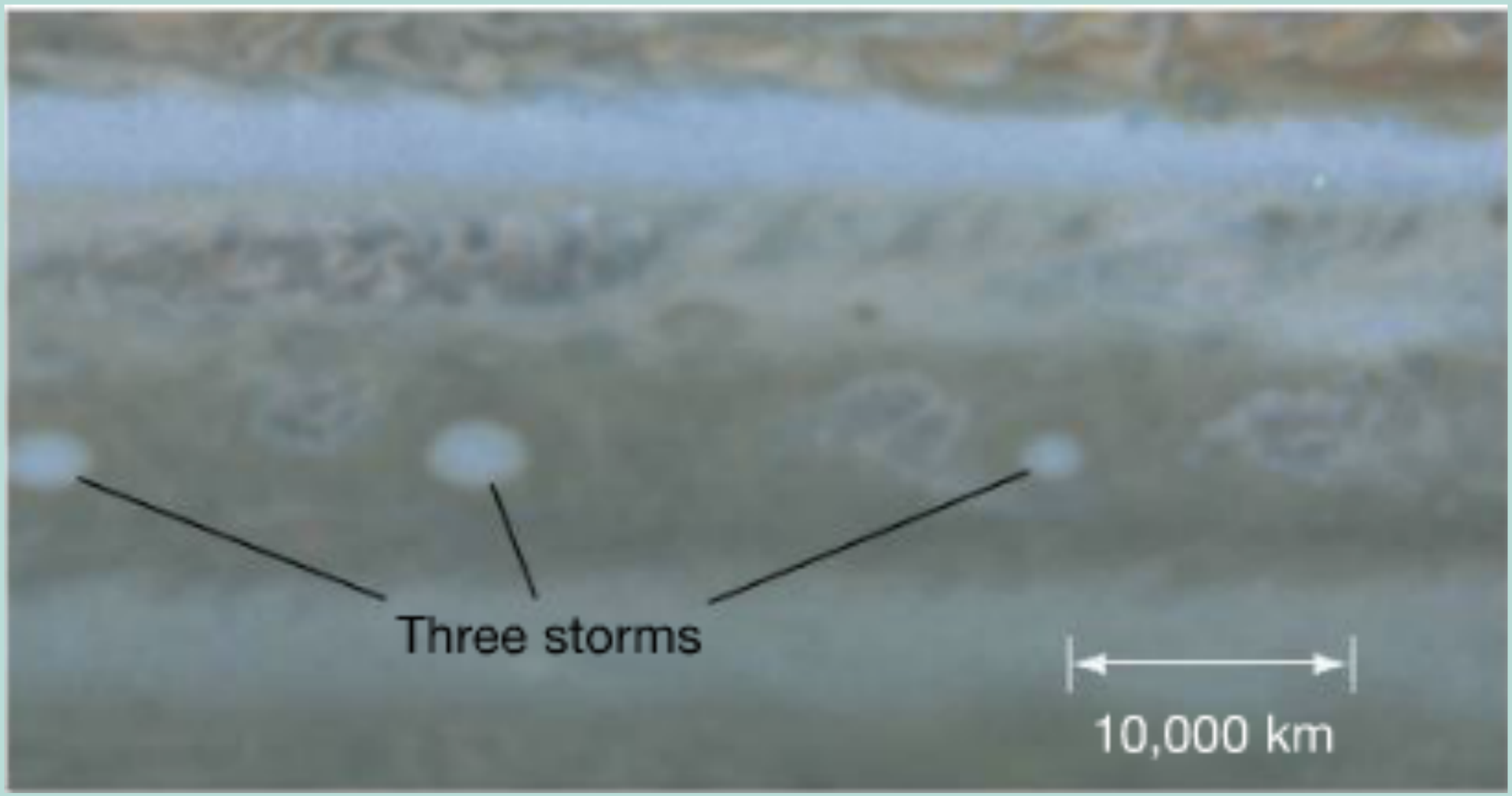
Brown Oval



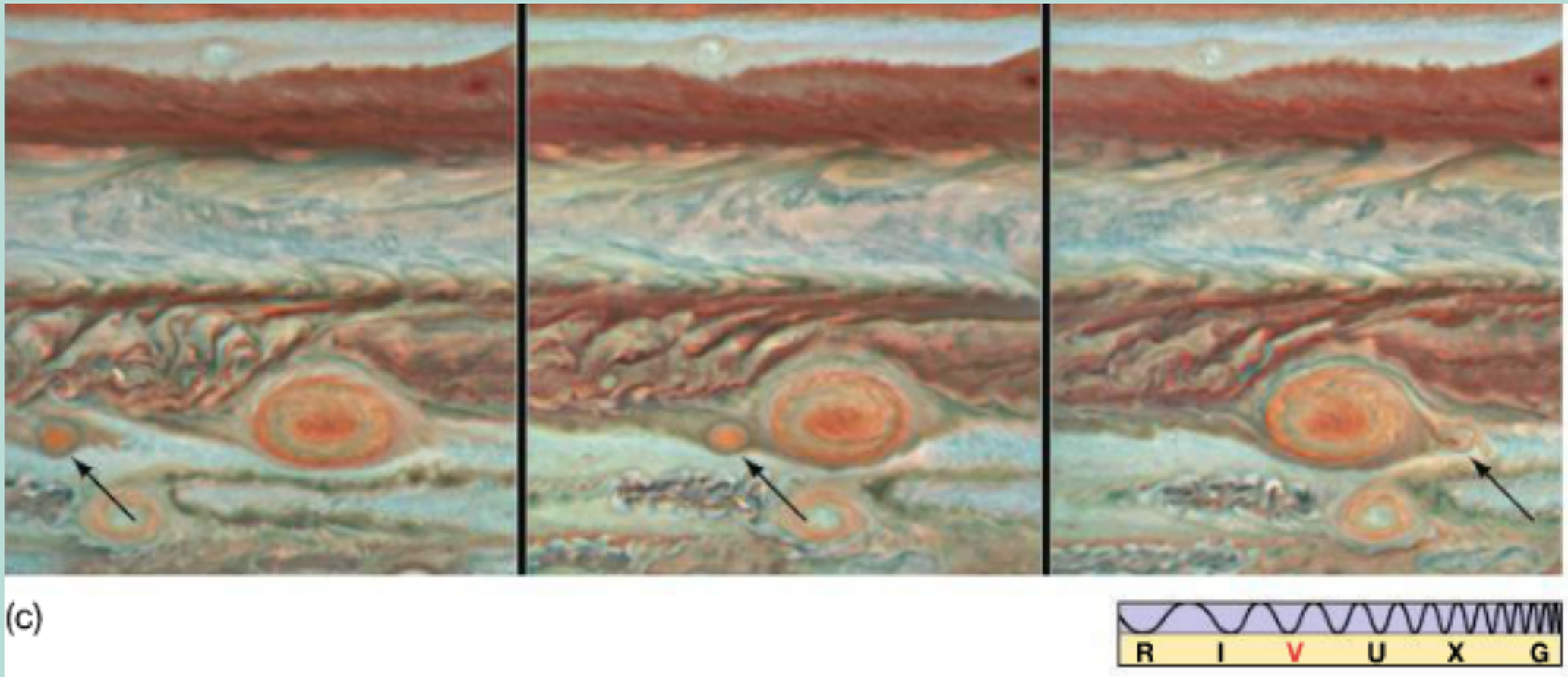
The brown oval is nearly as large as Earth's diameter.

