

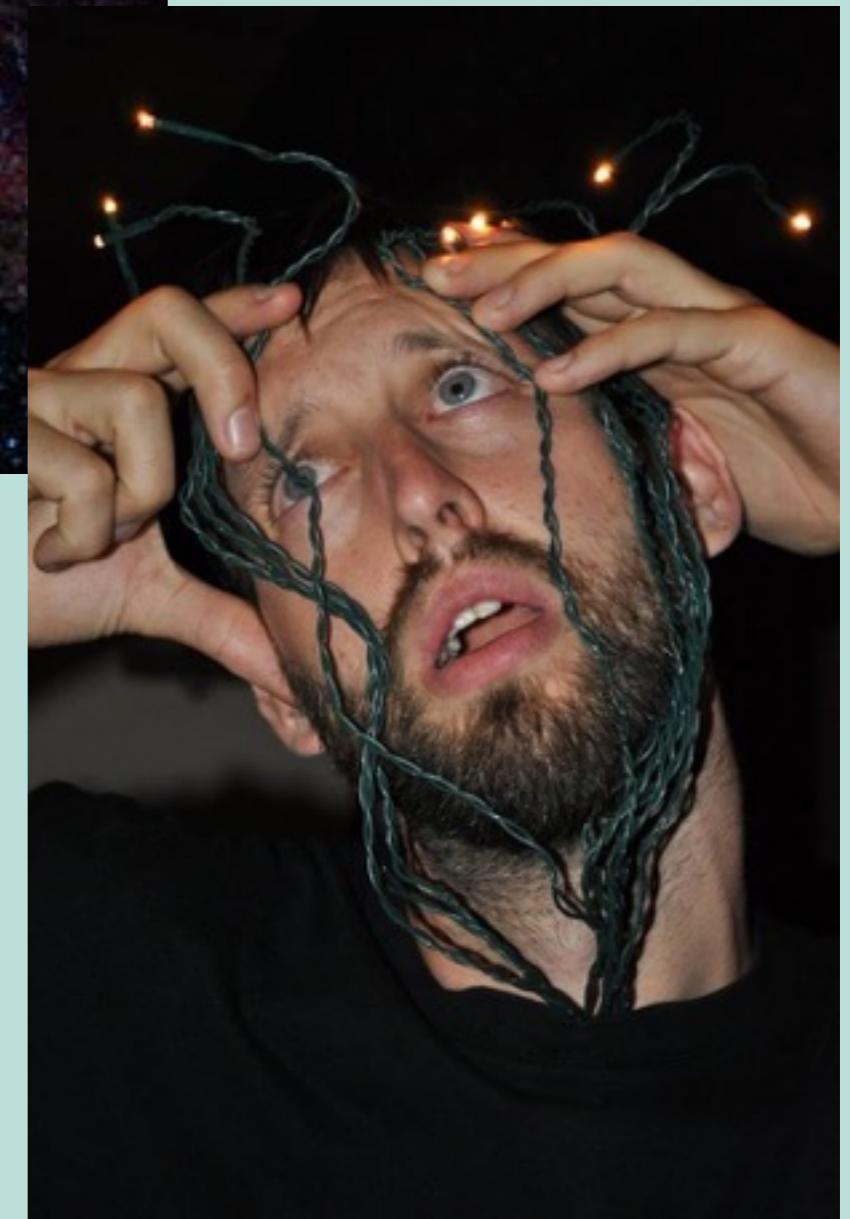


Lecture 11: Saturn

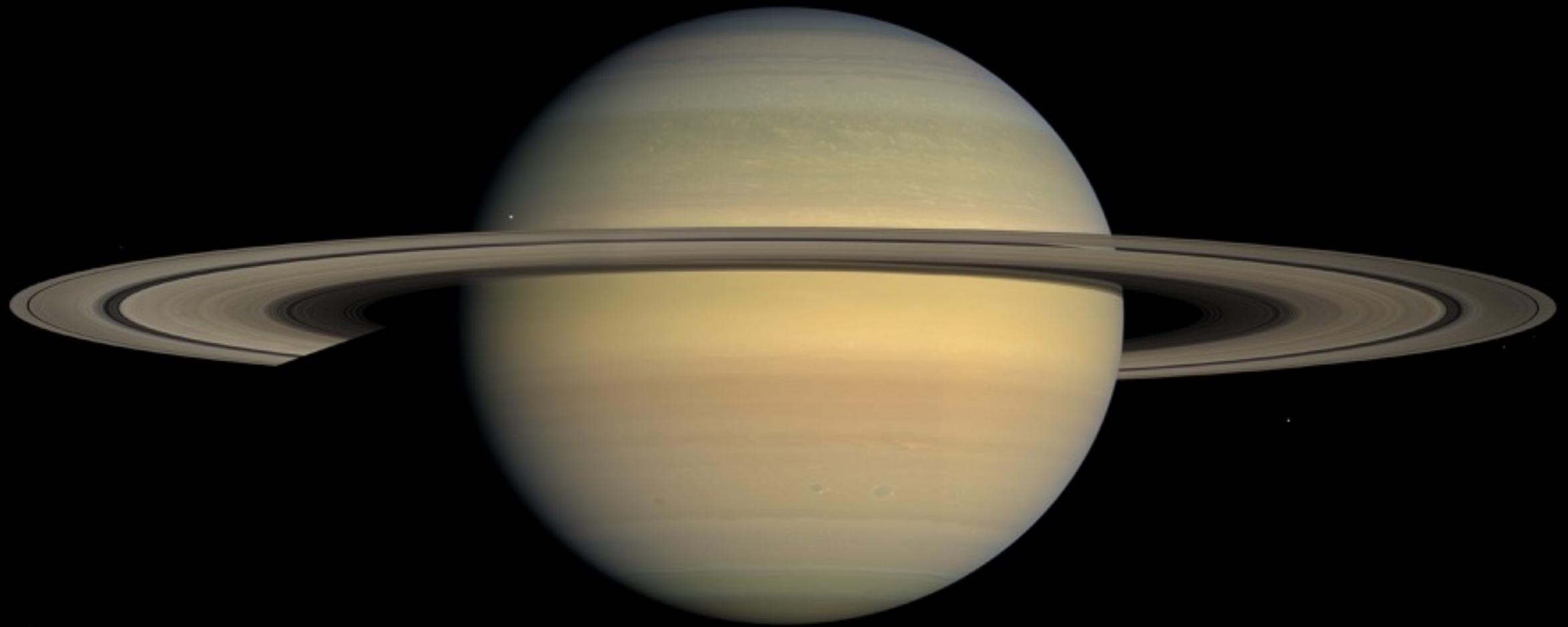


Astronomy

with your host:



Coop



Saturn

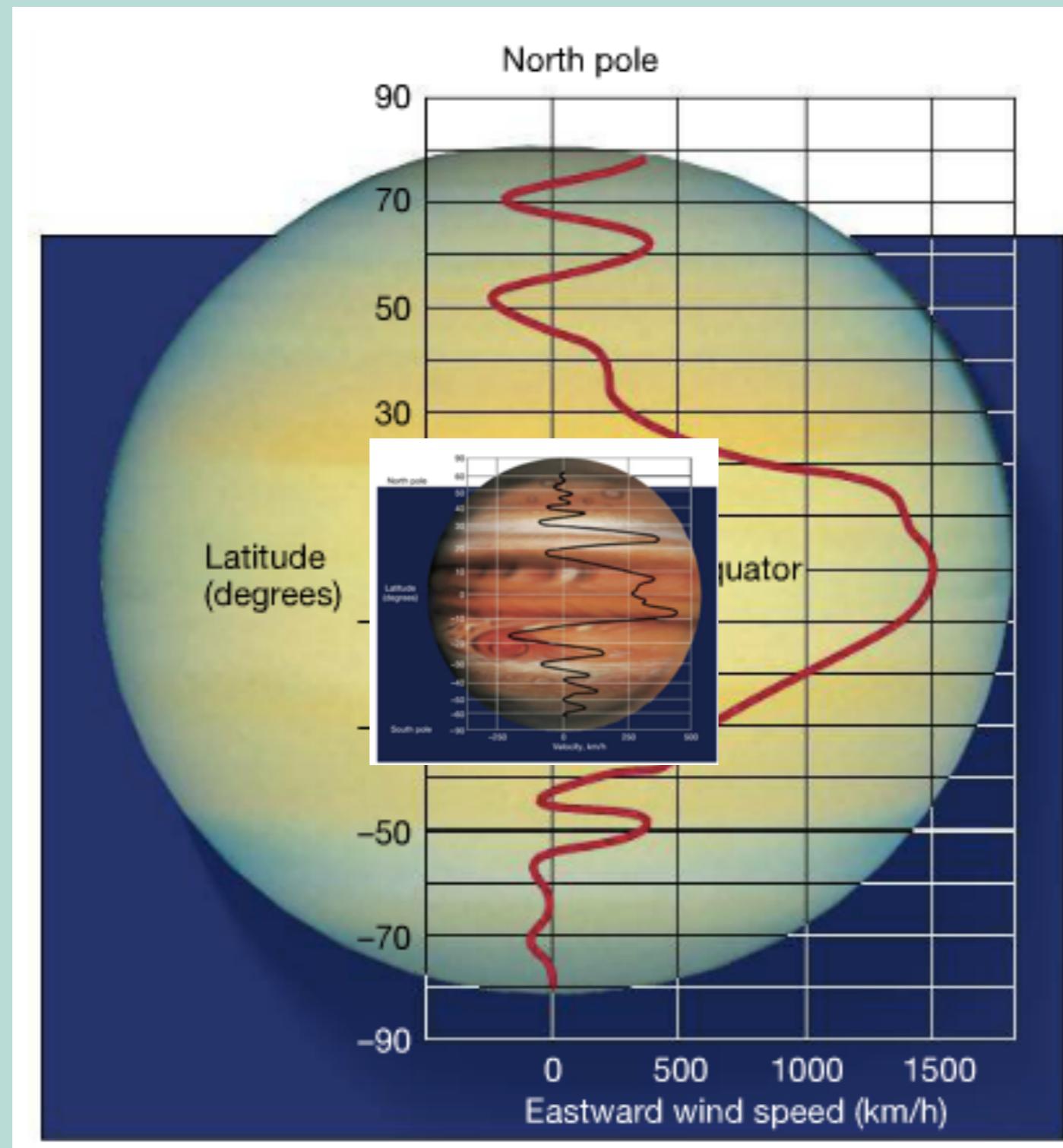
$m \sim 5.7\text{e}26 \sim 95 m_e$

$r \sim 5.7\text{e}7 \text{ km} \sim 9 r_e$

$d \sim 1.5\text{e}9 \text{ km} \sim 9.5 \text{ AU}$

density $\sim 687 \text{ kg/m}^3$

Saturn's Playing for Keeps



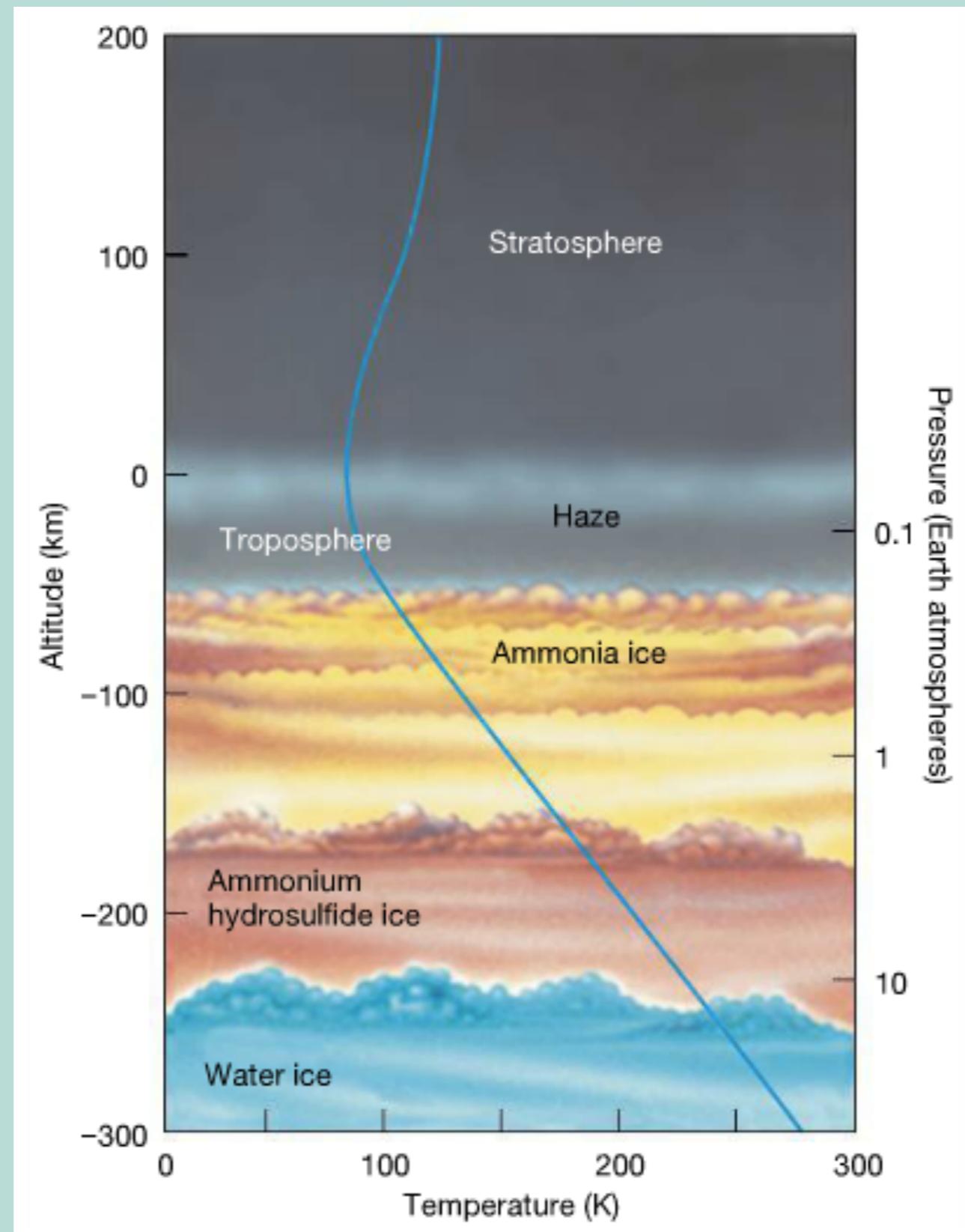
- $T = 10h\ 46min$ (and slowing)
- Very Flat (10% difference in polar radius)

Rotation Determined by Magnetosphere



- Saturn's magnetosphere is 1/1000th as powerful as Jupiter's, or about 20 times more powerful than earth.
- This means that at the top of Saturn's atmosphere, about 10 earth radii away from the center of the planet, the field is about as strong as earth's magnetic field.
- No major moons found inside magnetosphere = no plasma torus :(