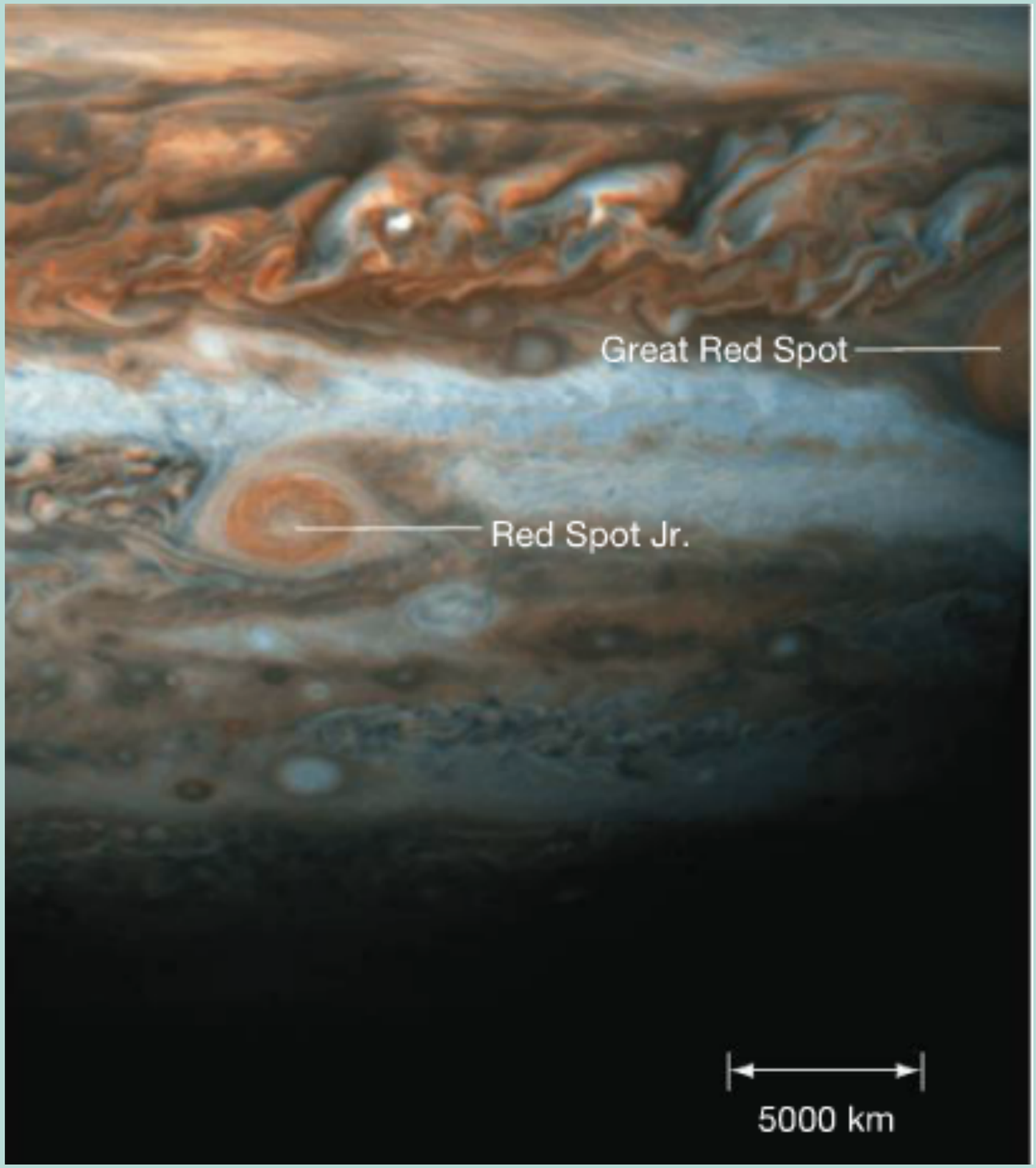
Appear only around 20 degrees north

White Ovals



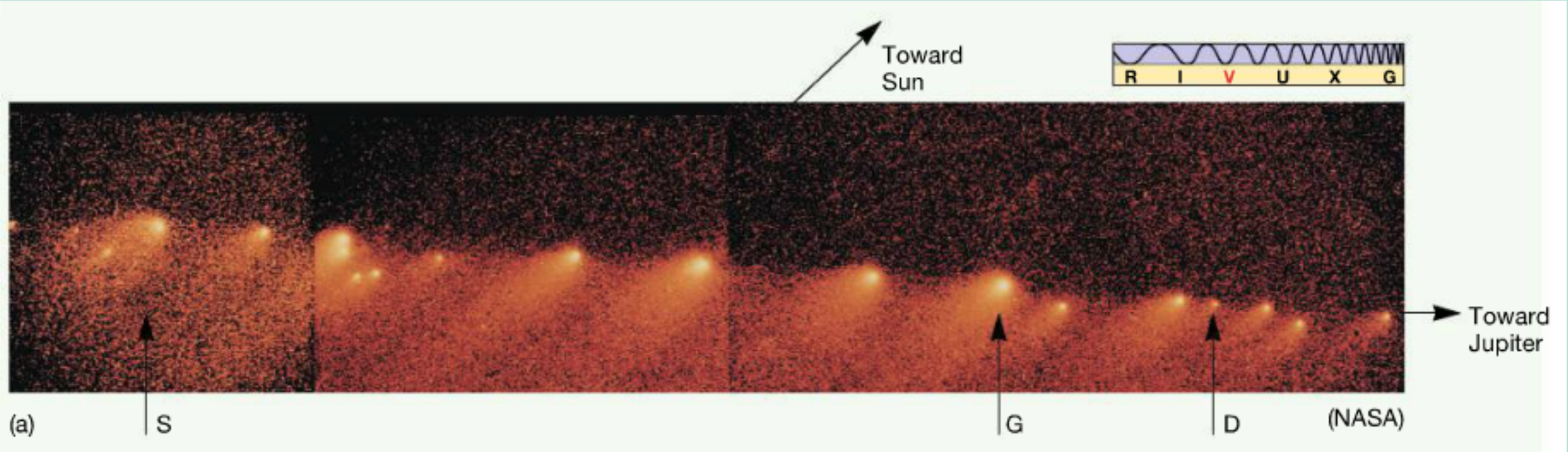
Jovian Storm Coalescence





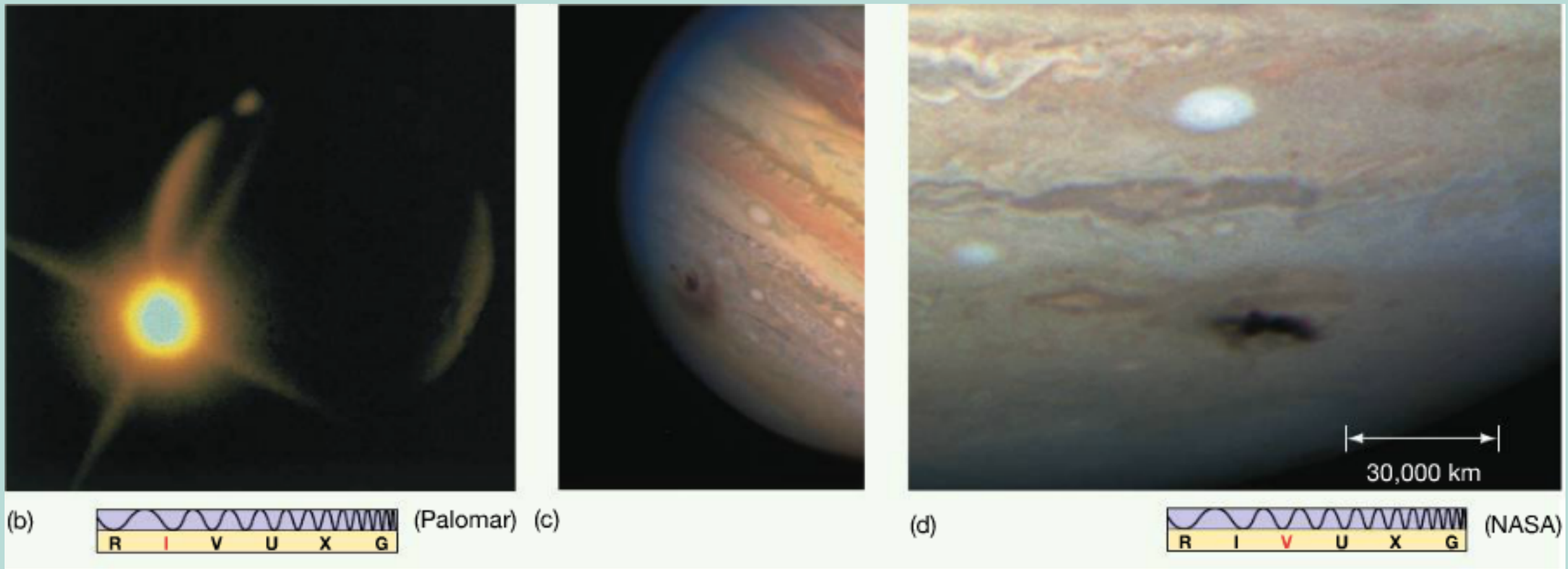
Red coloration may be due to storm intensity

Tidally Disrupted Comet

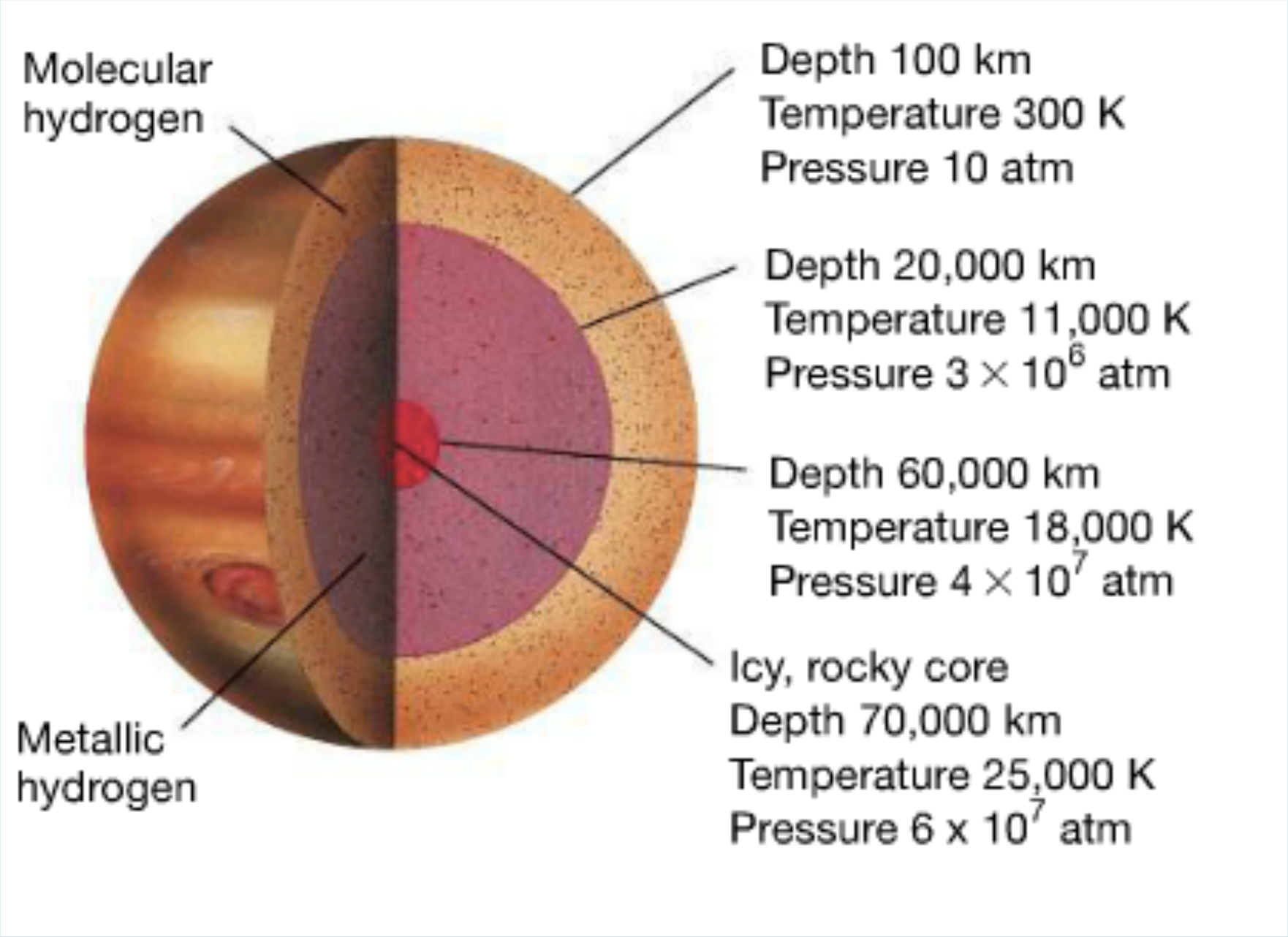


Each pearl is like a billion nukes.

Comet Collision

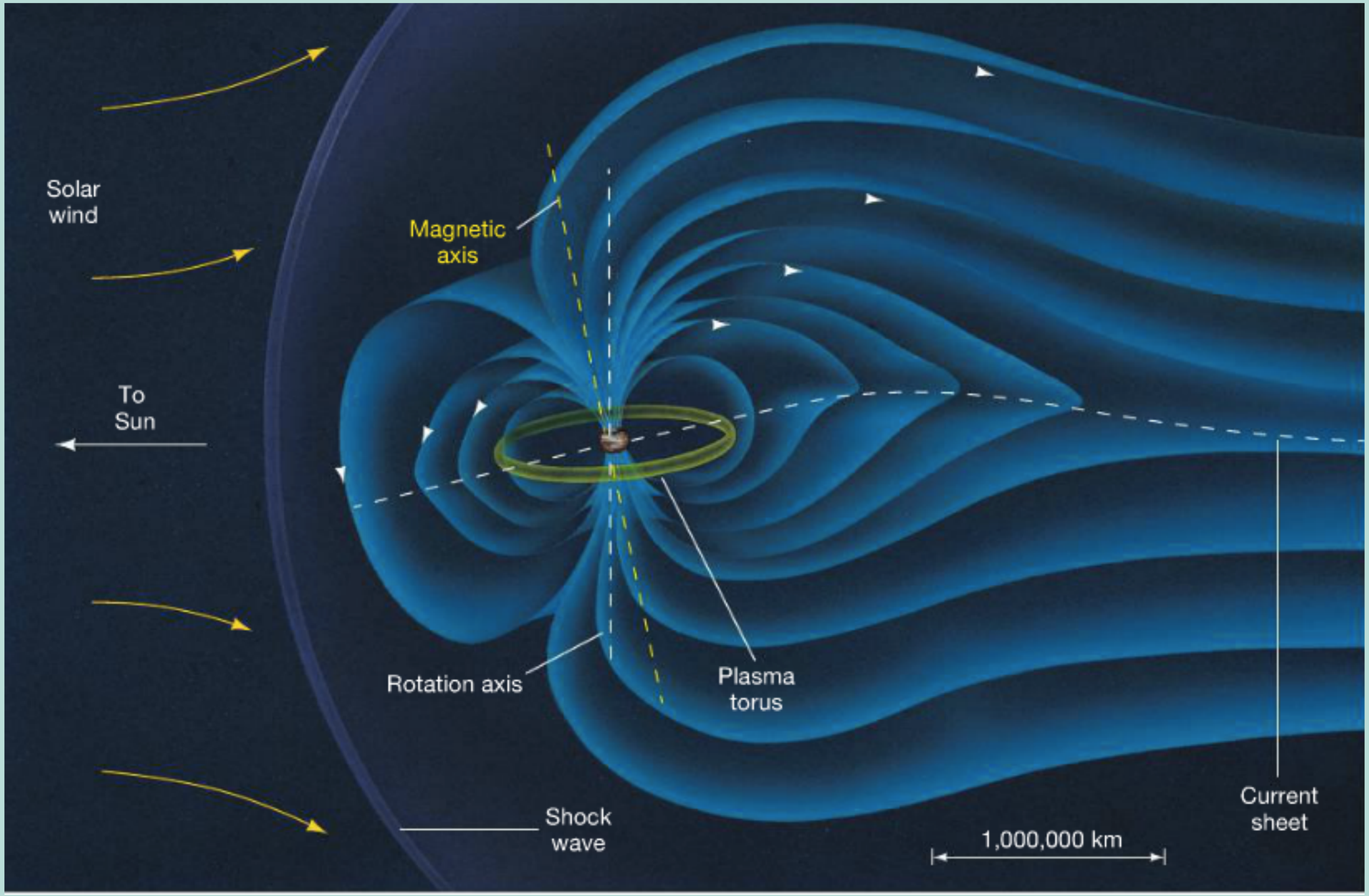


Jupiter's Core



More heat leaves jupiter than it receives from sun!

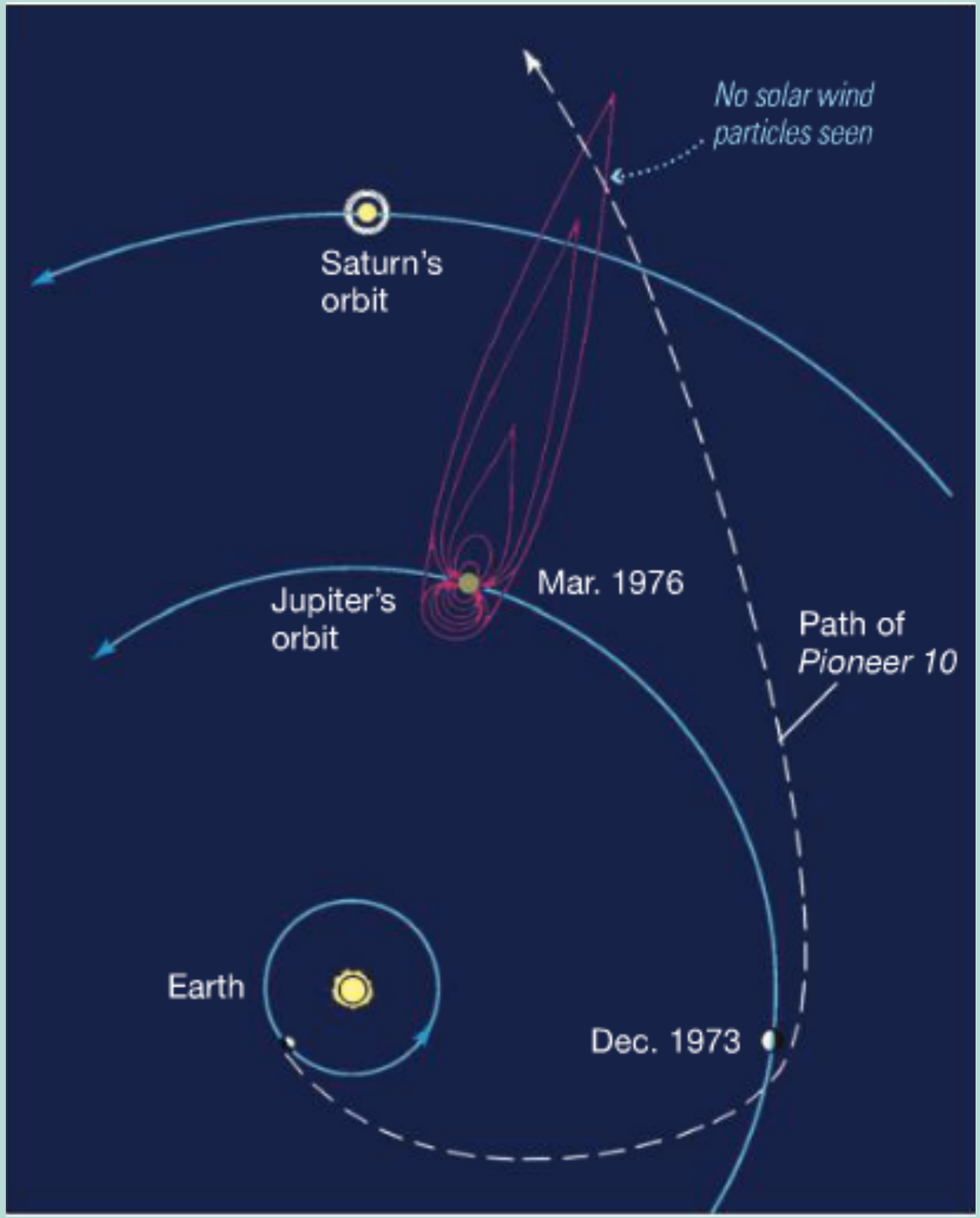
Jupiter's Magnetosphere



- ~10 times stronger field than earth

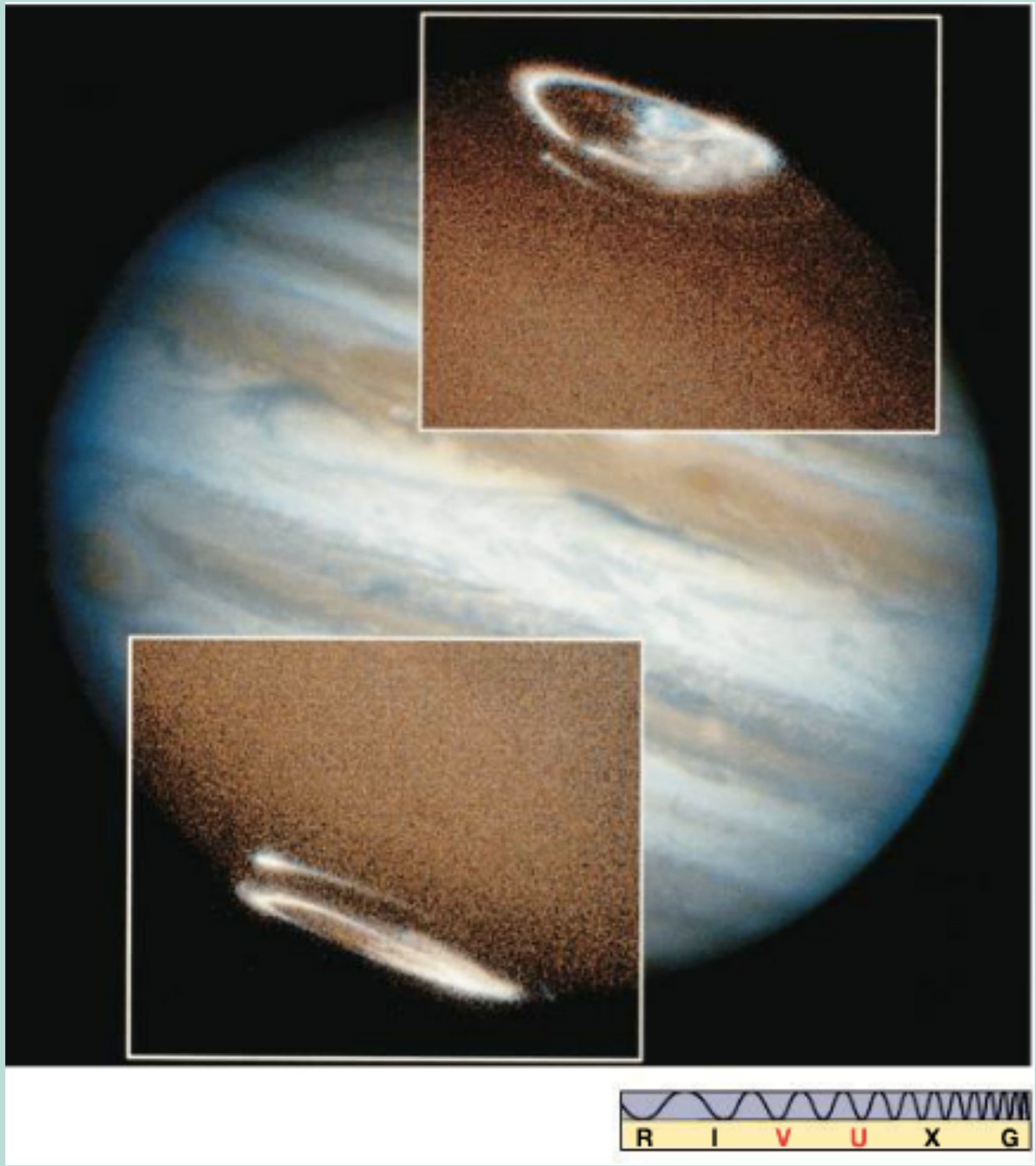
- ~18000 times stronger magnetic moment (careful!)

- volume larger than 1000000 earths (that’s larger than the sun!)

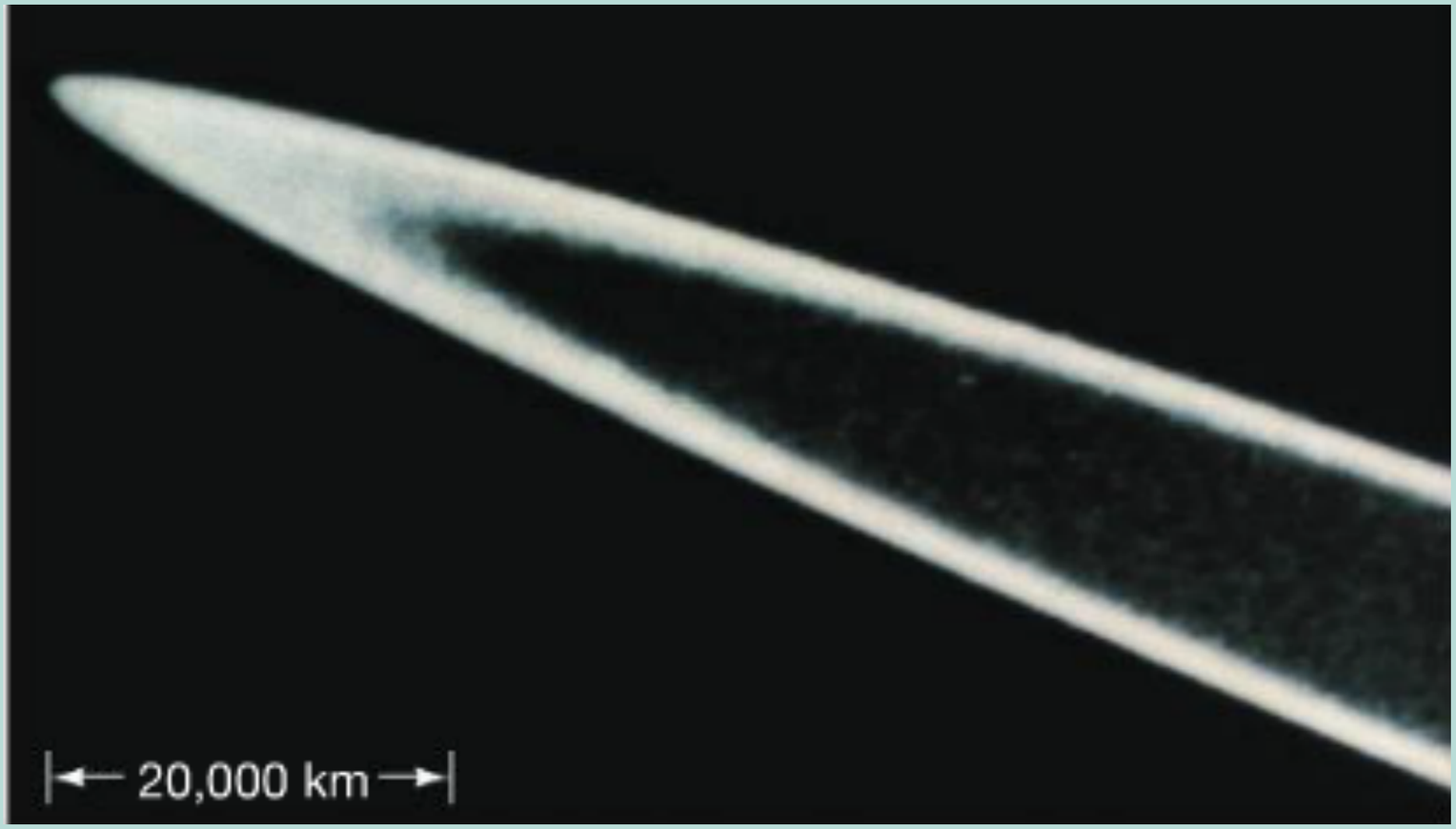


Don’t forget Saturn’s Orbit is almost 5 AU away from Jupiter!

Aurorae



Jupiter has rings!

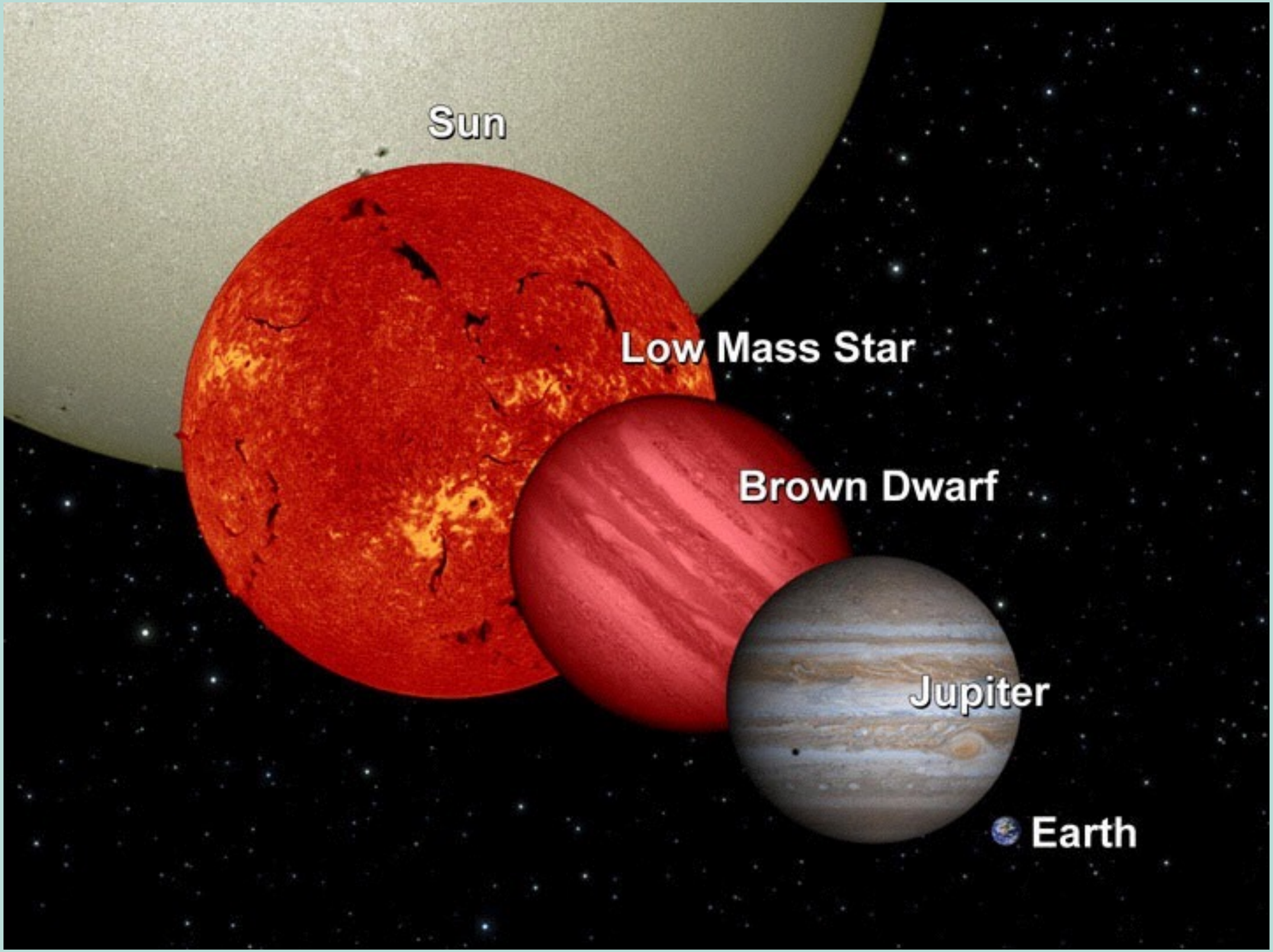


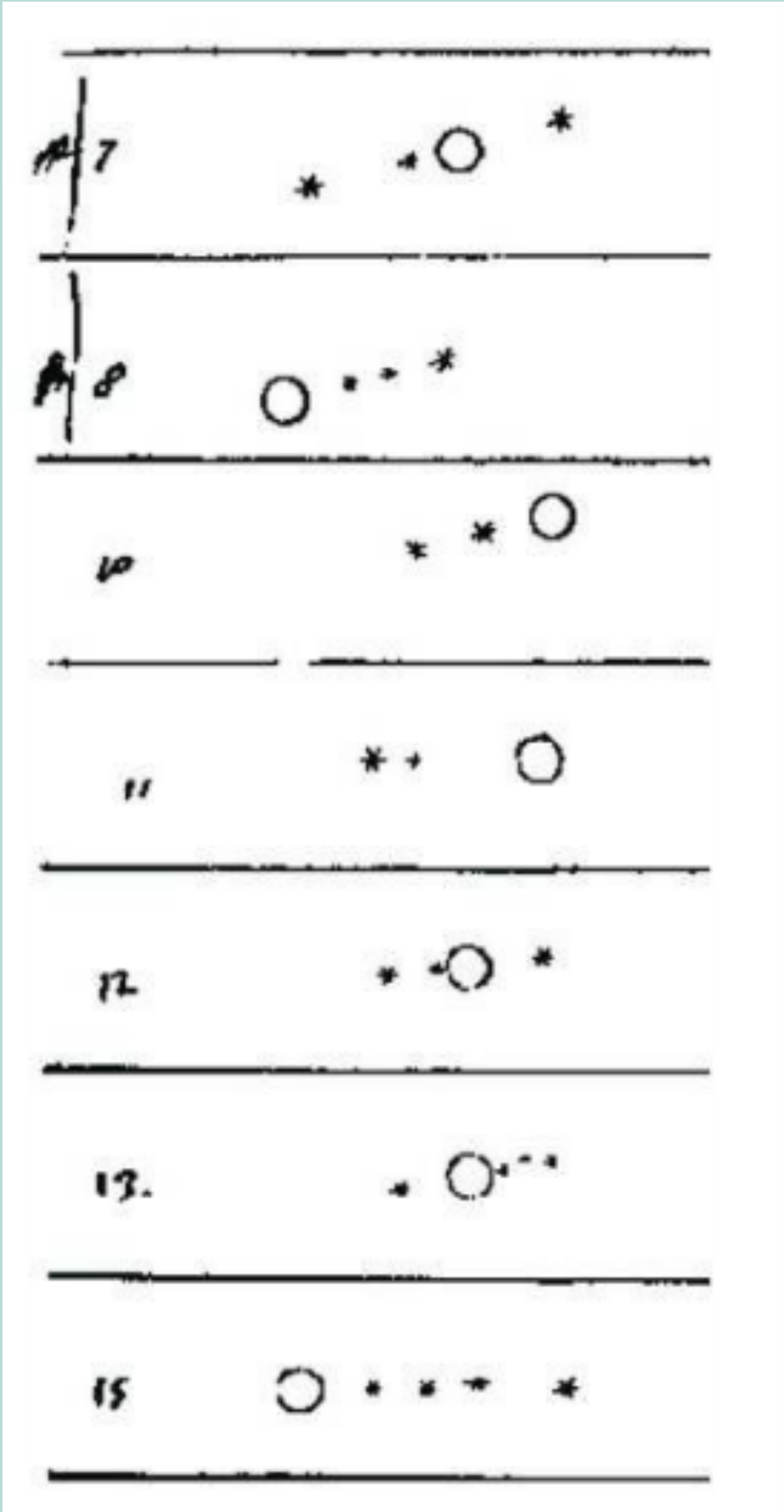
Almost a Star?