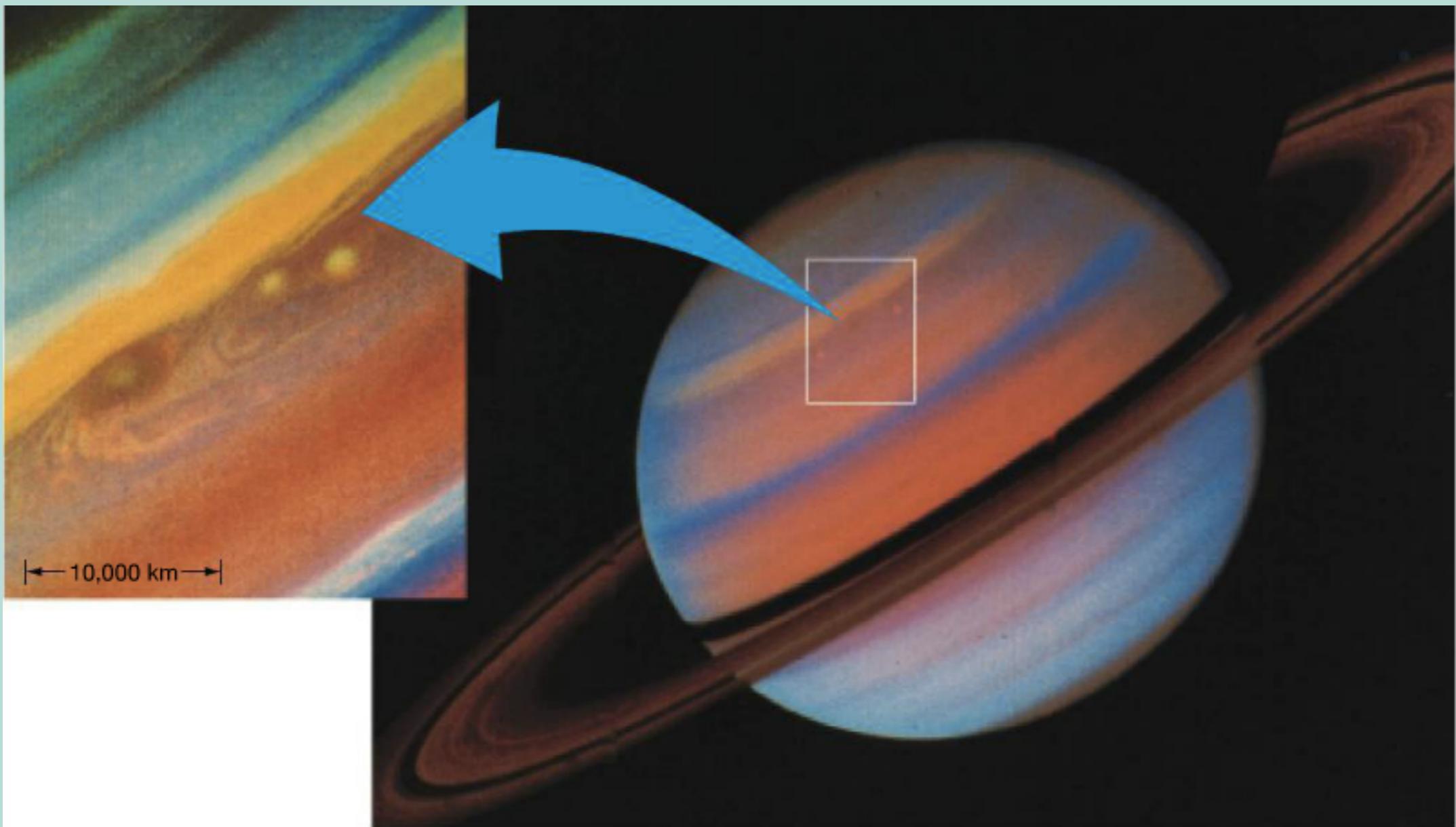
Saturn's Atmosphere



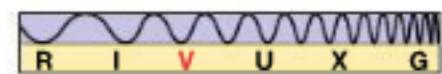
92.4% molecular hydrogen,
7.4% helium,
.2% methane,
.02% ammonia

Why so little helium?

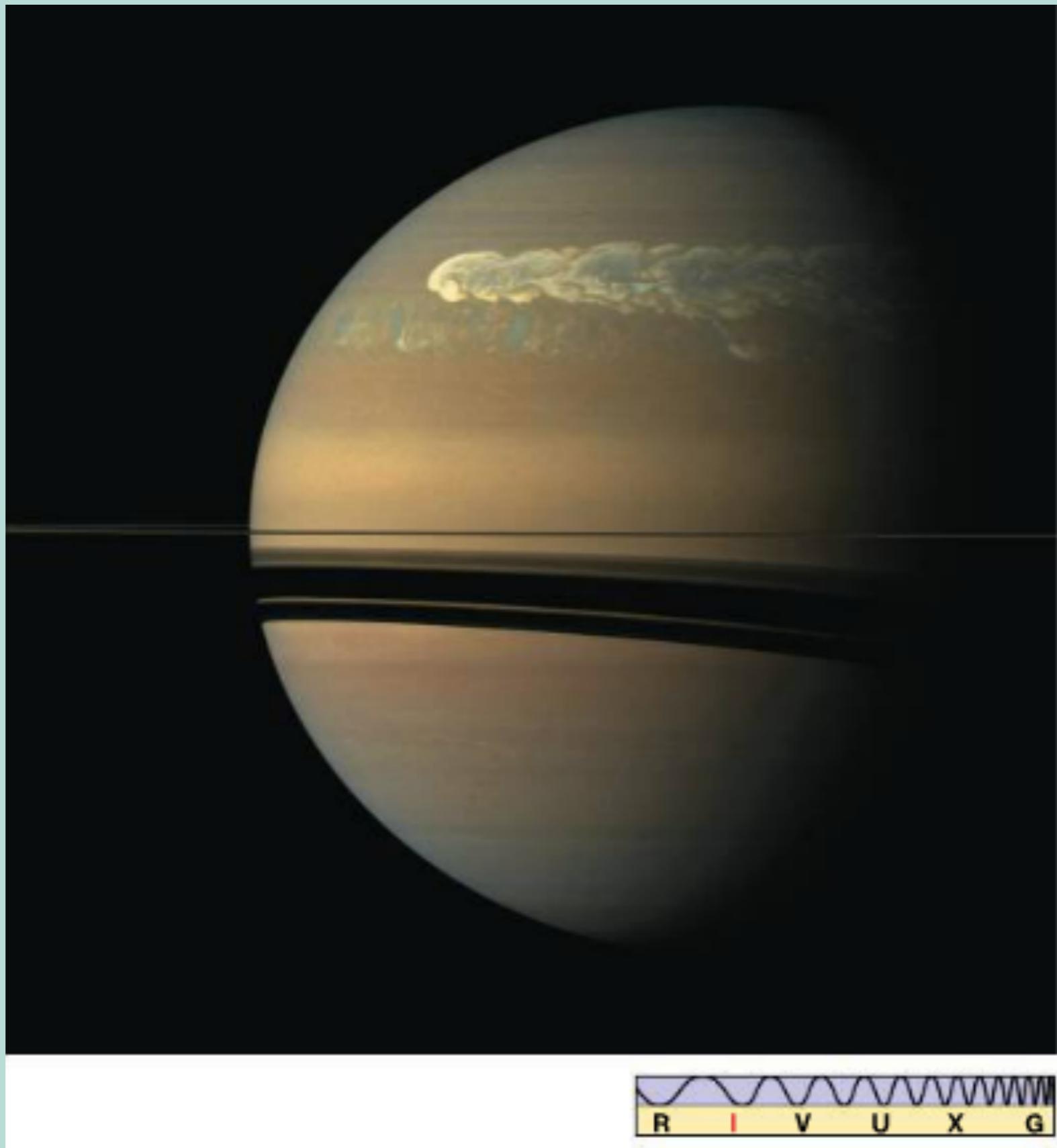
Enhanced Cloud Structure



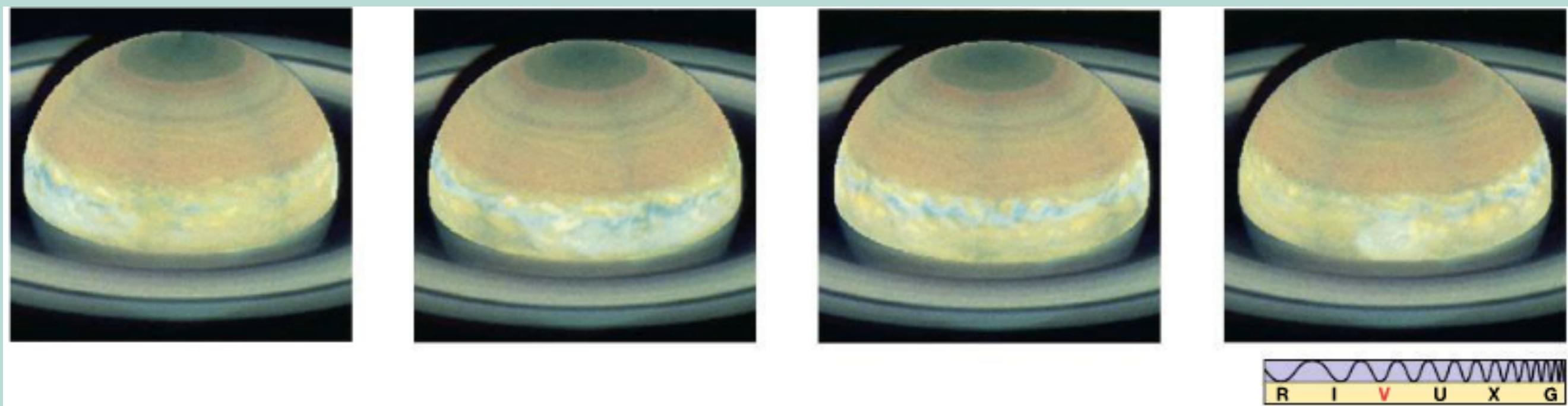
▲ **FIGURE 12.4** **Saturn's Cloud Structure** More structure is seen in Saturn's cloud cover when



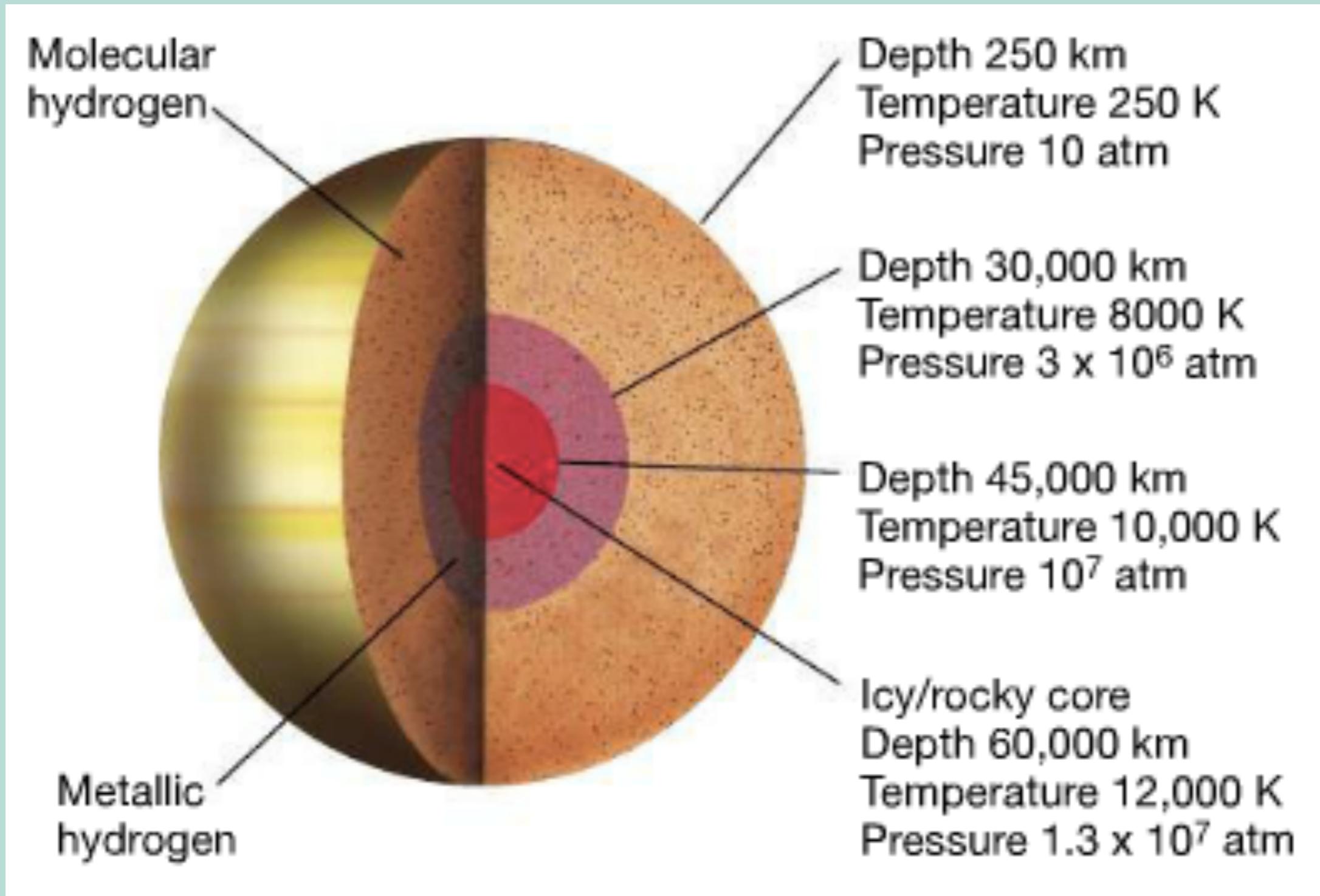
Saturn's Megastorms



Saturn's Megastorms

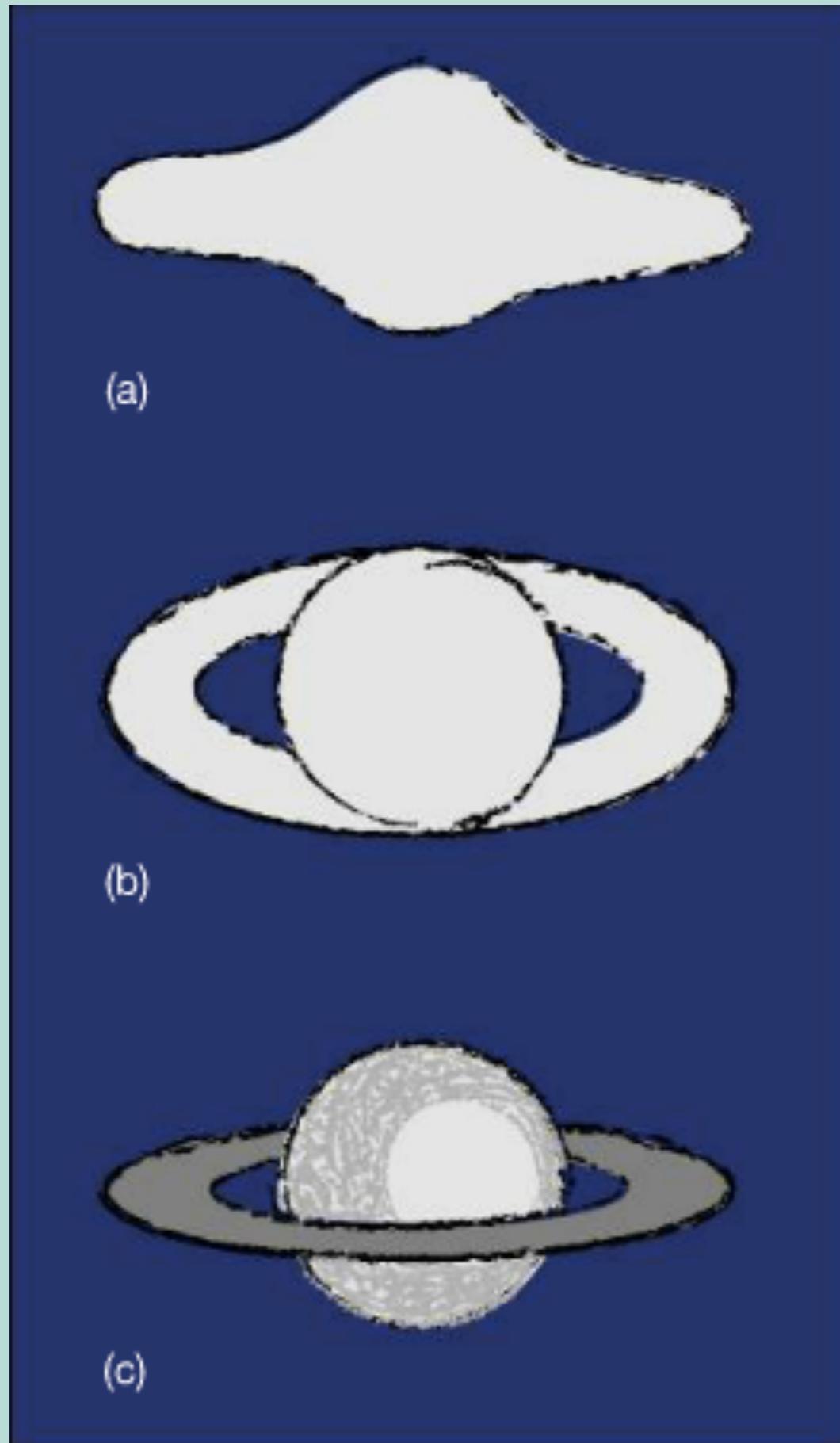


Saturn's Interior



Helium condensation

- Like Jupiter, Saturn emits more energy than it receives from the sun.
- The traditional explanation (left over heat from its formation) doesn't hold up in this case
- The answer comes from the very same solution to the hydrogen mystery: at the lower pressures and temperatures of Saturn's interior, helium dissolves poorly in liquid hydrogen, thus forms droplets and sinks to the core, depleting the atmosphere of helium and gaining energy in gravitational release



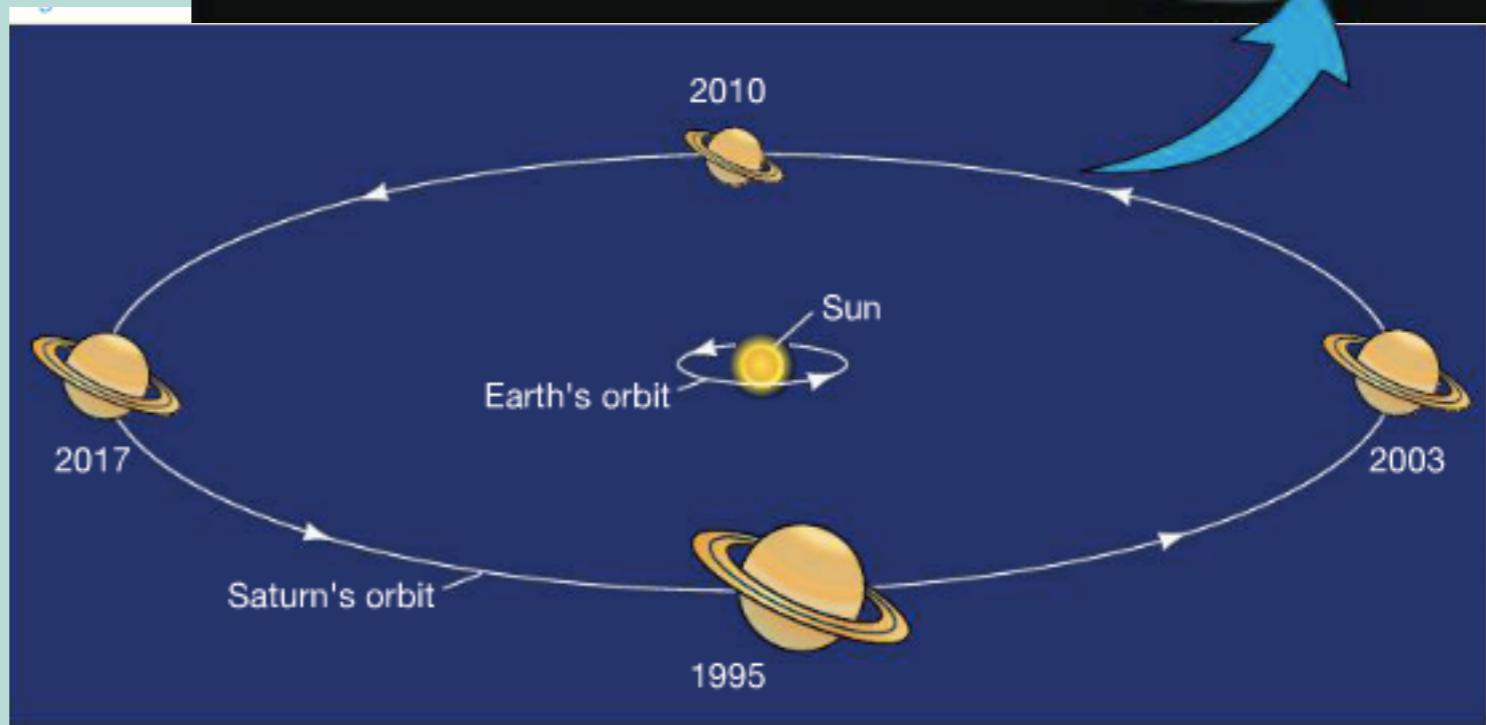
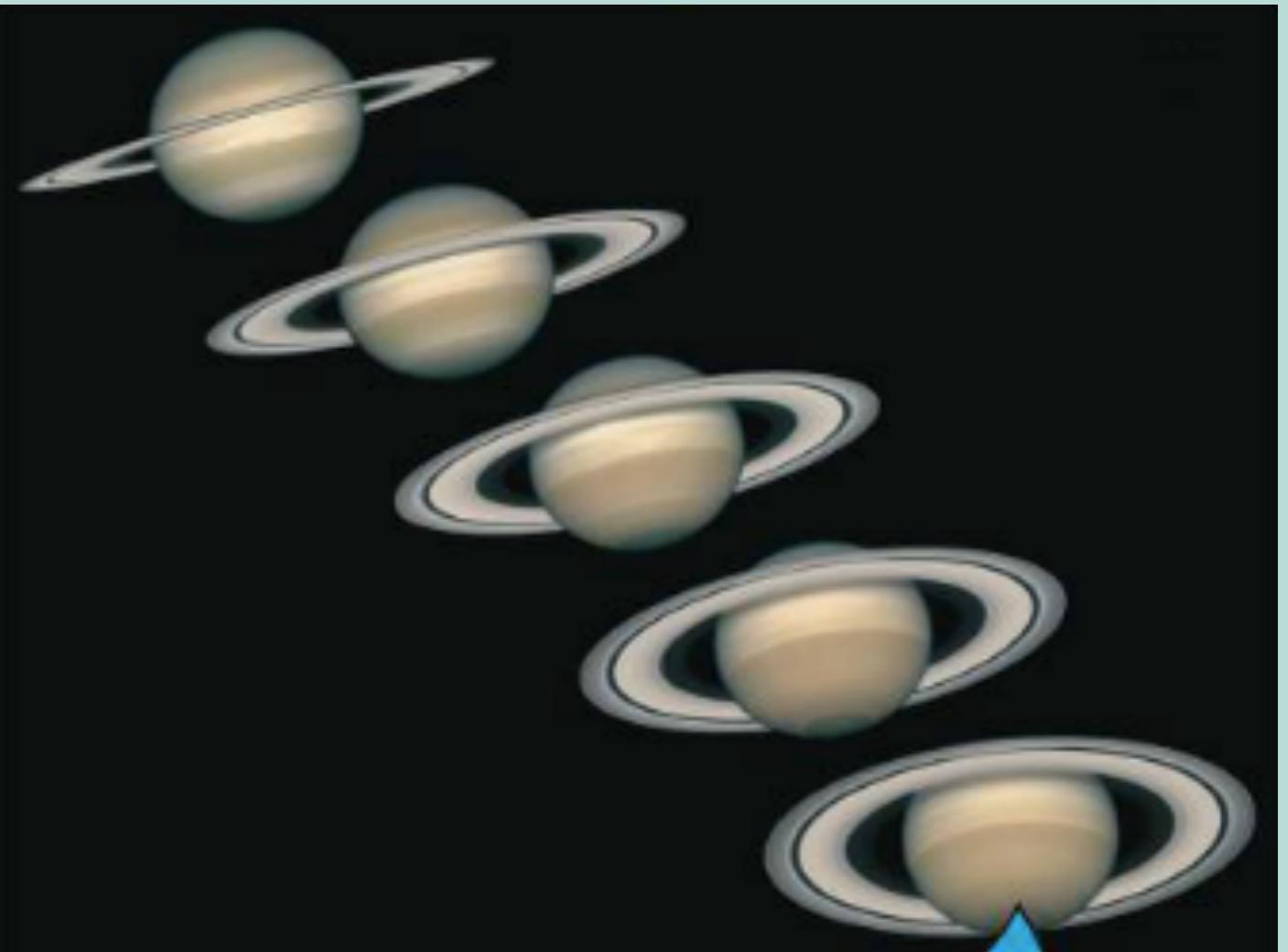
Galileo (1610)

Galileo (1616)

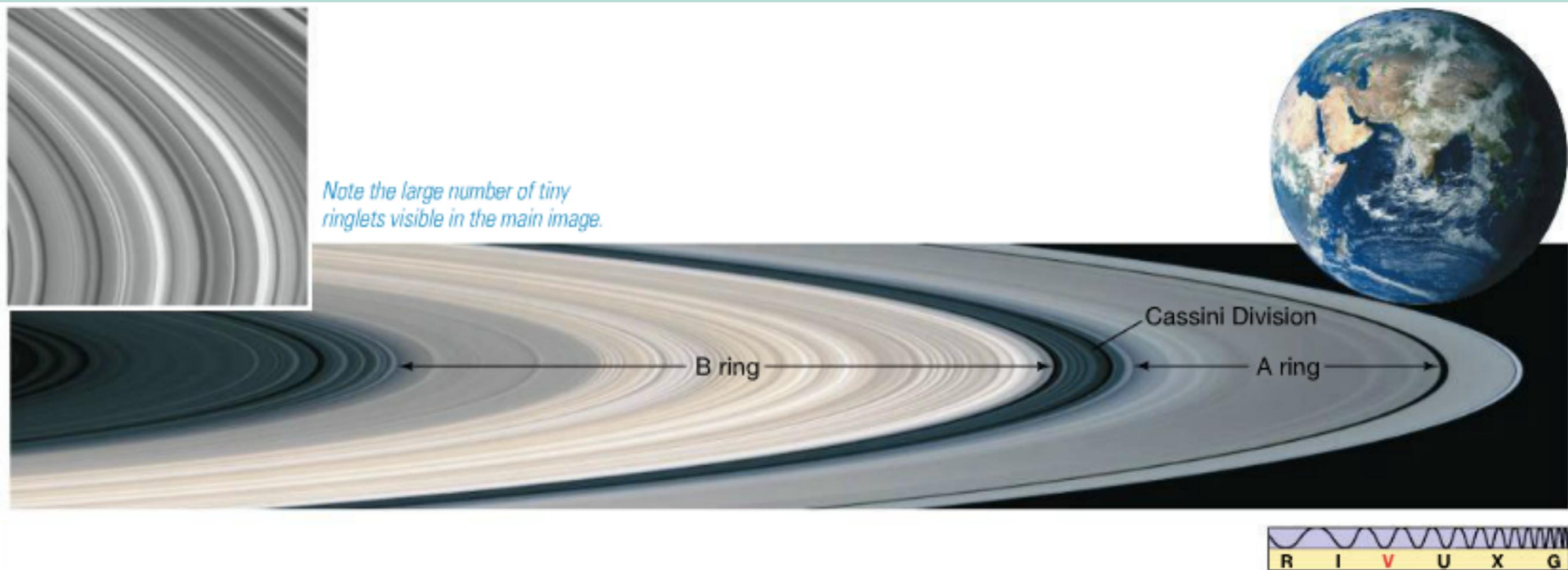
Huygens (1655)

Earth Point of View

(Rings sometimes go out of view entirely)