Jupiter just doesn't have enough mass to make it hot enough to create the conditions for nuclear fusion in its core (25,000 K not 10,000,000 K)

In the past, it was much hotter and thus much brighter, perhaps 100 times brighter than the moon!

The limit for fusing deuterium (brown dwarf) however is about 13 M_J, so it was close!

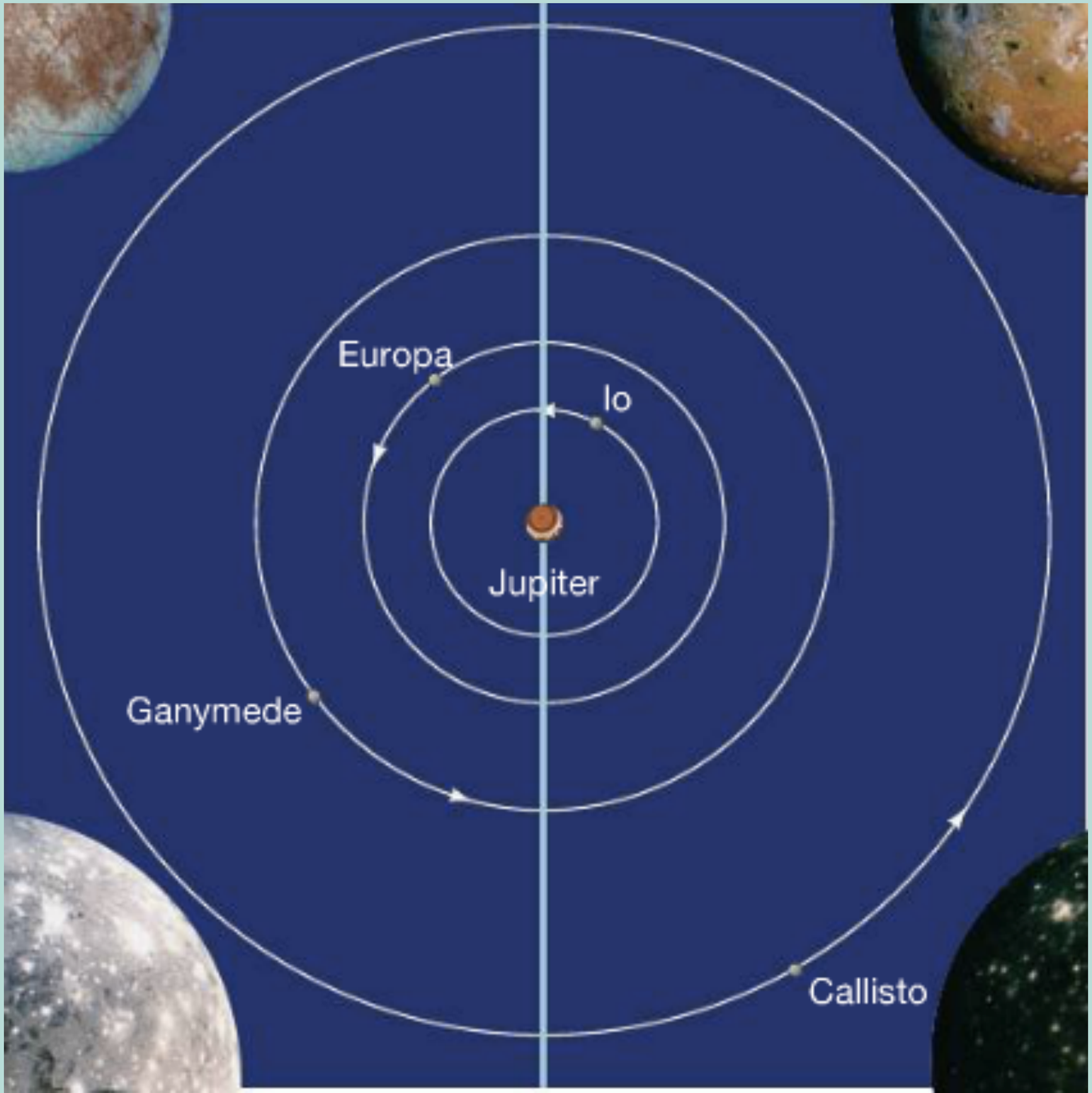

Sun
Low Mass Star
Brown Dwarf
Jupiter
Earth



…remember these guys?