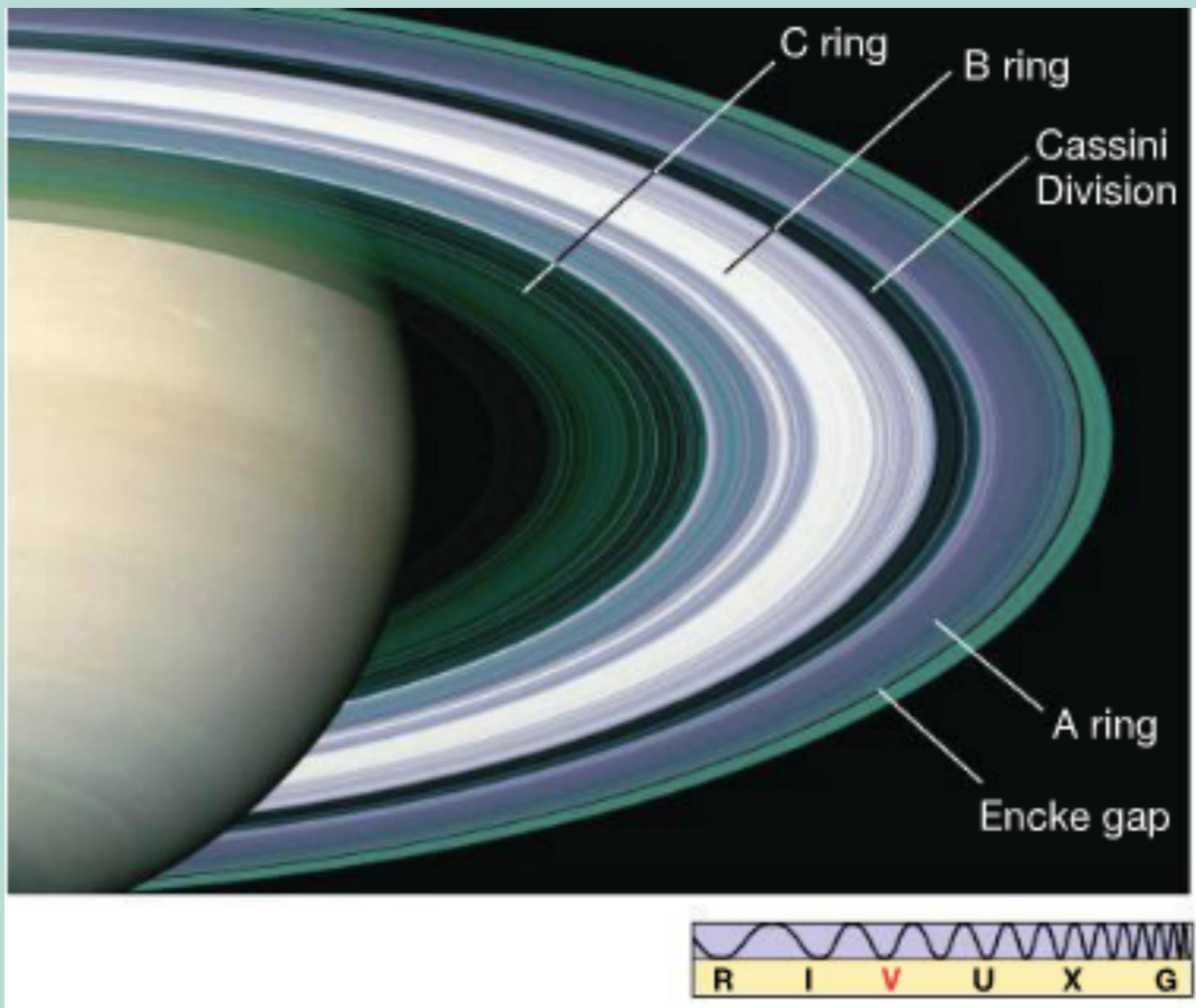
Ring Structure





b. 1625 Genova, d. 1712 Paris
Giovanni Cassini

- Discovered Iapetus, Rhea, Tethys and Dione
- First to observe differential rotation of Jupiter's atmosphere
- Co-discovered Great Red Spot
- Using terrestrial parallax and a close passing of Mars, calculated the scale of the solar system (Paris - French Guyana)
- Strong supporter of the geocentric solar system early in his career.

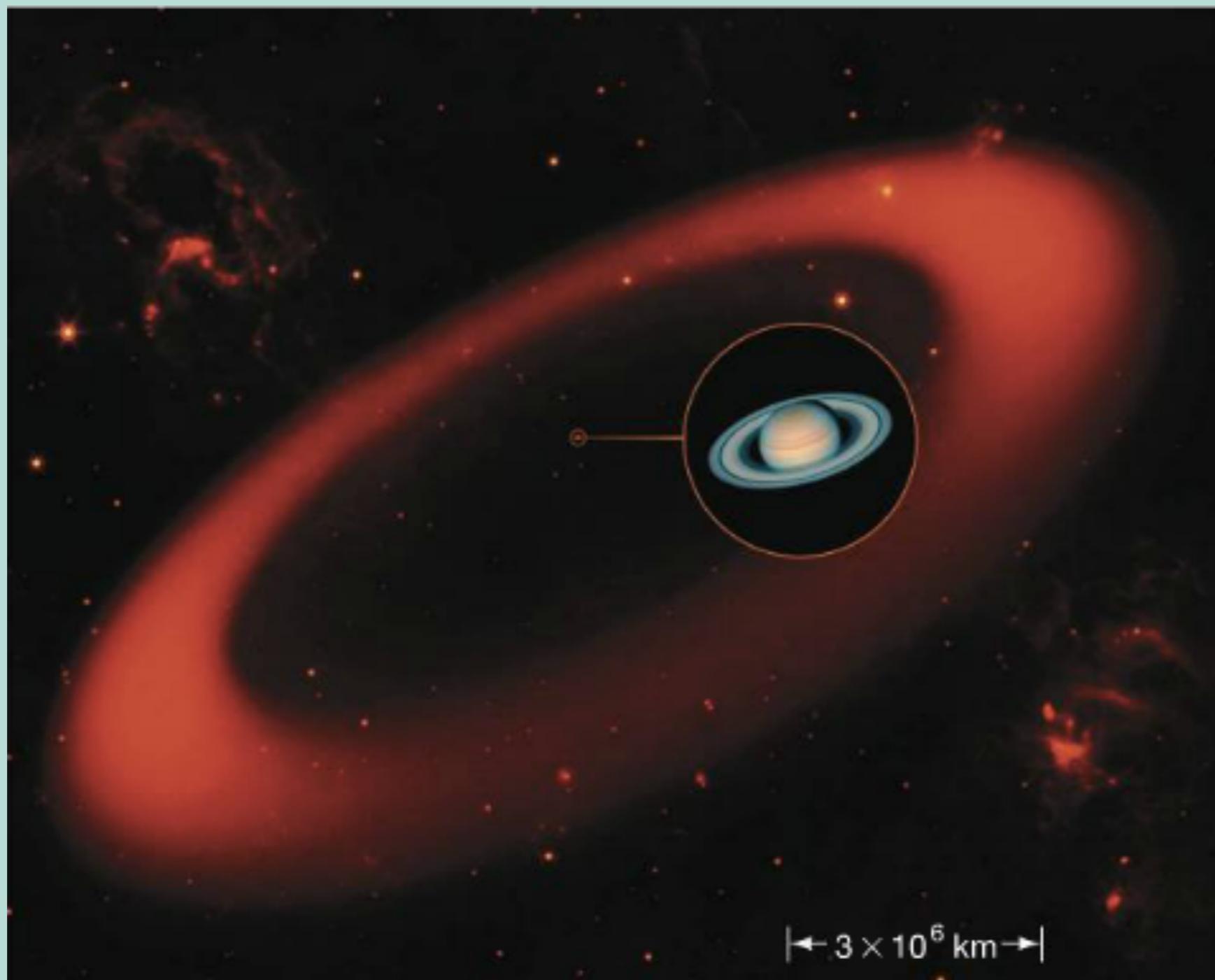


Only ~10 meters thick!!

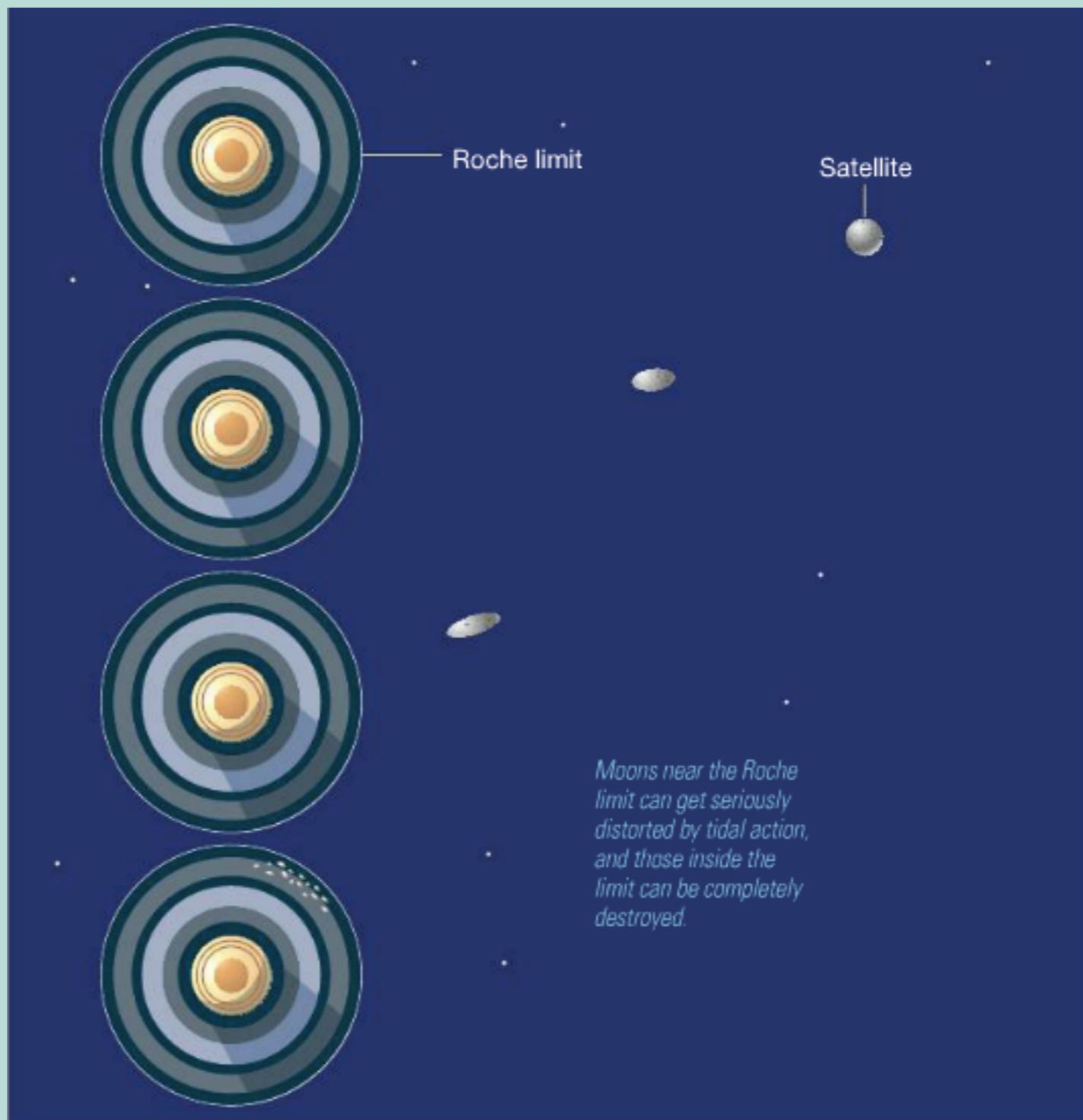
TABLE 12.1 The Rings of Saturn

Ring	Inner Radius (km)	Outer Radius (planetary radii)	Width (km)
D	67,000	1.11	74,700
C	74,700	1.24	92,000
B	92,000	1.53	117,500
Cassini division	117,500	1.95	122,300
A	122,300	2.03	136,800
Encke gap*	133,400	2.22	133,700
F	140,300	2.33	140,400
G	165,800	2.75	173,800
E	180,000	3.00	480,000
			300,000