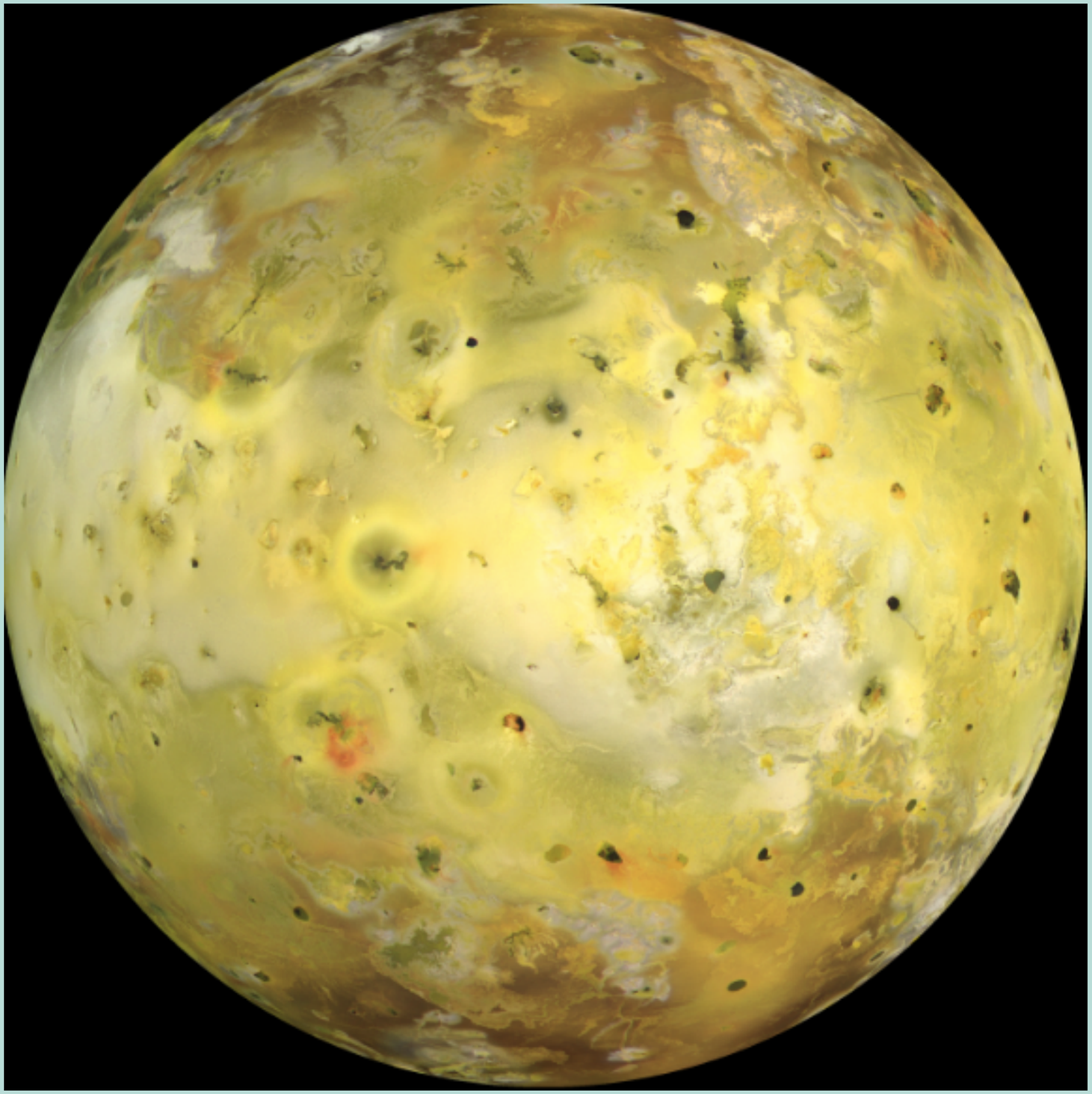
from a better ground based telescope

Galilean Moons



+63 smaller guys

Io

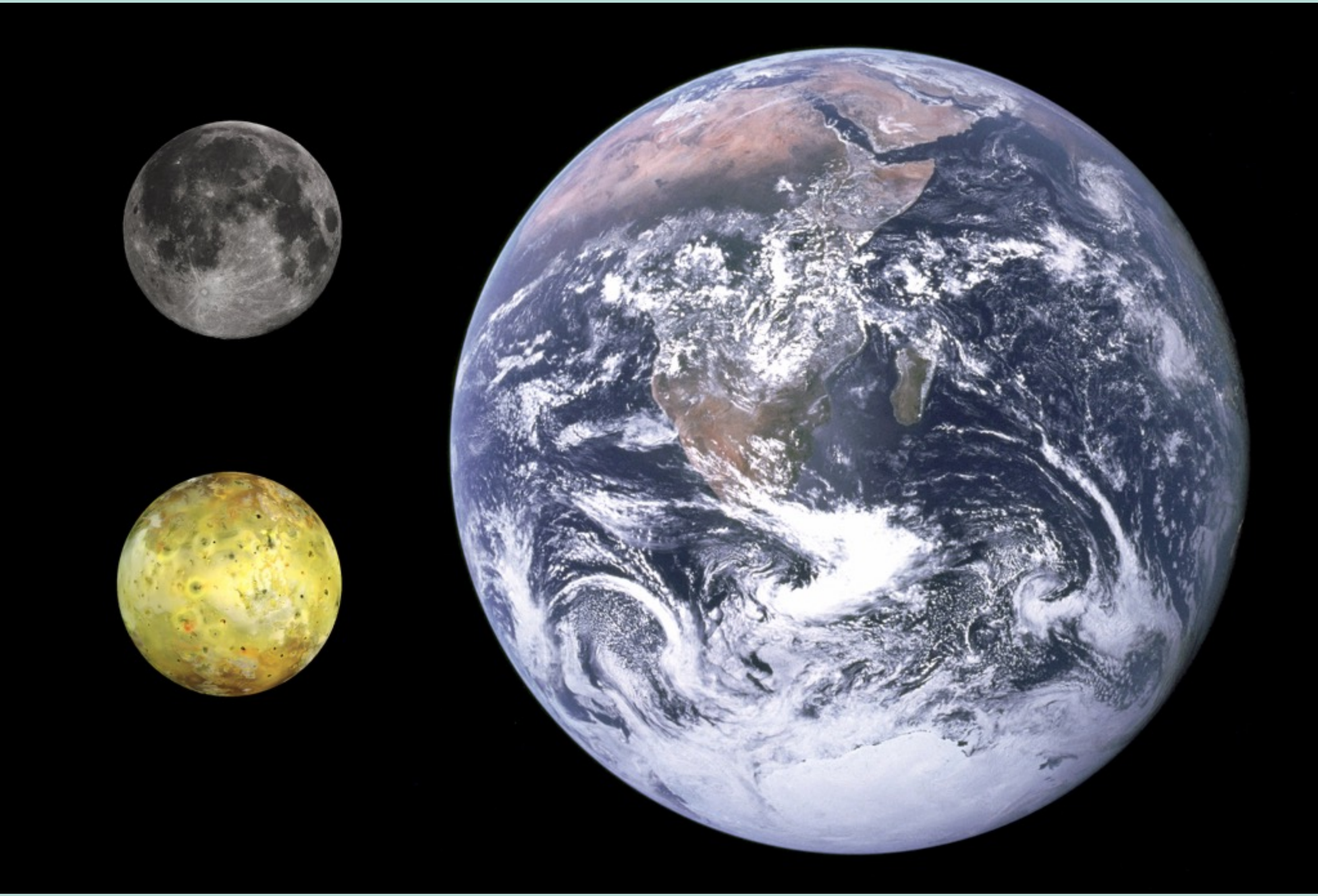


m~ 9 e22 kg
~ 1.2 m_m

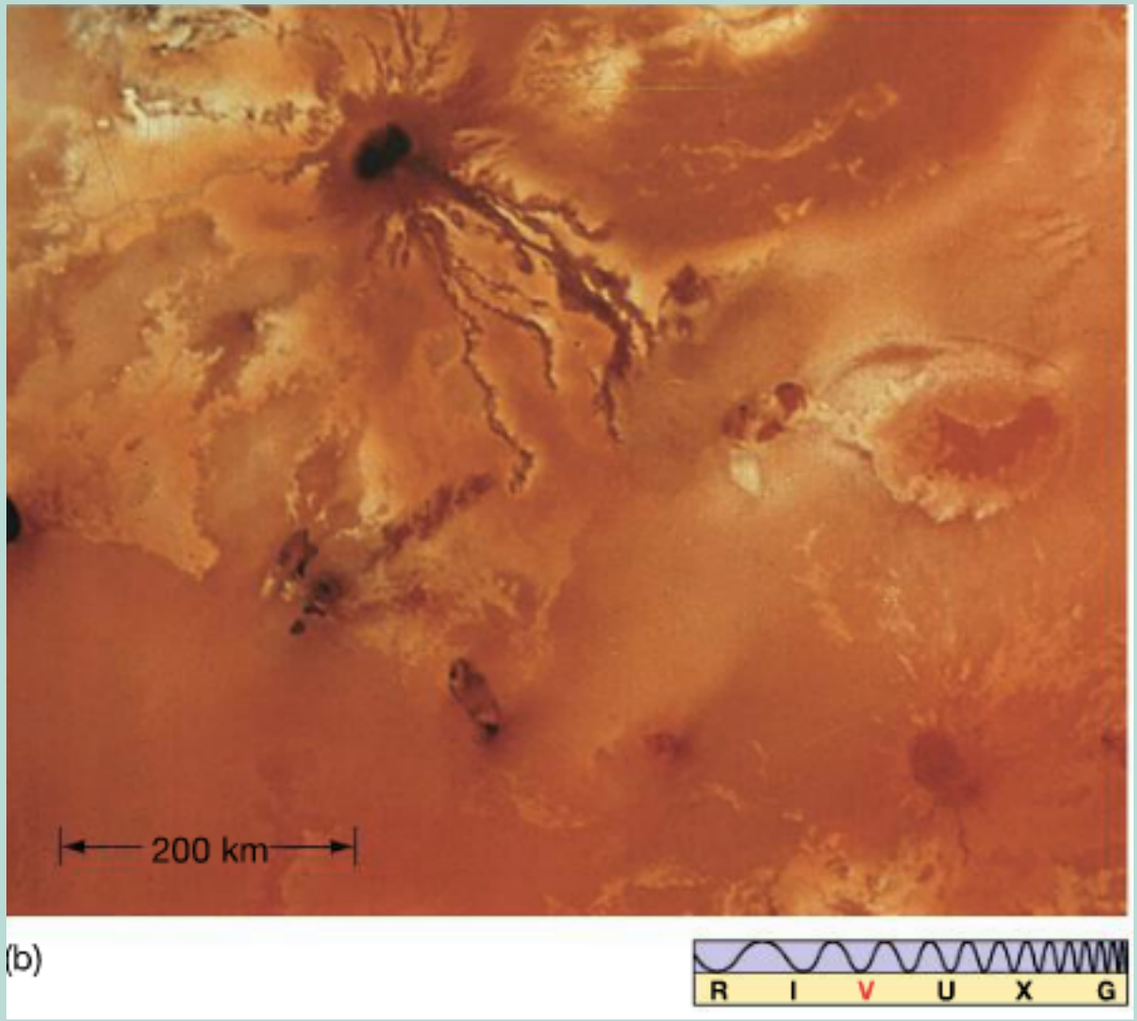
r~ 1.8 e3 km
~ 1.05 r_m

d~ 4.2 e5 km
~ 6.1 R_J

density~
3500 kg/m^3

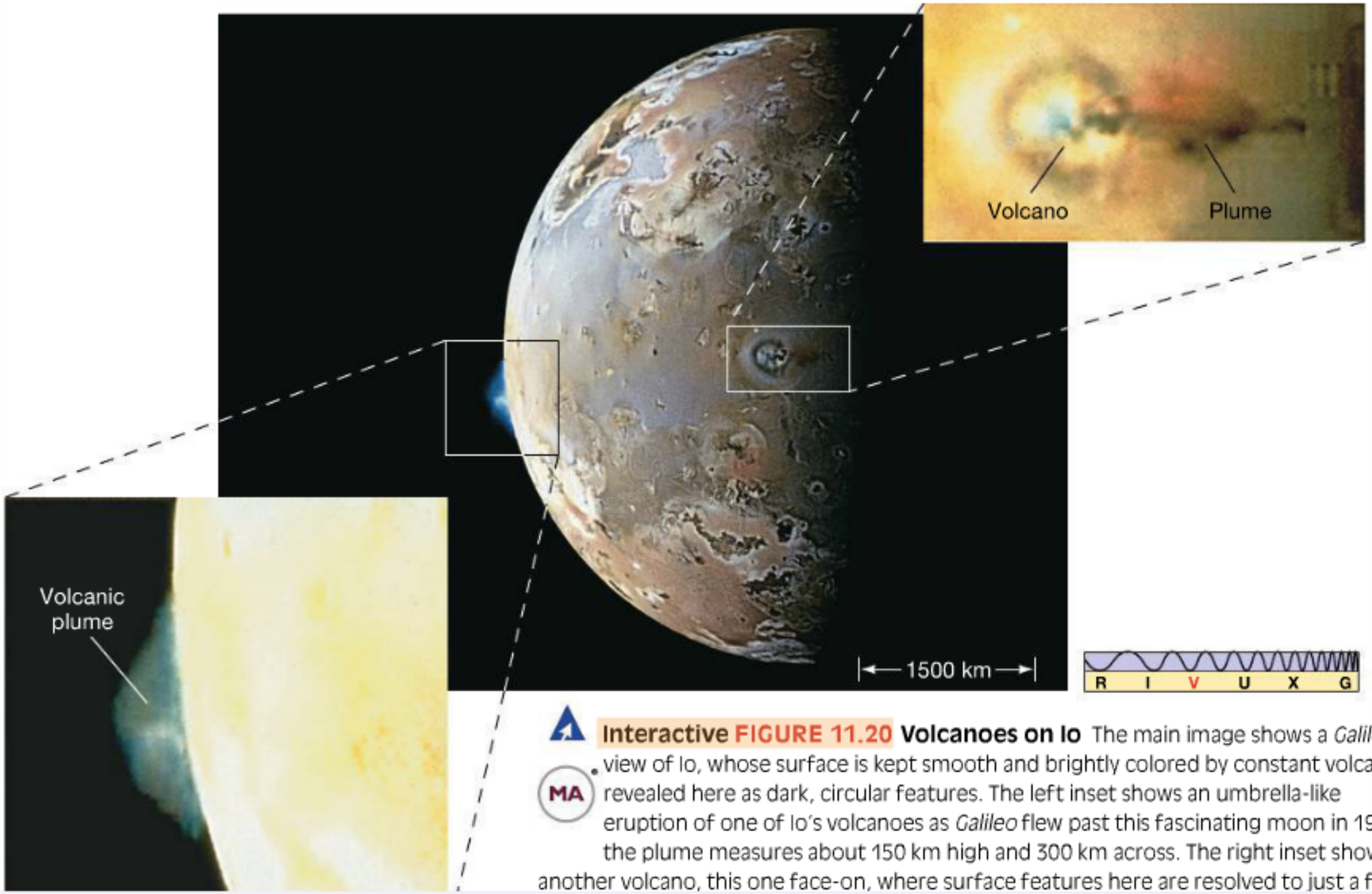


Close up on Io



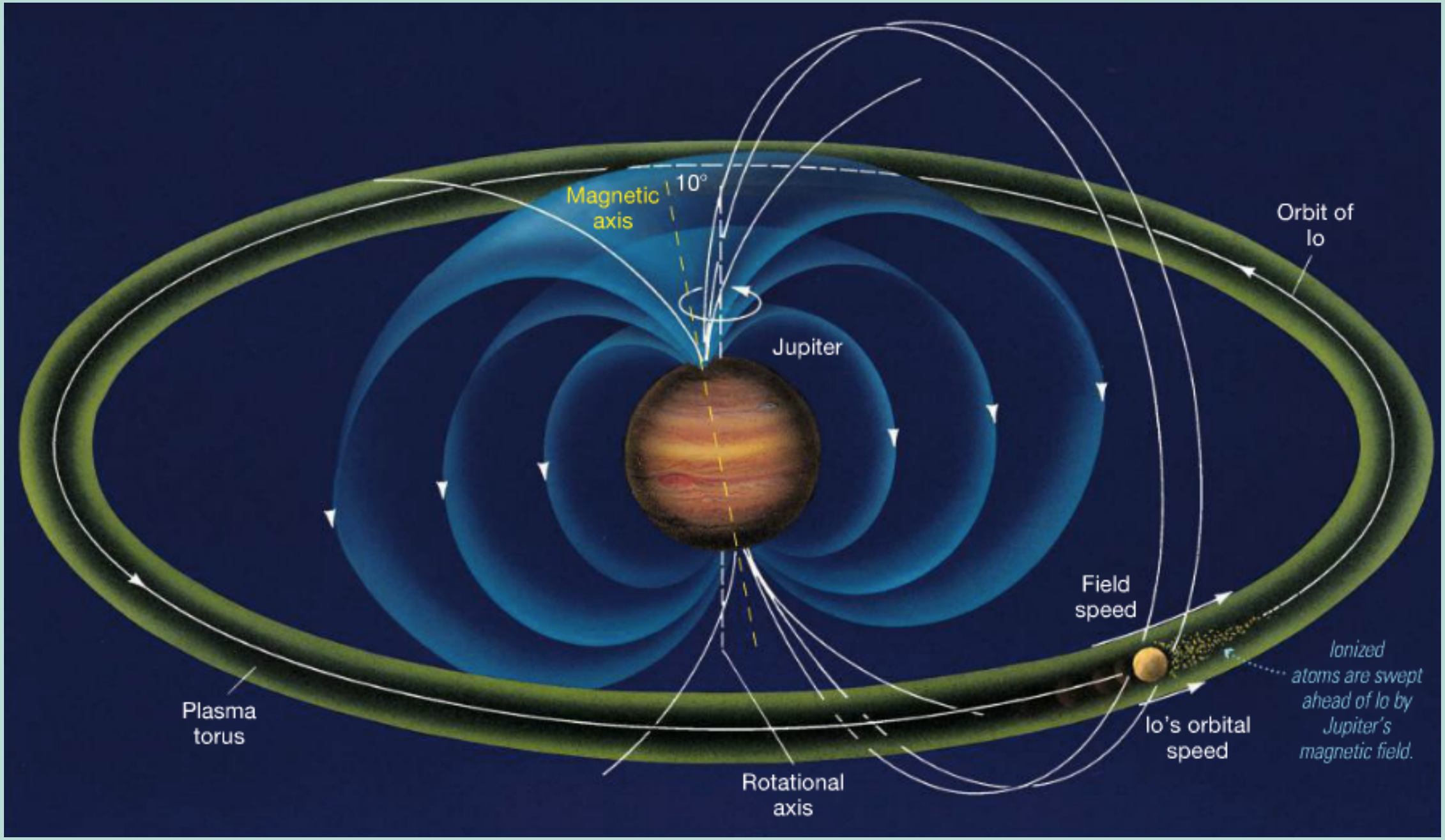
Where does the heat come from?

Loki and Prometheus



Interactive FIGURE 11.20 Volcanoes on Io The main image shows a *Galileo* view of Io, whose surface is kept smooth and brightly colored by constant volcanism, revealed here as dark, circular features. The left inset shows an umbrella-like eruption of one of Io's volcanoes as *Galileo* flew past this fascinating moon in 1997; the plume measures about 150 km high and 300 km across. The right inset shows another volcano, this one face-on, where surface features here are resolved to just a few