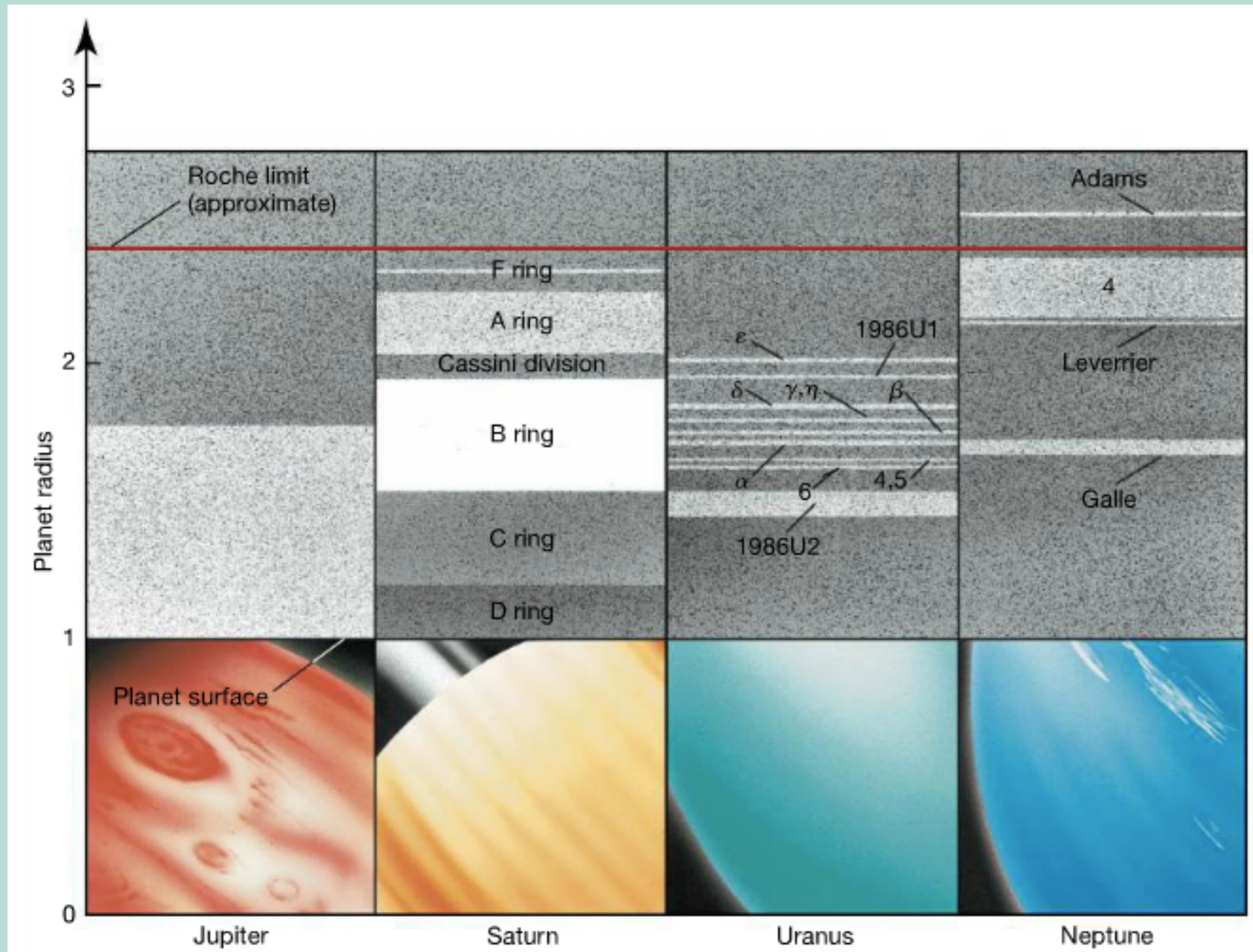
Ash nazg durbatuluk



Roche Limit

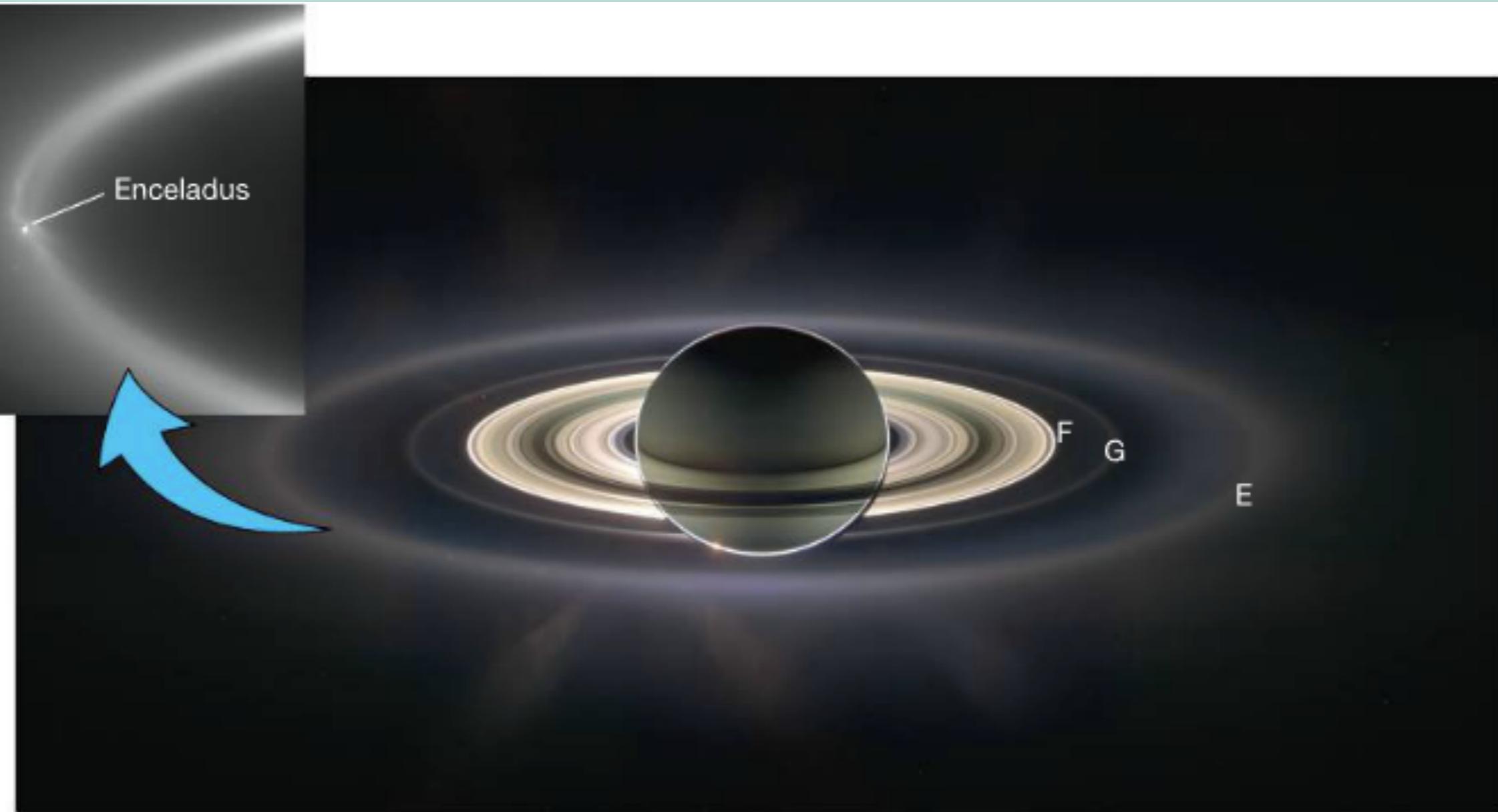


Jovian Ring Systems

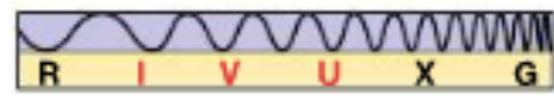


Happy Birthday Anthony!

Ring Sweepers



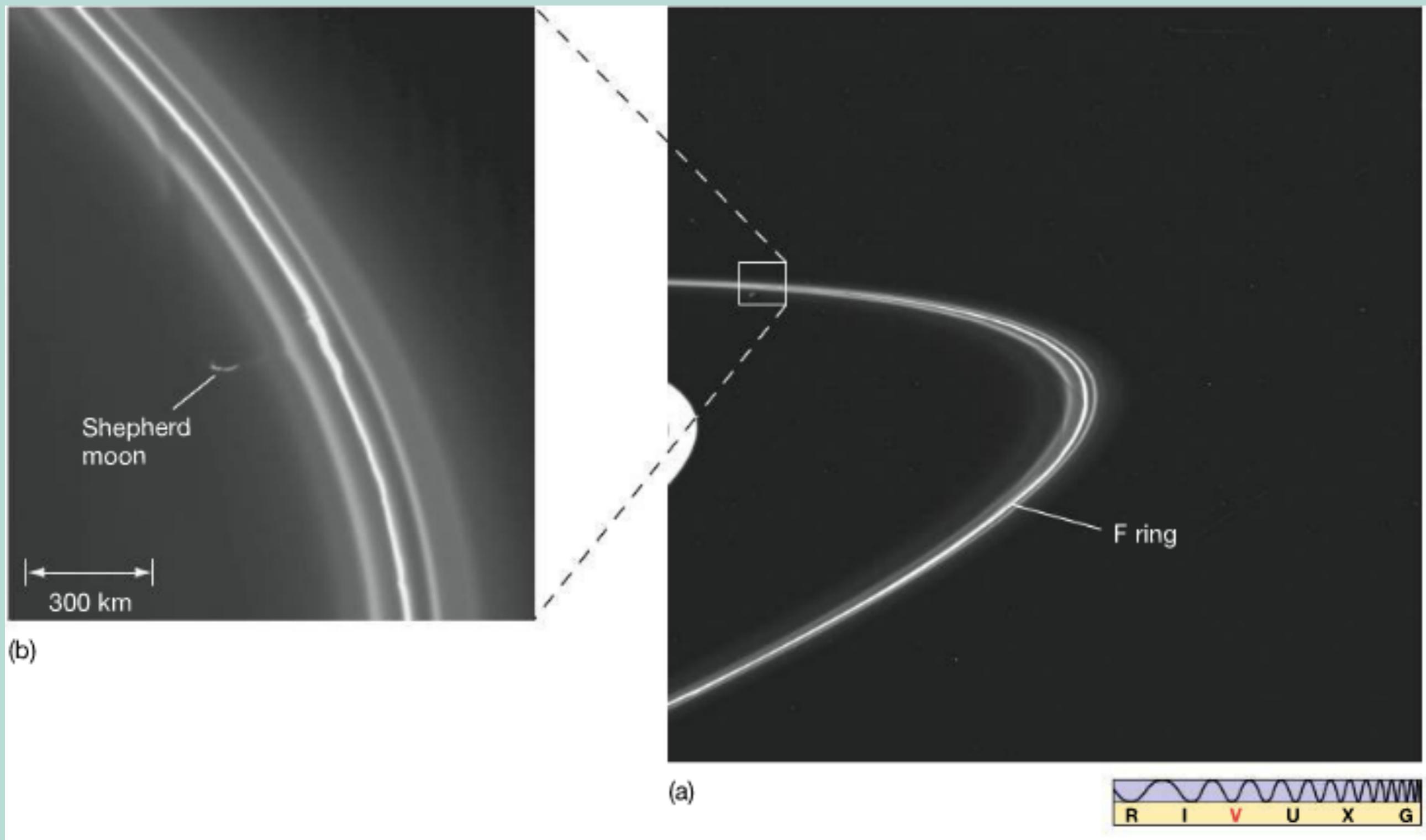
▲ FIGURE 12.15 Back-Lit Rings Cassini took this spectacular image of Saturn's rings as it passed



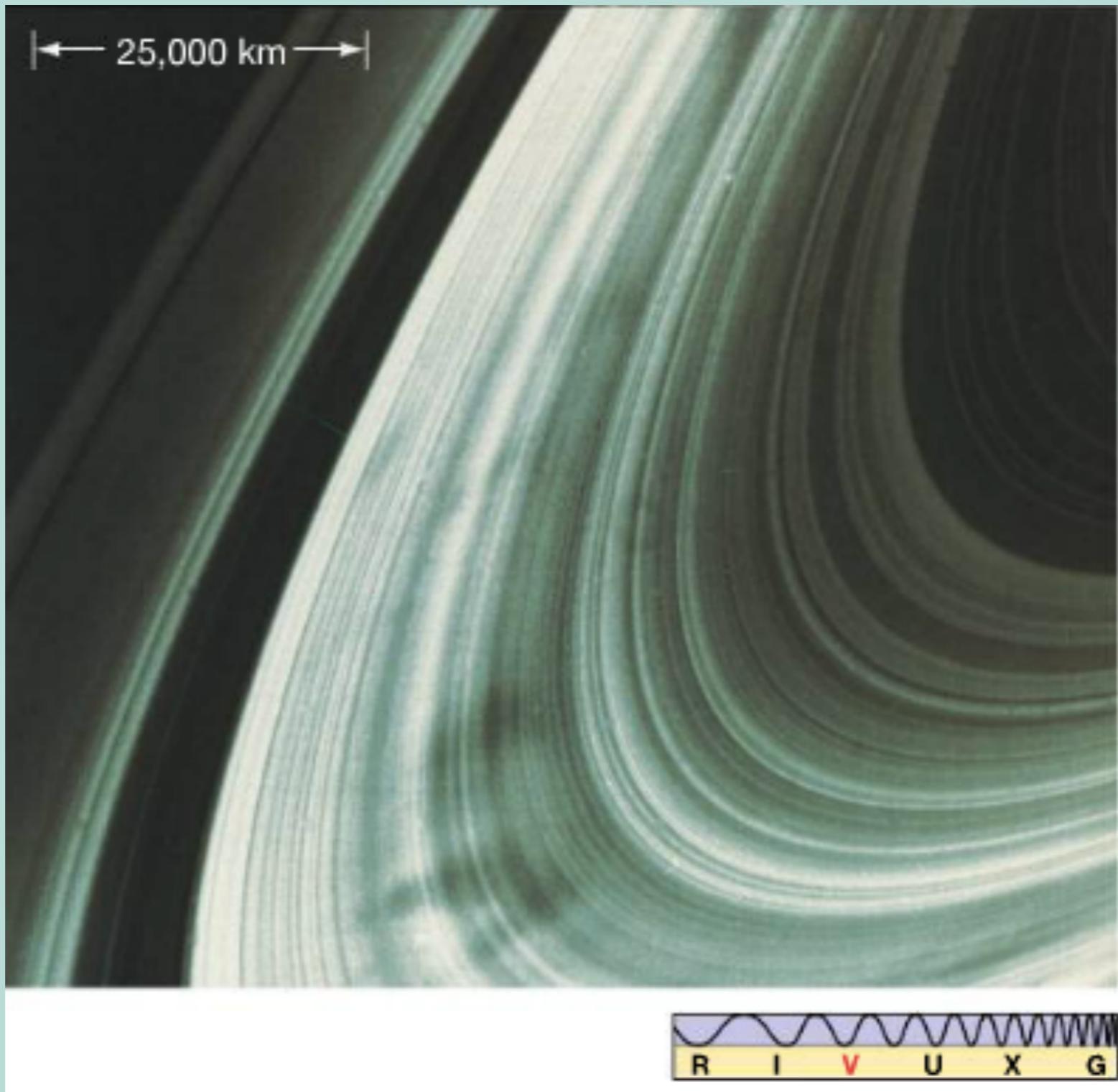
Orbital Resonance



Braided Outer Rings and shepherd satellites



Spokes



Saturn's Moons

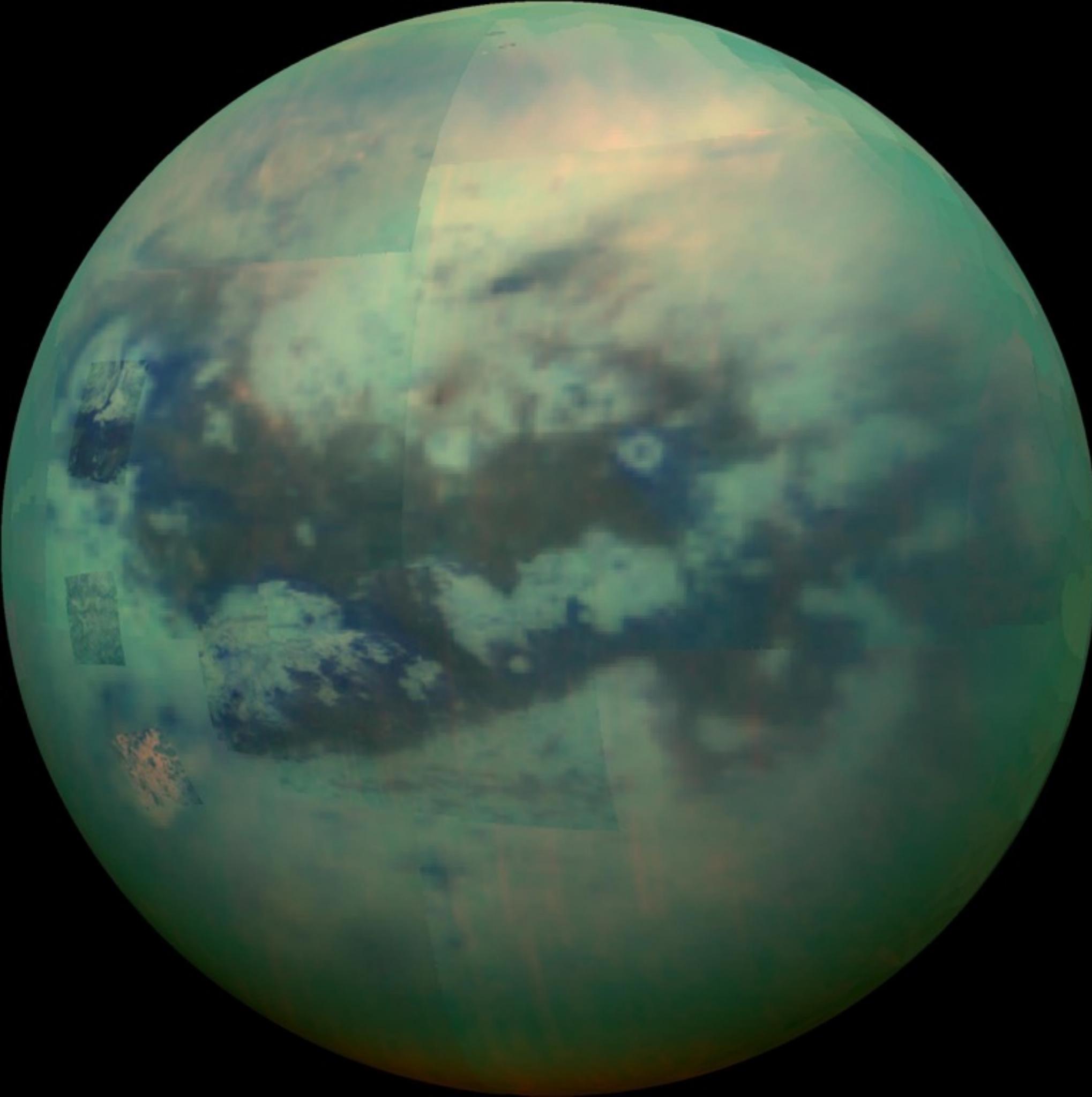
Table 12.2 The Major Moons of Saturn*

Name	Distance from Saturn (km)	Distance from Saturn (planetary radii)	Orbit Period (days)	Size (longest diameter, km)	Mass** (Earth moon masses)	Density (kg/m ³)	Density (g/cm ³)
Mimas	186,000	3.08	0.94	398	0.00051	1100	1.1
Enceladus	238,000	3.95	1.37	498	0.00099	1100	1.1
Tethys	295,000	4.89	1.89	1060	0.0085	1000	1.0
Dione	377,000	6.26	2.74	1120	0.014	1400	1.4
Rhea	527,000	8.74	4.52	1530	0.032	1200	1.2
Titan	1,220,000	20.3	16.0	5150	1.83	1900	1.9
Hyperion	1,480,000	24.6	21.3	370			
Iapetus	3,560,000	59.1	79.3	1440	0.022	1000	1.0

* Moons larger than 300 km in diameter only.