Io Plasma Torus



Europa

m~ 4.8 e22 kg
~ .65 m_m

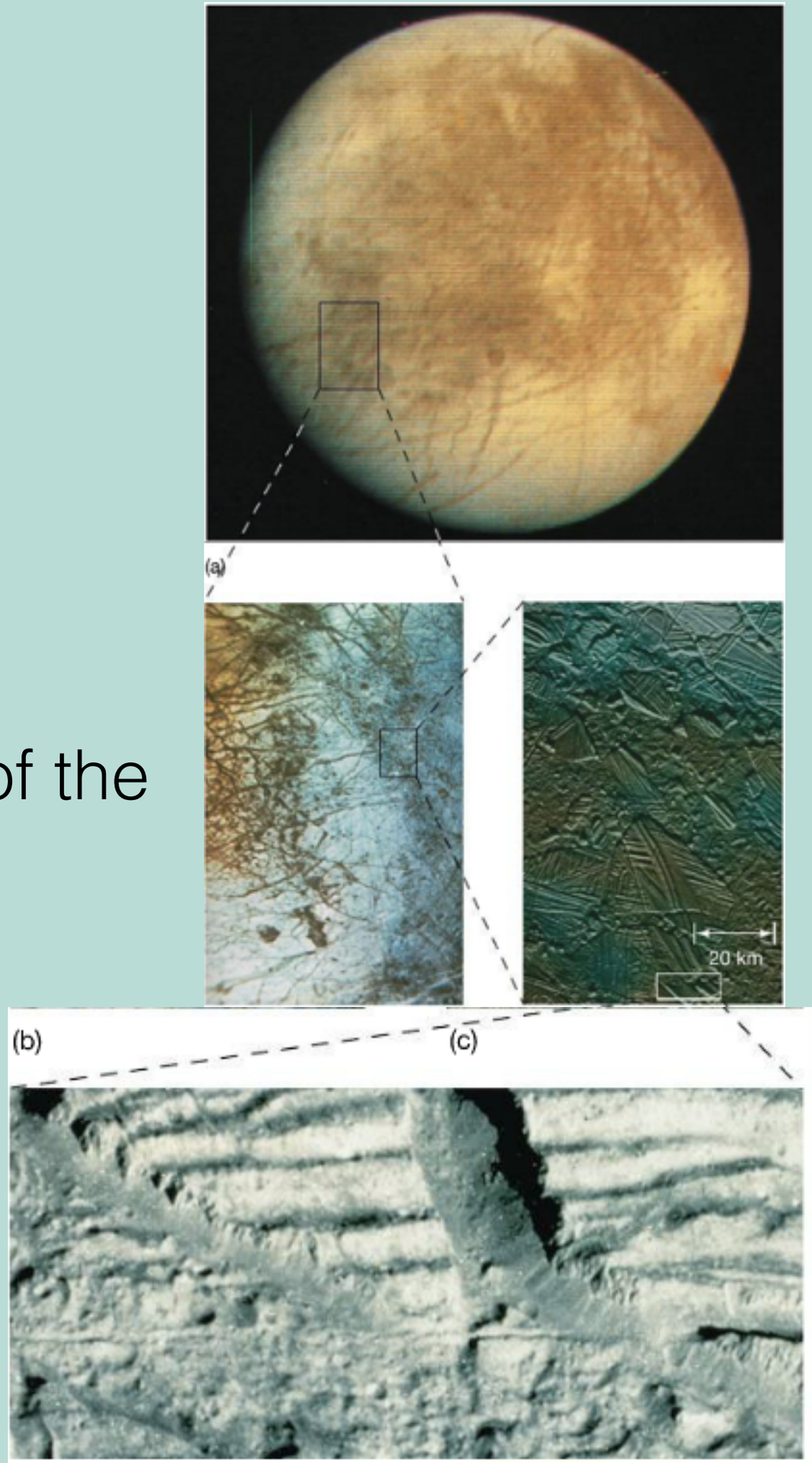
r~ 1.6 e3 km
~ .9 r_m

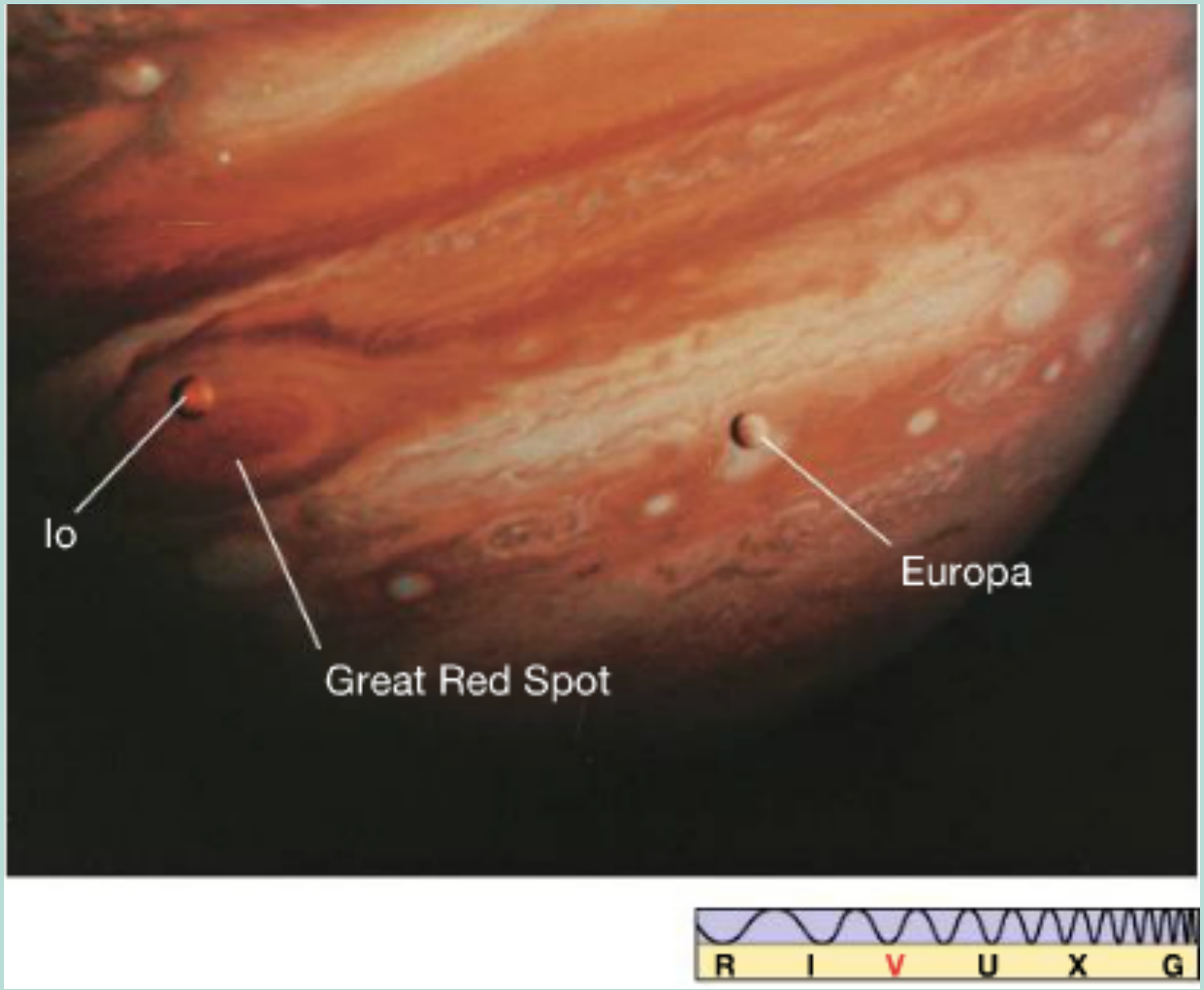
d~ 6.7 e5 km
~ 10 R_J

density~
3000 kg/m^3

Ice Cracks On Europa

Conjectured to contain MOST of the water in the solar system!




Io
Great Red Spot
Europa
R
I
V
U
X
G

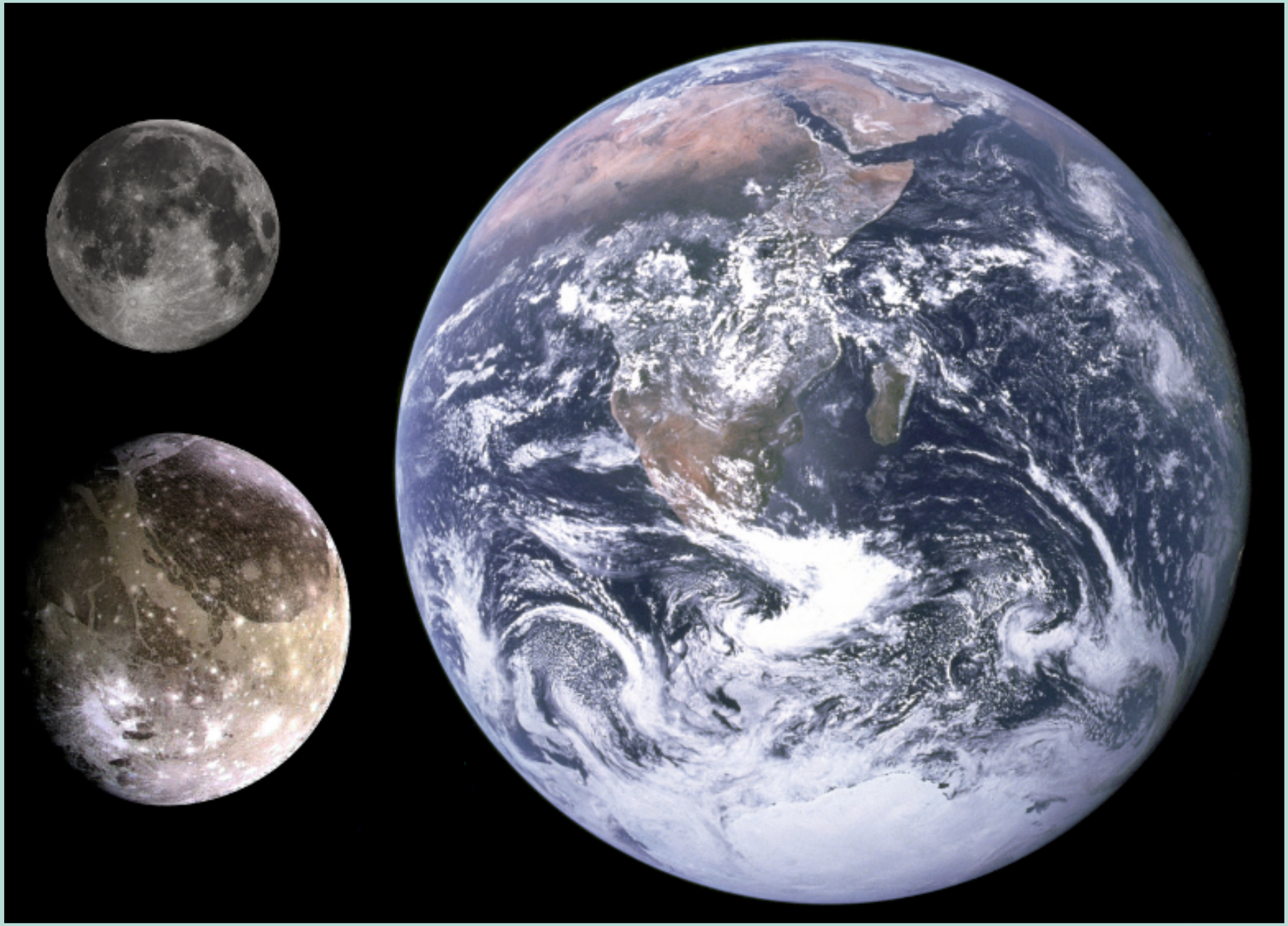
Ganymede

m~ 1.5 e23 kg
~ 2 m_m

r~ 2.6 e3 km
~ 1.5 r_m

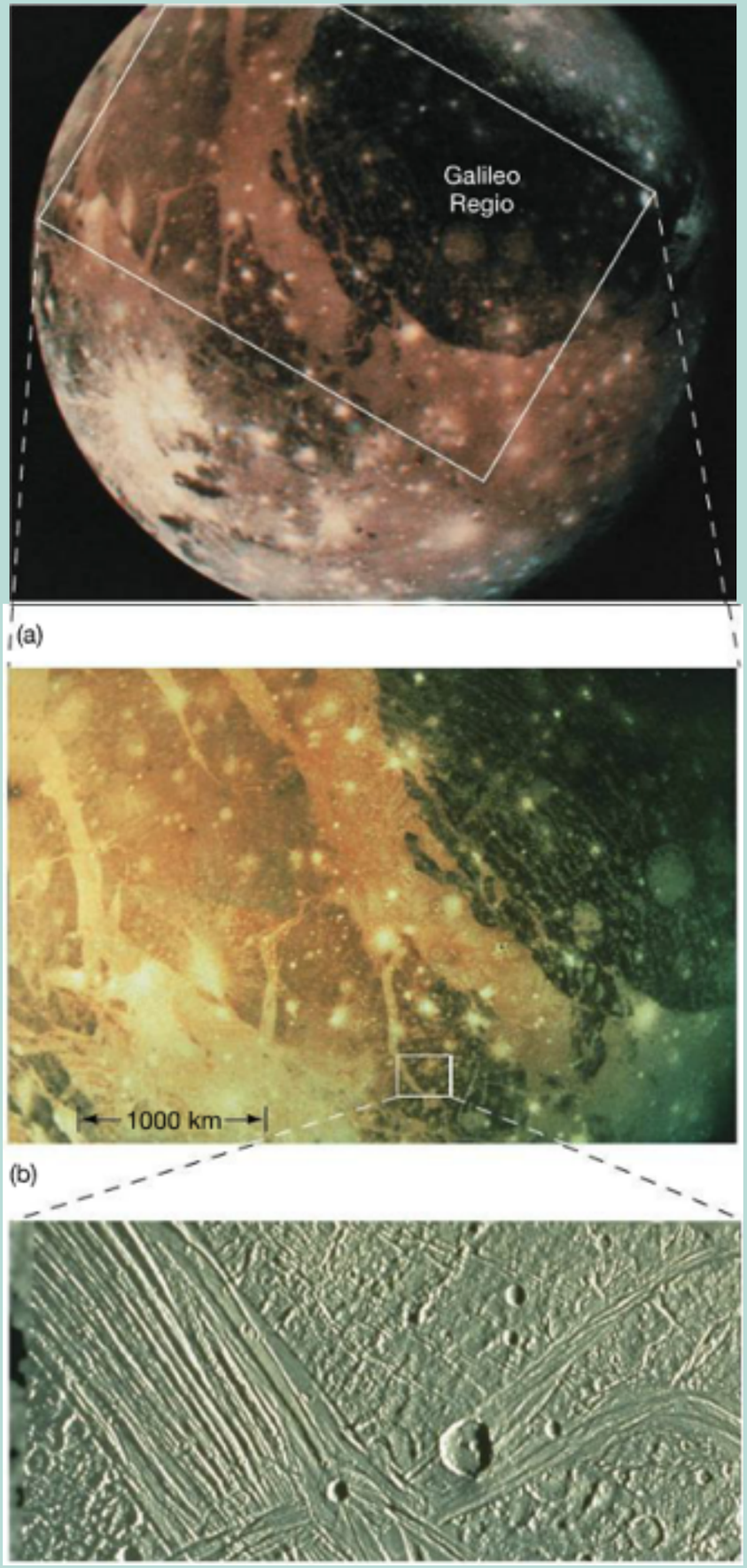
d~ 1 e6 km
~ 15.4 R_J

density~
2000 kg/m^3



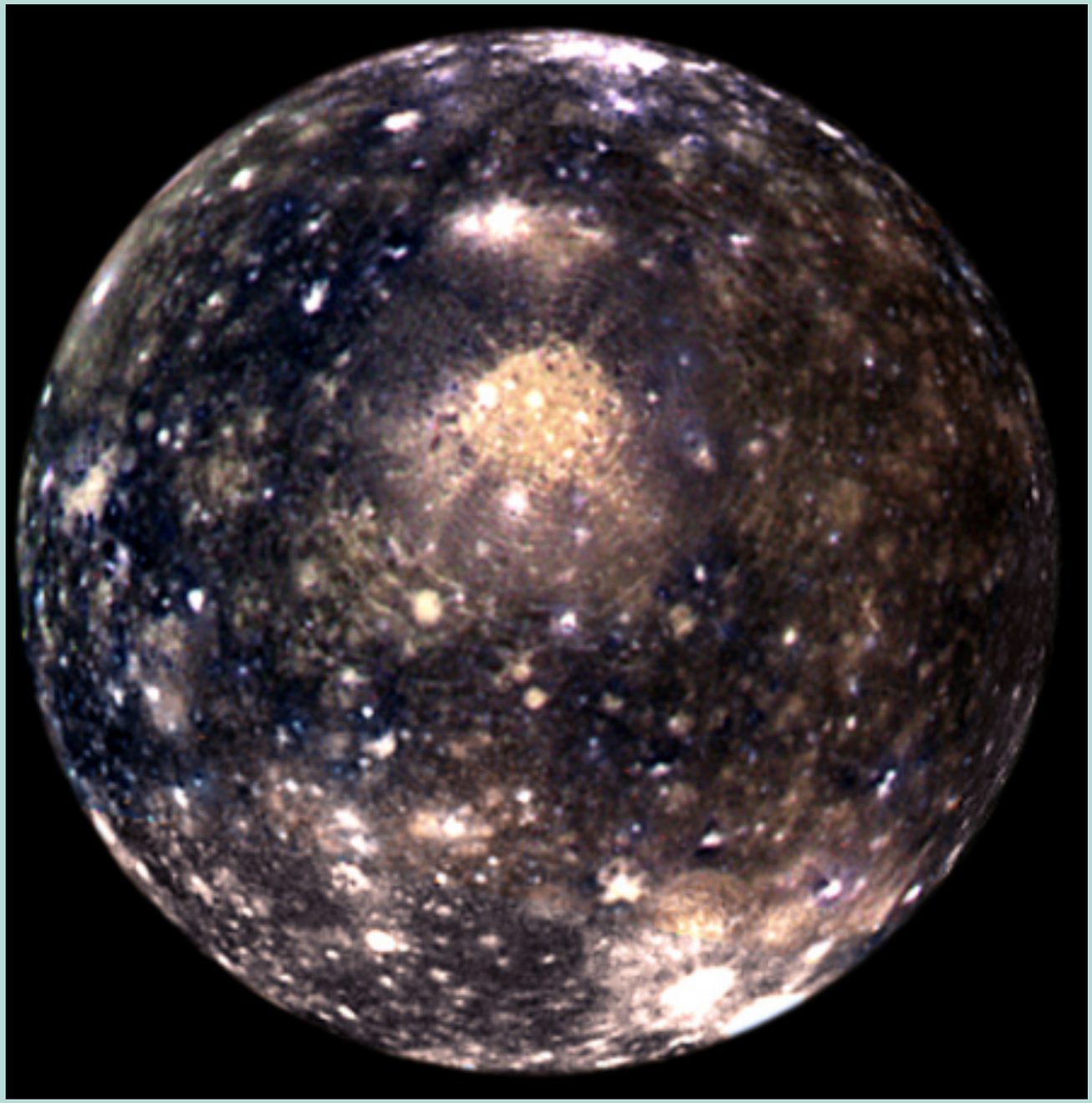
To scale comparison

Crustal Cracks on Ganymede



Ganymede cooled somewhat recently. The mechanism for keeping it hot for so long is unknown…

Callisto



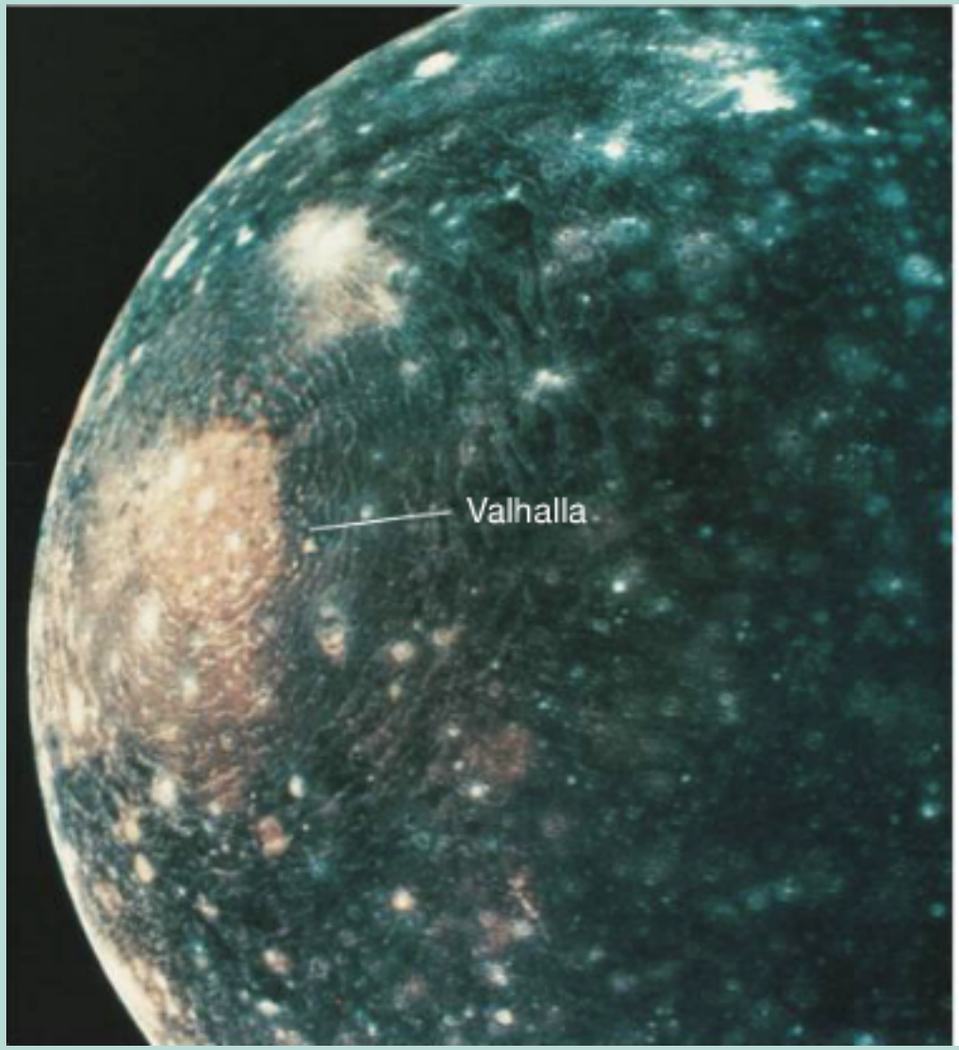
m~ 1 e23 kg
~ 1.5 m_m

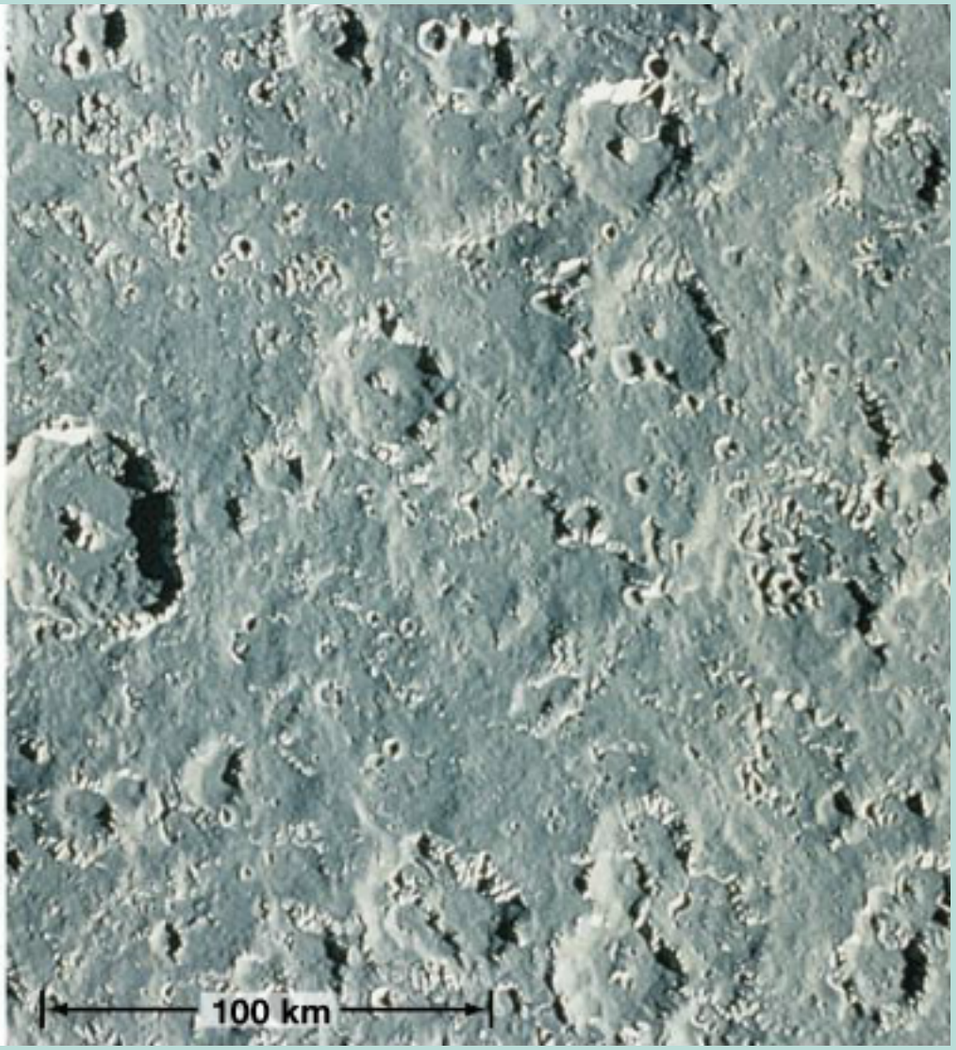
r~ 2.4 e3 km
~ 1.38 r_m

d~ 1.8 e6 km
~ 26 R_J

density~
1800 kg/m^3

Valhalla





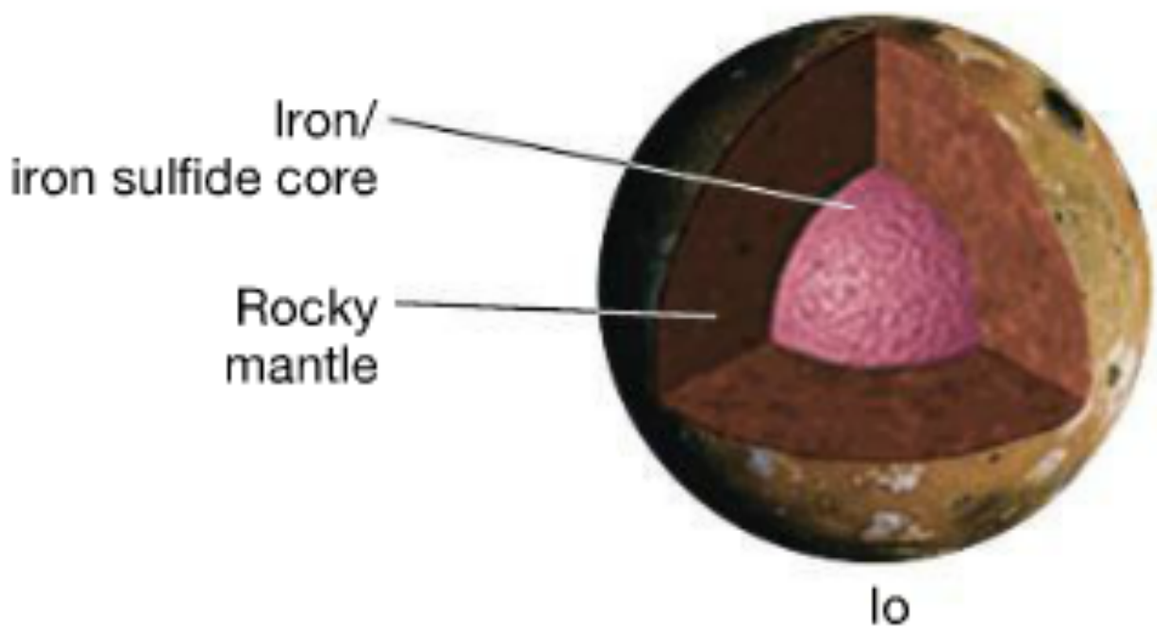
Moon Comparison

TABLE 11.1 The Major Moons of Jupiter*

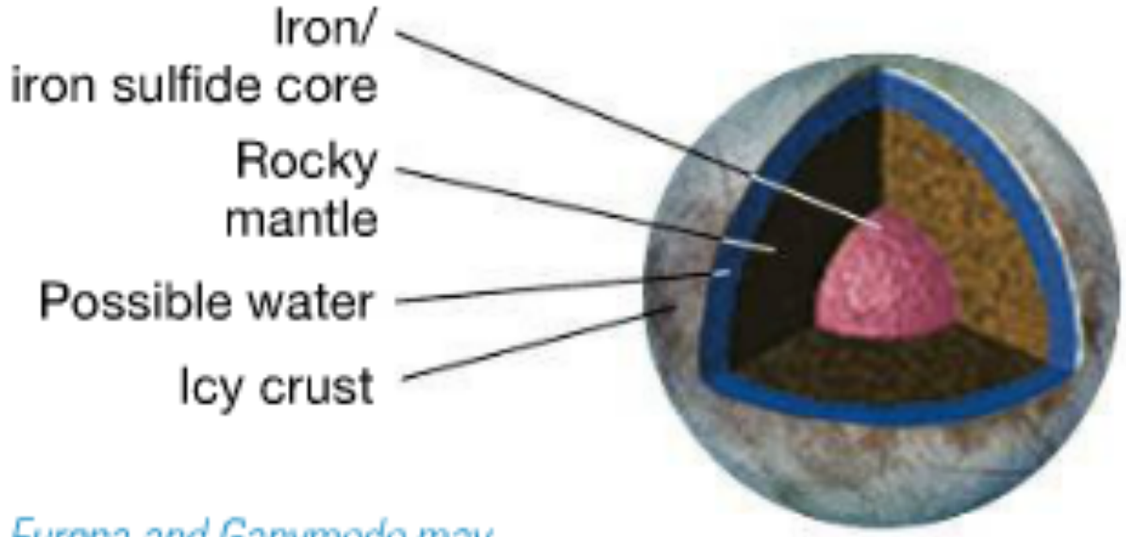
Name	Distance from Jupiter (km)	Distance from Jupiter (planetary radii)	Orbital Period (days)	Size (longest diameter, km)	Mass** (Earth Moon masses)	Density (kg/m^3)	Density (g/cm^3)
Io	422,000	5.90	1.77	3640	1.22	3500	3.5
Europa	671,000	9.38	3.55	3130	0.65	3000	3.0
Ganymede	1,070,000	15.0	7.15	5270	2.02	1900	1.9
Callisto	1,880,000	26.3	16.7	4800	1.46	1900	1.9