** Mass of Earth's Moon = 7.4×10^{22} kg = 1.3×10^{-4} Saturn masses.

(62 total)



Titan

$m \sim$

$1.3e23 \text{ kg} \sim$
 $1.8 m_m$

$r \sim$

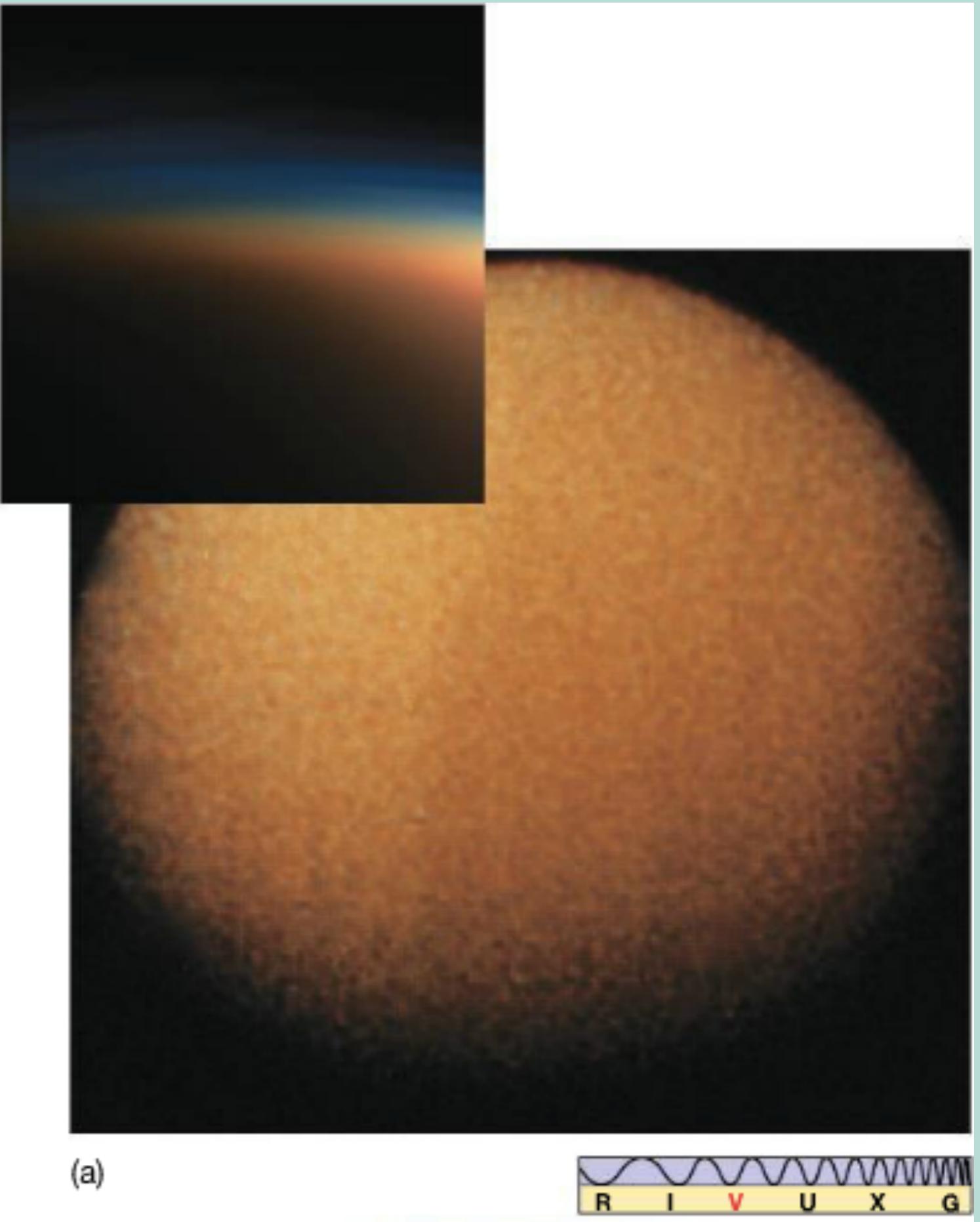
$2.5e3 \text{ km} \sim$
 $1.5 r_m$

$d \sim$

$21.3 R_s \sim$
 $3 d_m$

density ~
1880

Titan from Cassini



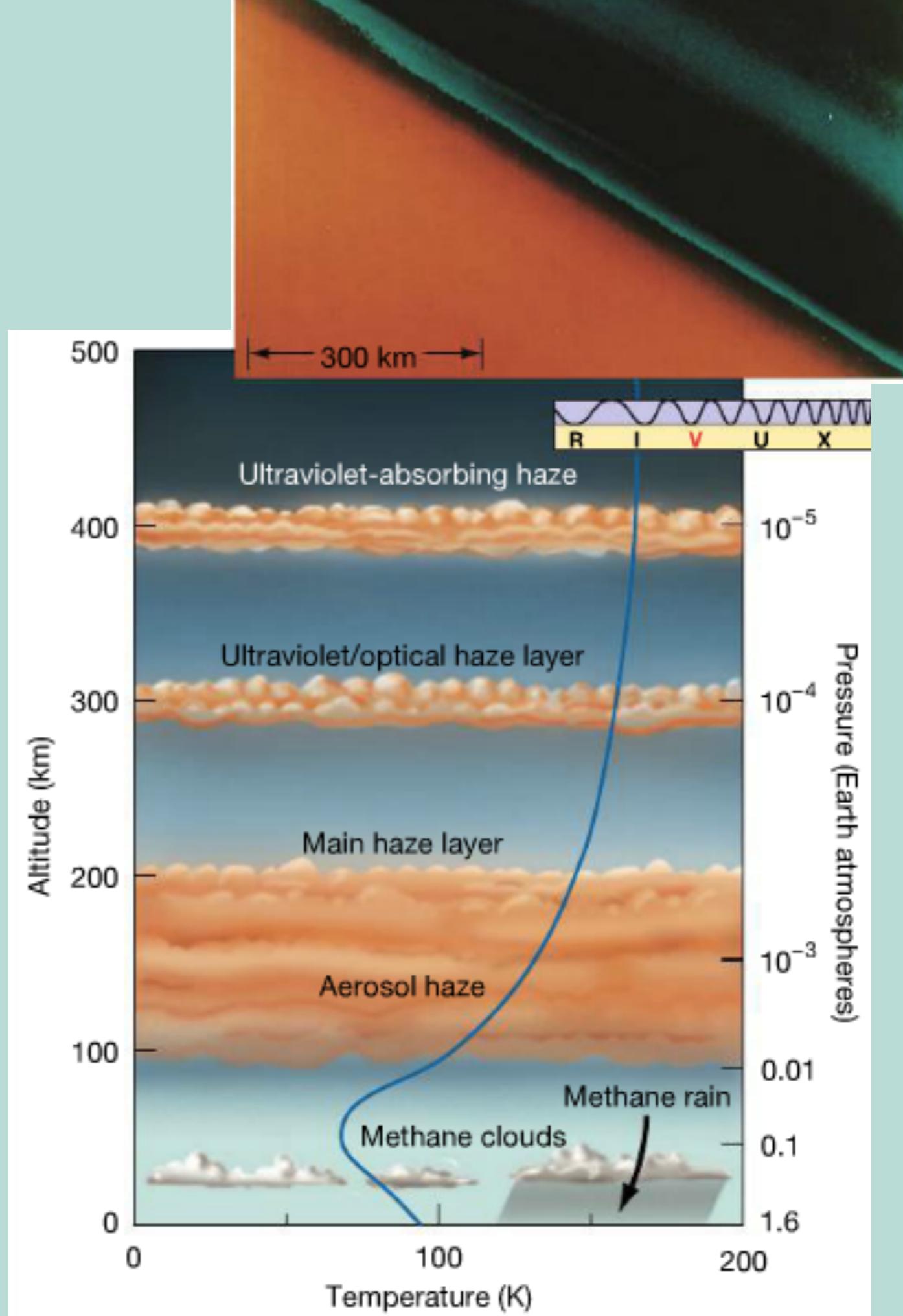
Titan from Mauna Kea

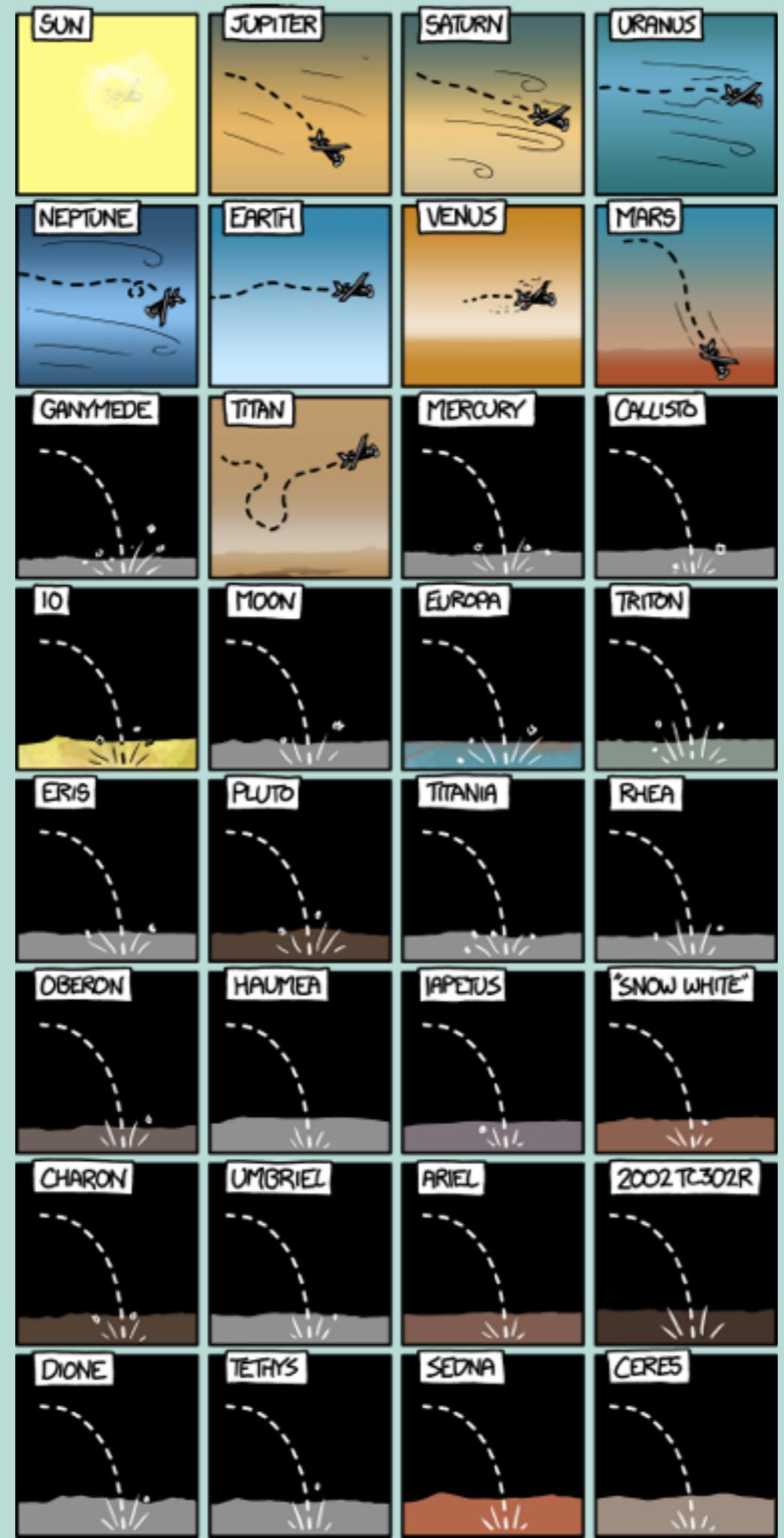


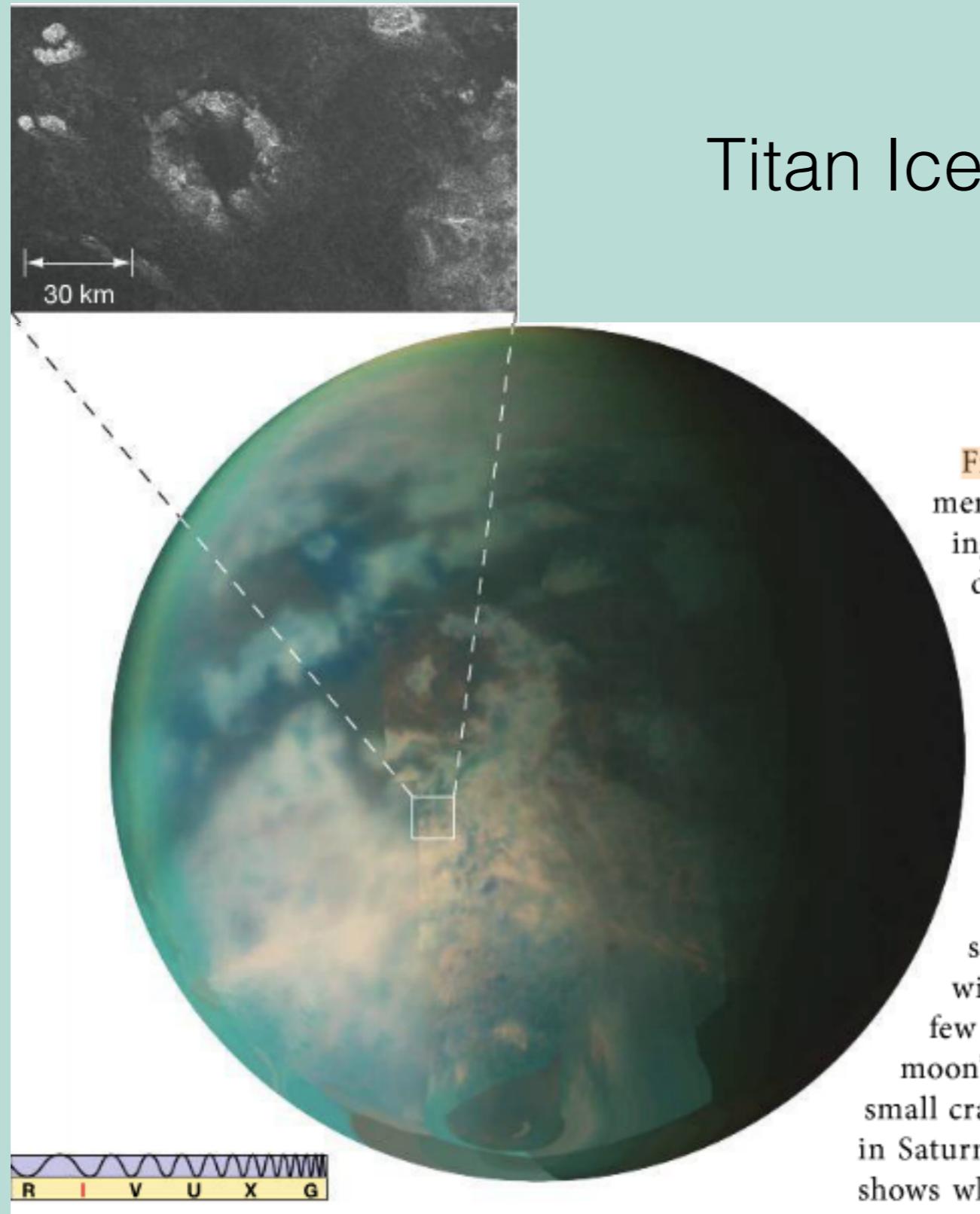
(b)