Inner Moons

Outer Moons

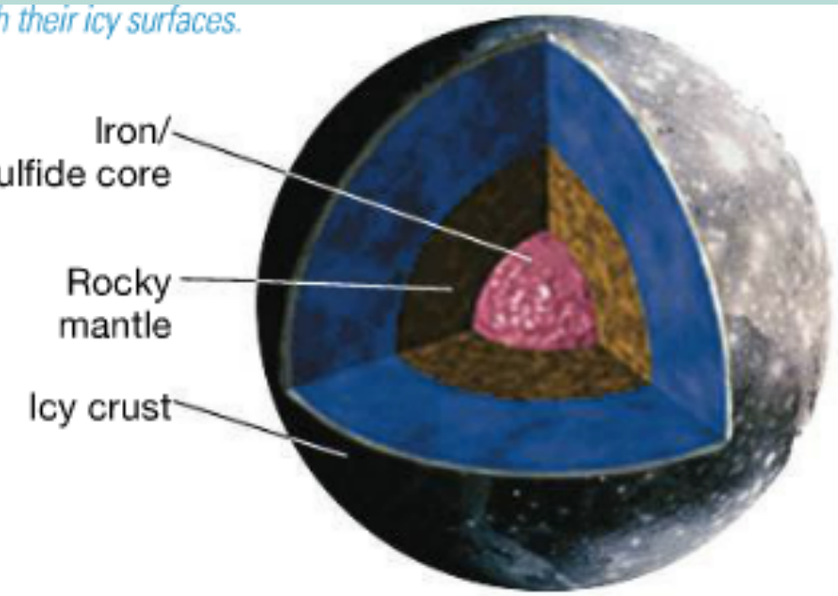


Io

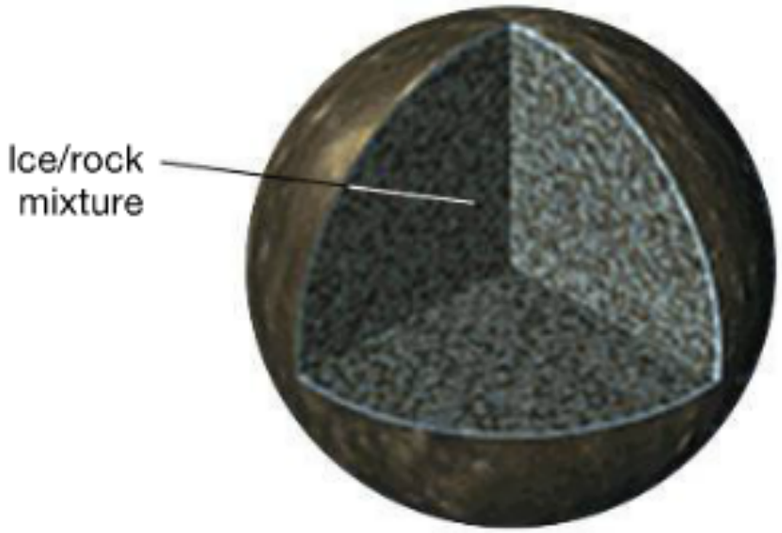


Europa

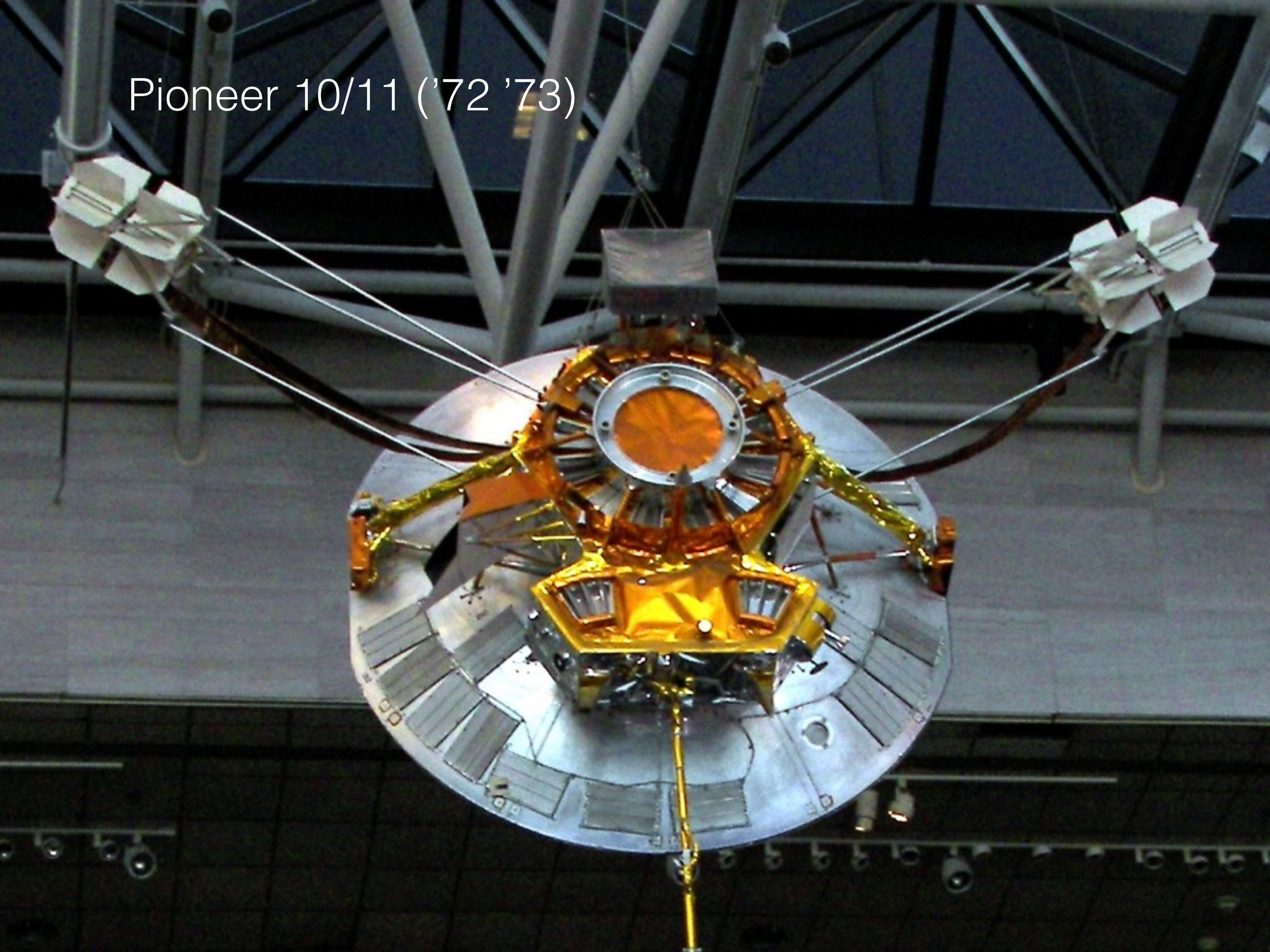
Europa and Ganymede may have layers of liquid water beneath their icy surfaces.



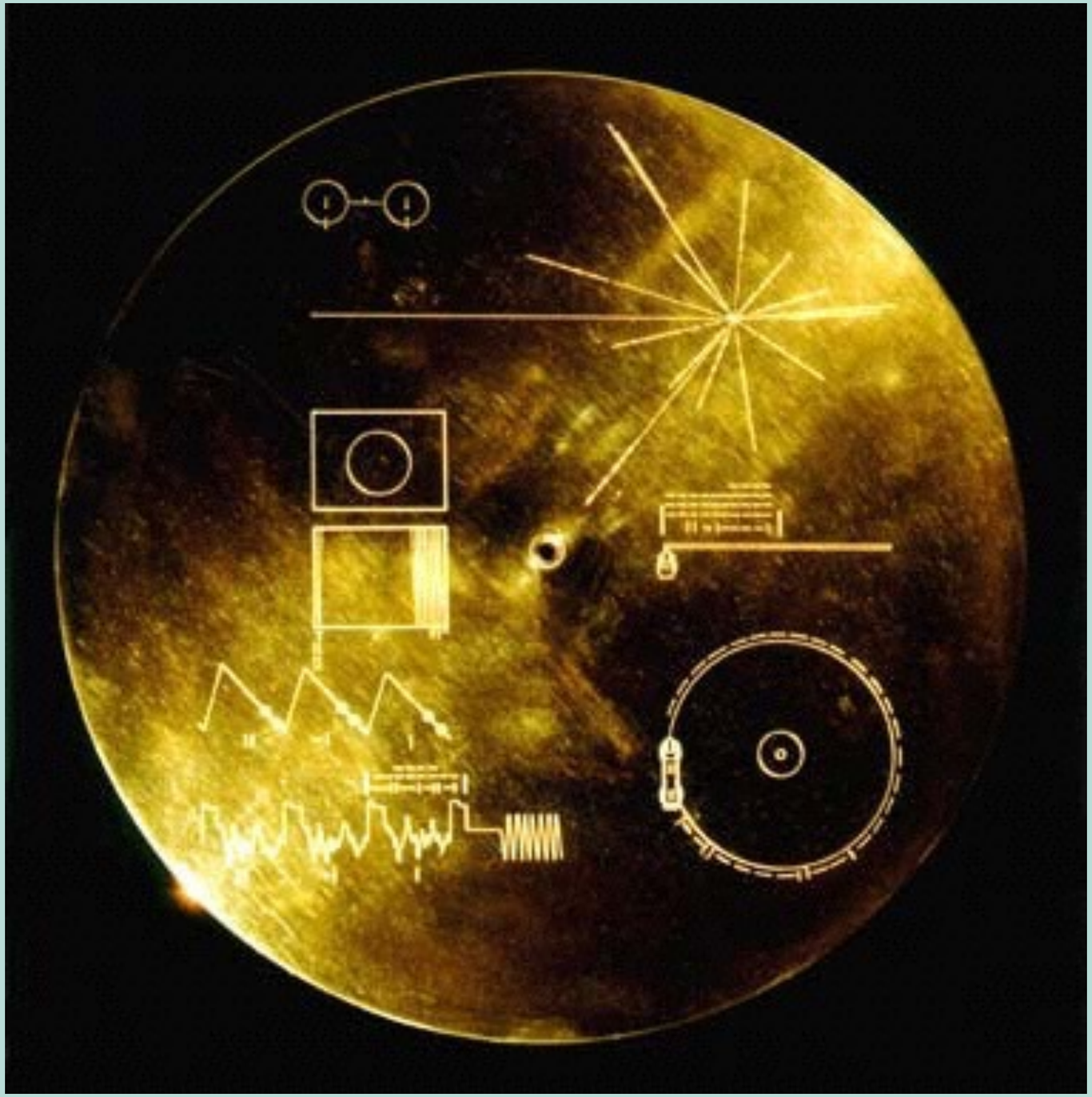
Ganymede



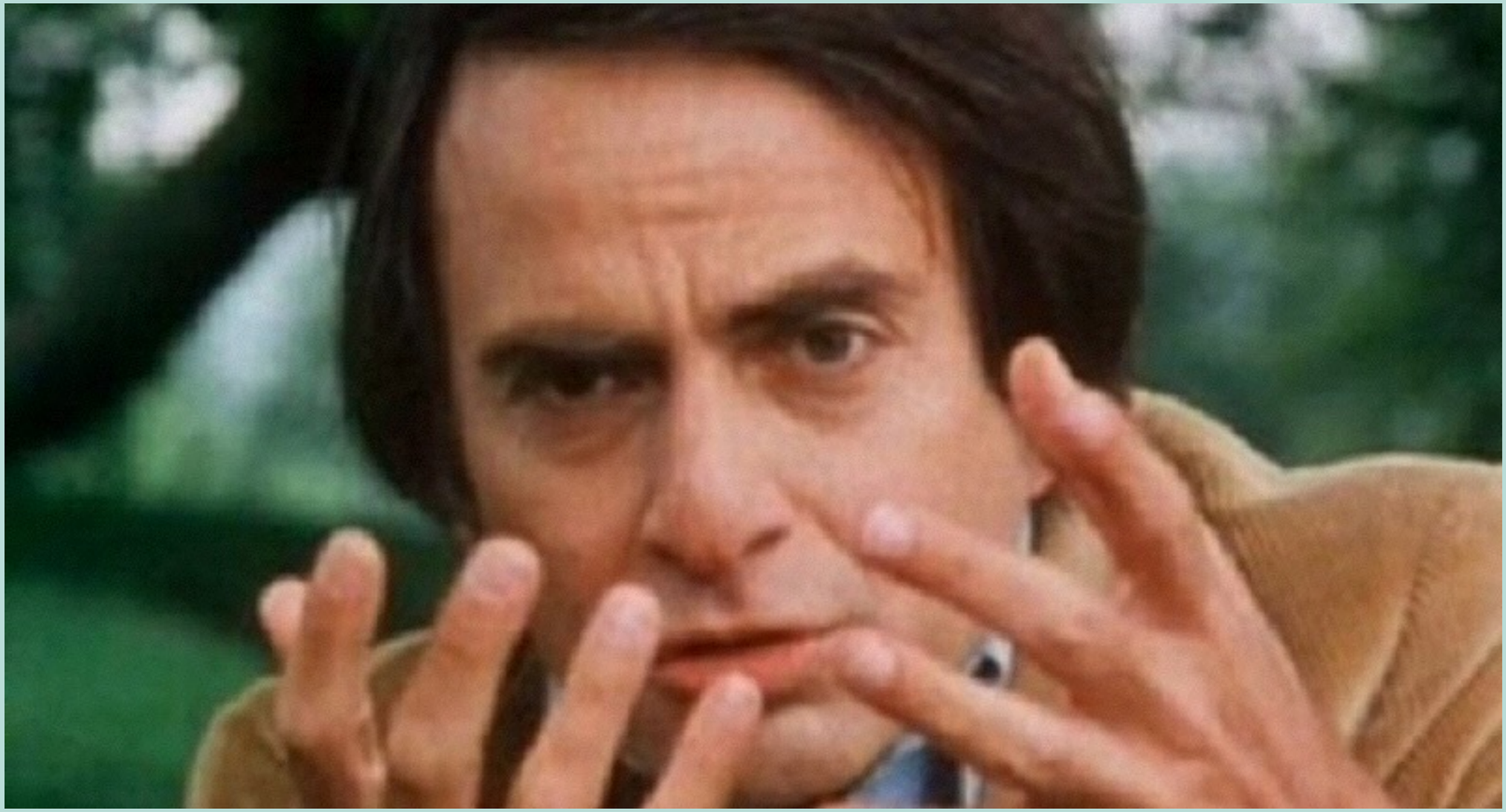
Callisto


Pioneer 10/11 ('72 '73)

Voyager (1977)



Golden Record



- Included 116 images of humans, nature, things about the earth and our solar system.

- Included numerous recordings of natural sounds from birds and whales, wind and surf.

- Included sounds of Mozart, Bach, Rock and roll (not the Beatles though)

- Included a recording of brain waves while the person thought about what it's like to be a human and fall in love.