Titan's Atmosphere



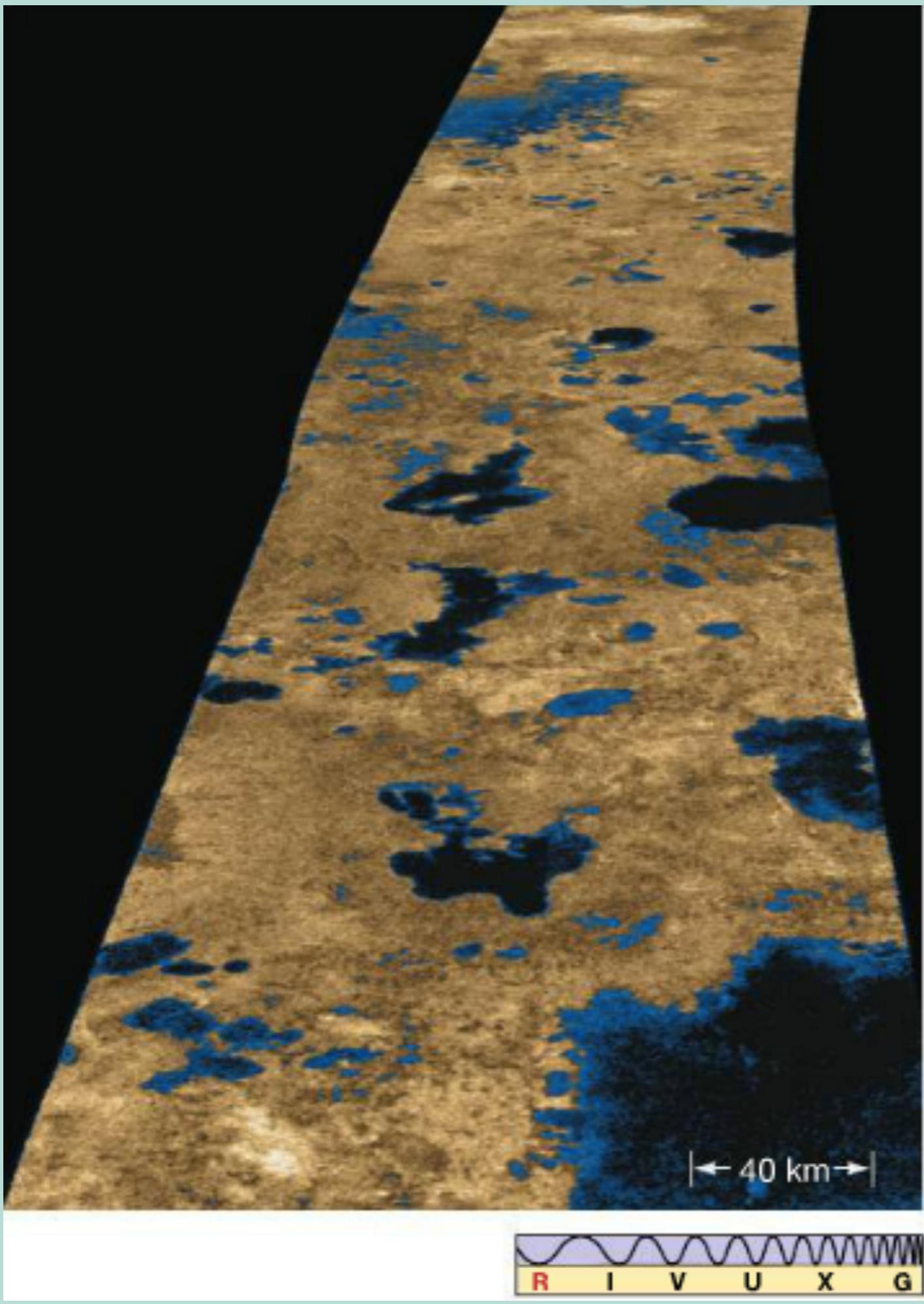




Titan Ice Volcanos

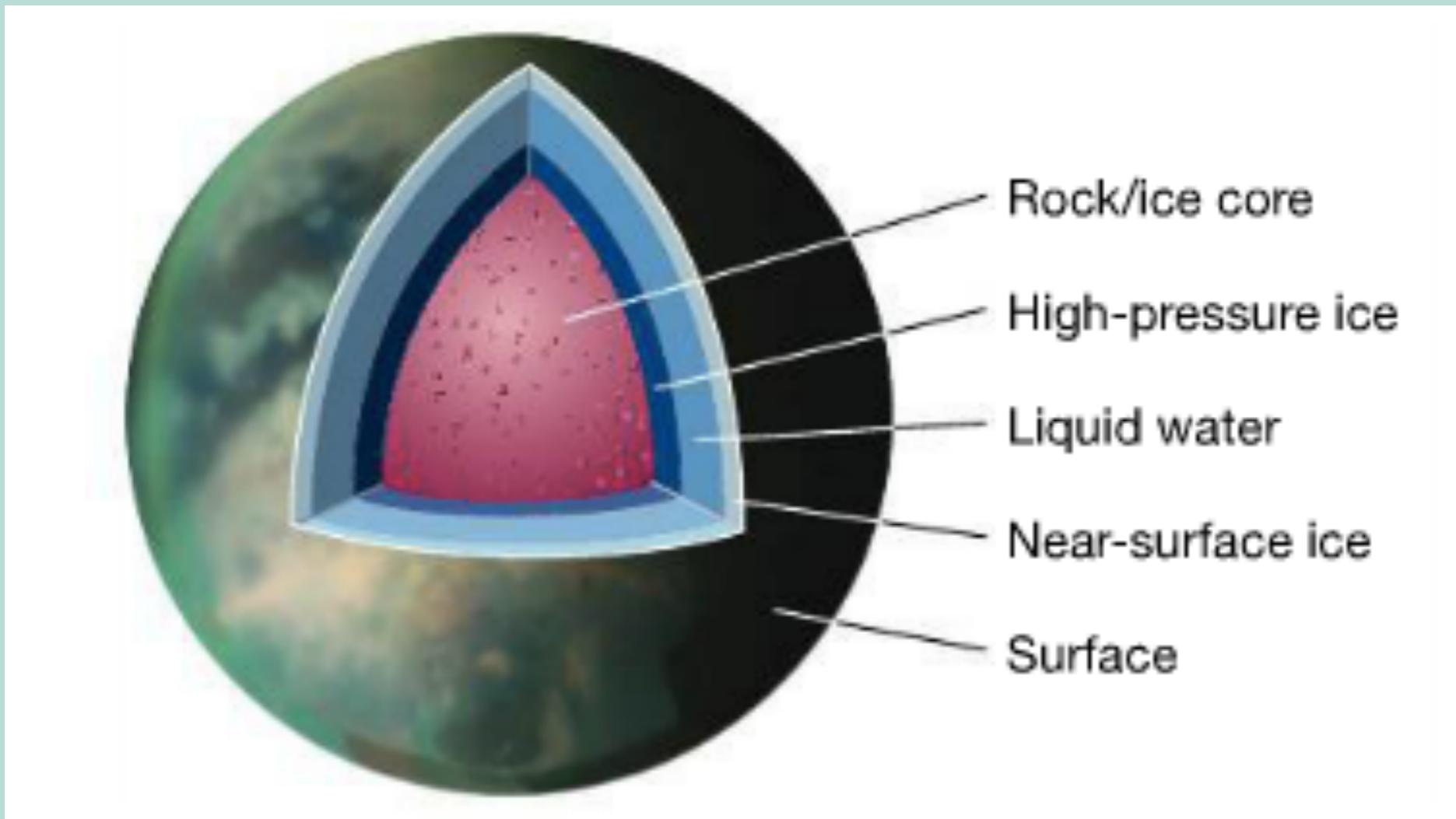
Figure 1. Global map of Titan's surface showing the location of the ice volcano. The inset shows a detailed view of the ice volcano. The color calibration bar at the bottom shows the filters used to create the global map. The figure is captioned as follows:

Figure 1. Global map of Titan's surface showing the location of the ice volcano. The inset shows a detailed view of the ice volcano. The color calibration bar at the bottom shows the filters used to create the global map. The figure is captioned as follows:



Methane Lakes
(from Arecibo)

Titan's Interior



Huygens Space Probe



2004-2005

Christiaan Huygens

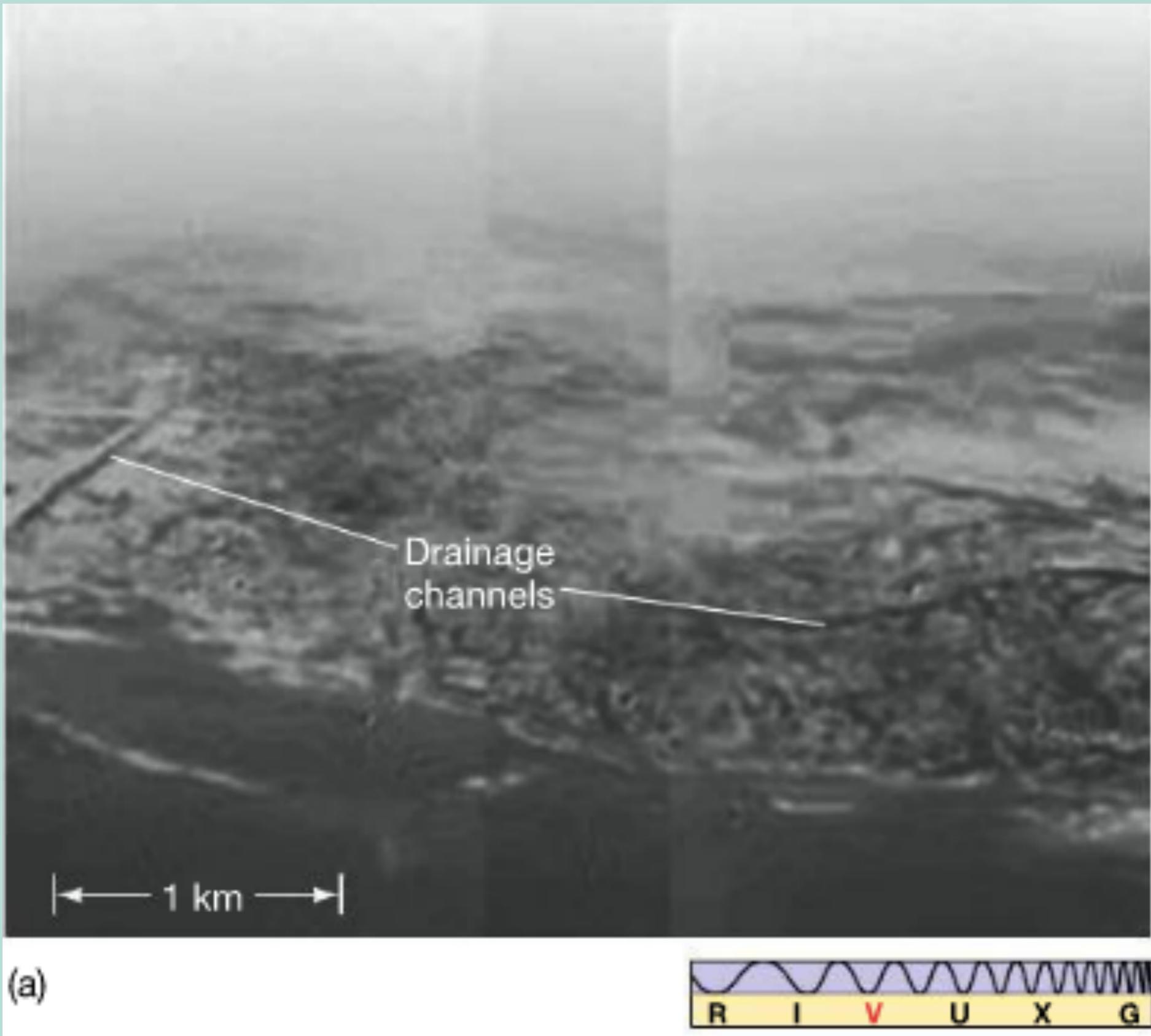
b. 1629 The Hague d. 1695 The Hague



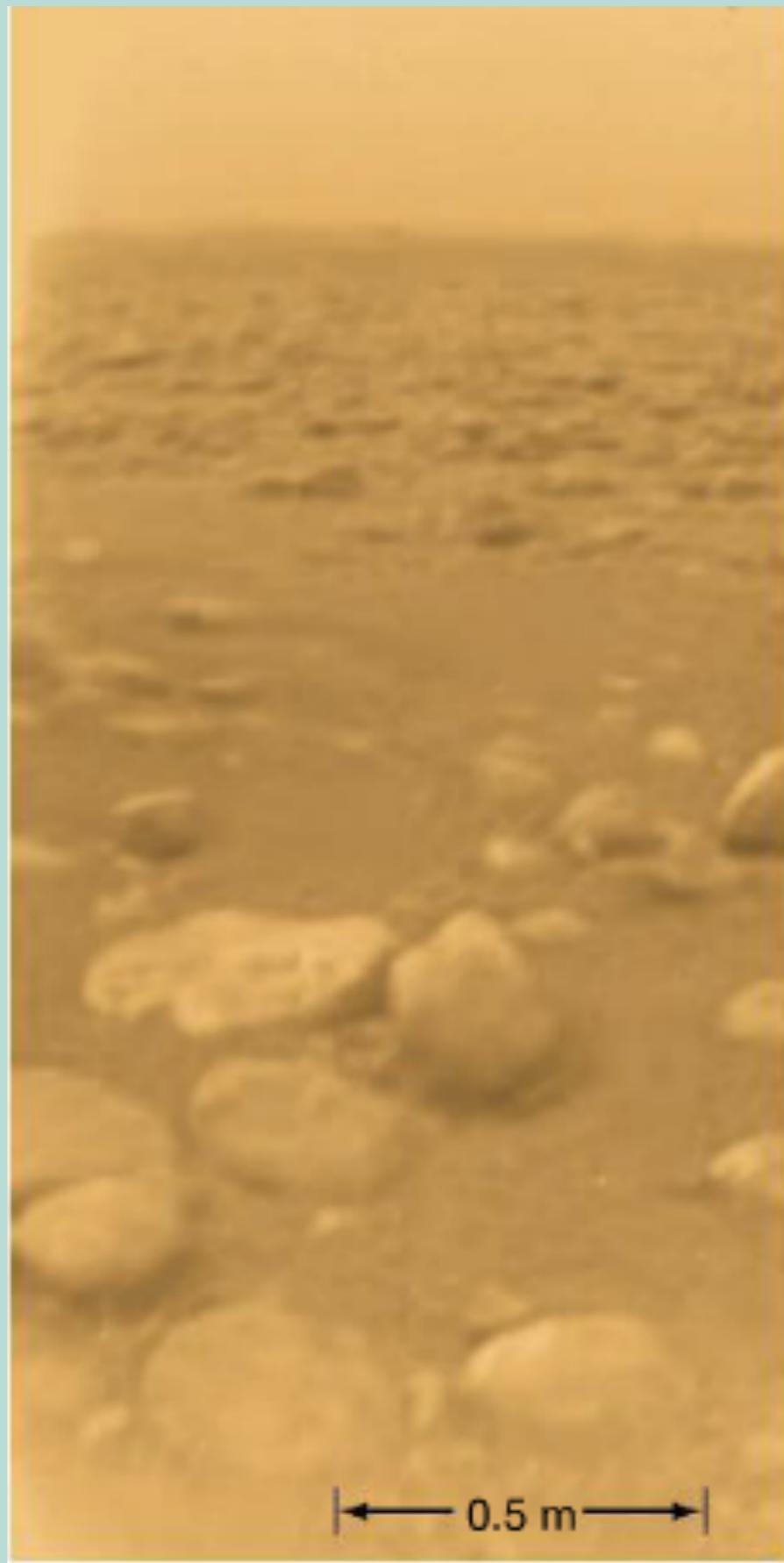
Did everything... mechanics,
simple harmonic motion, optics,
wave theory of light (longitudinal),
analyzed Saturn's rings,
discovered Titan, tried to figure out
how far away the stars are etc etc

Super into aliens.

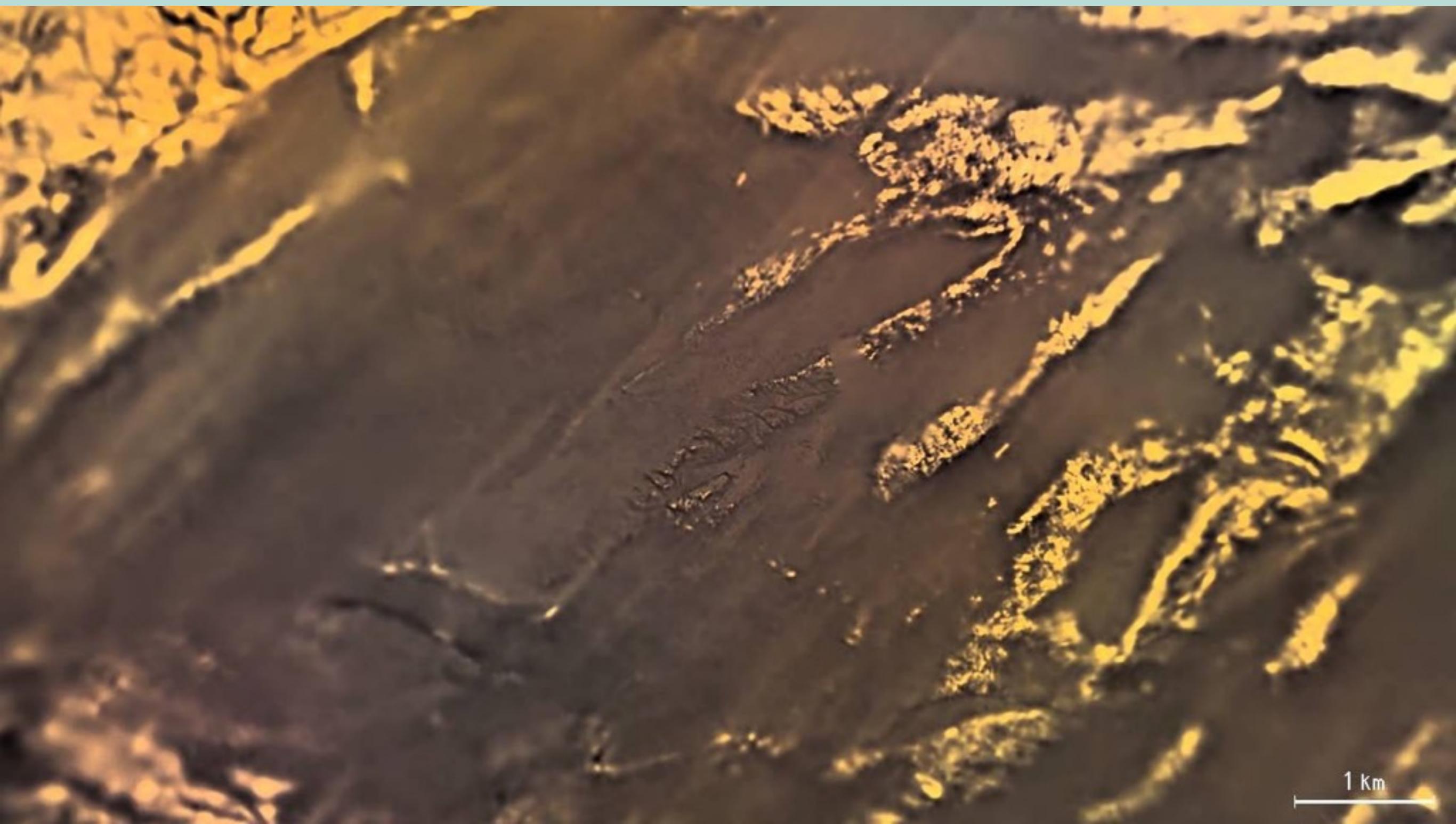
Titans Surface



Titans Surface

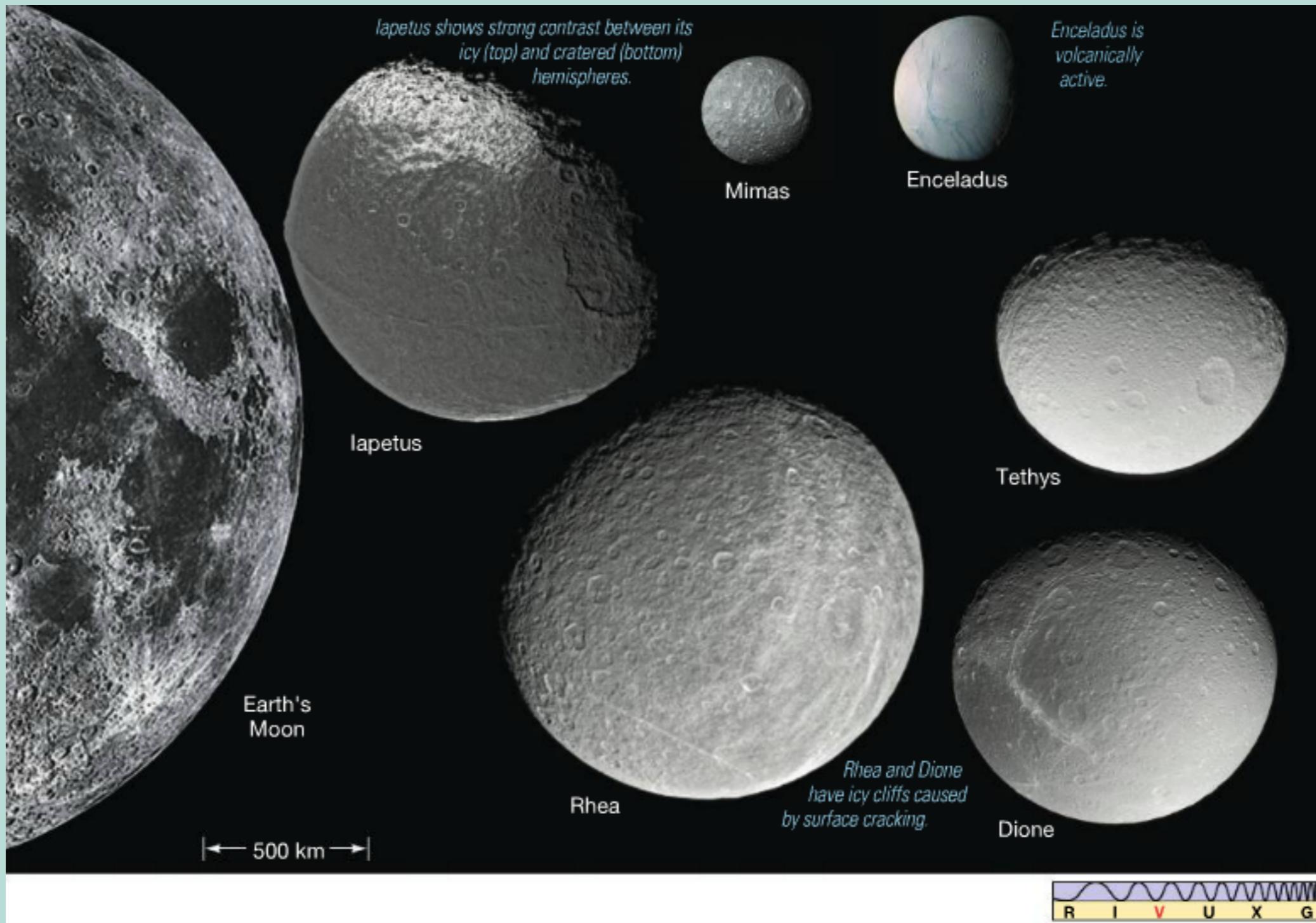


Titans Surface



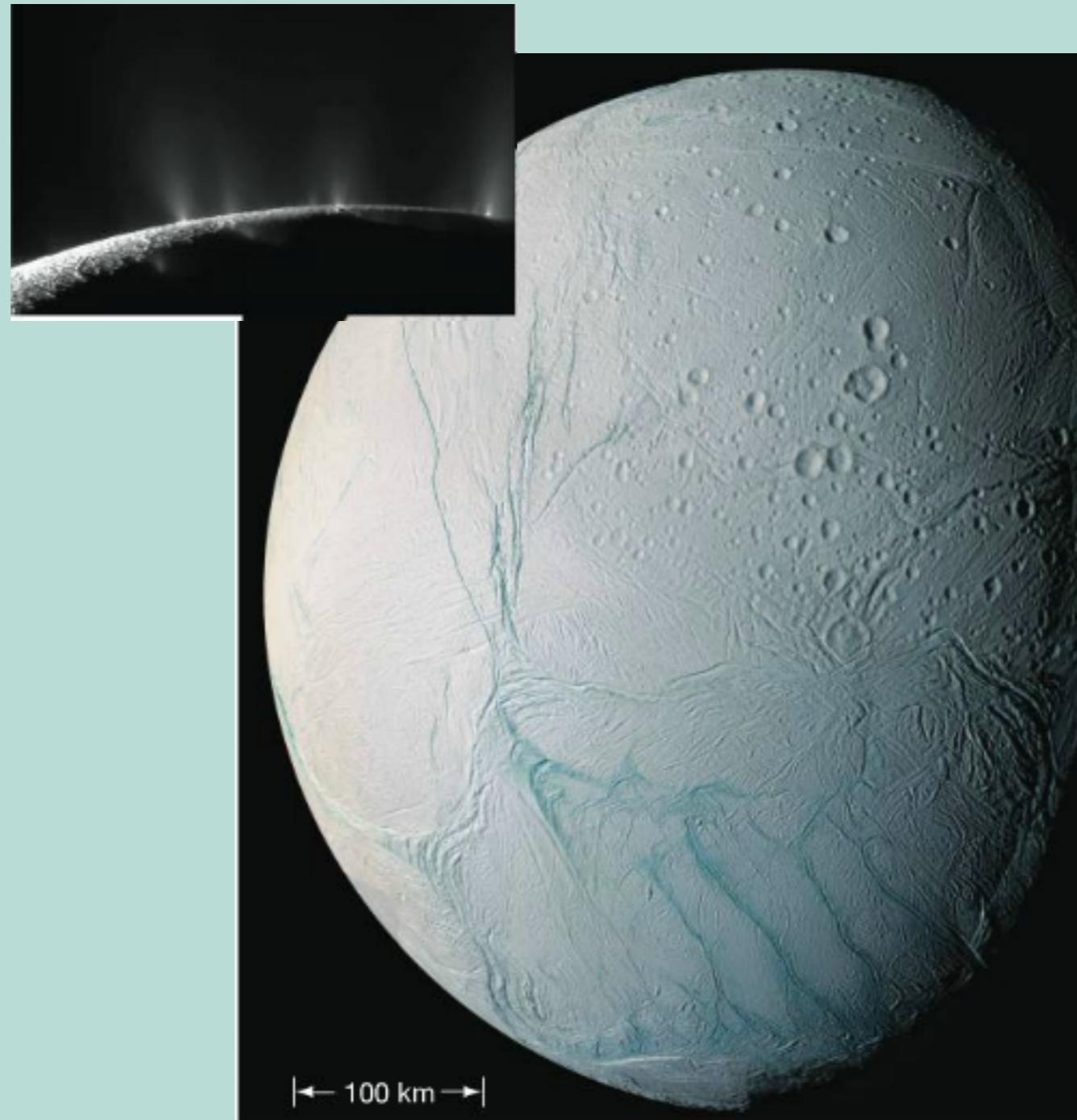
1 Km





Medium Moons

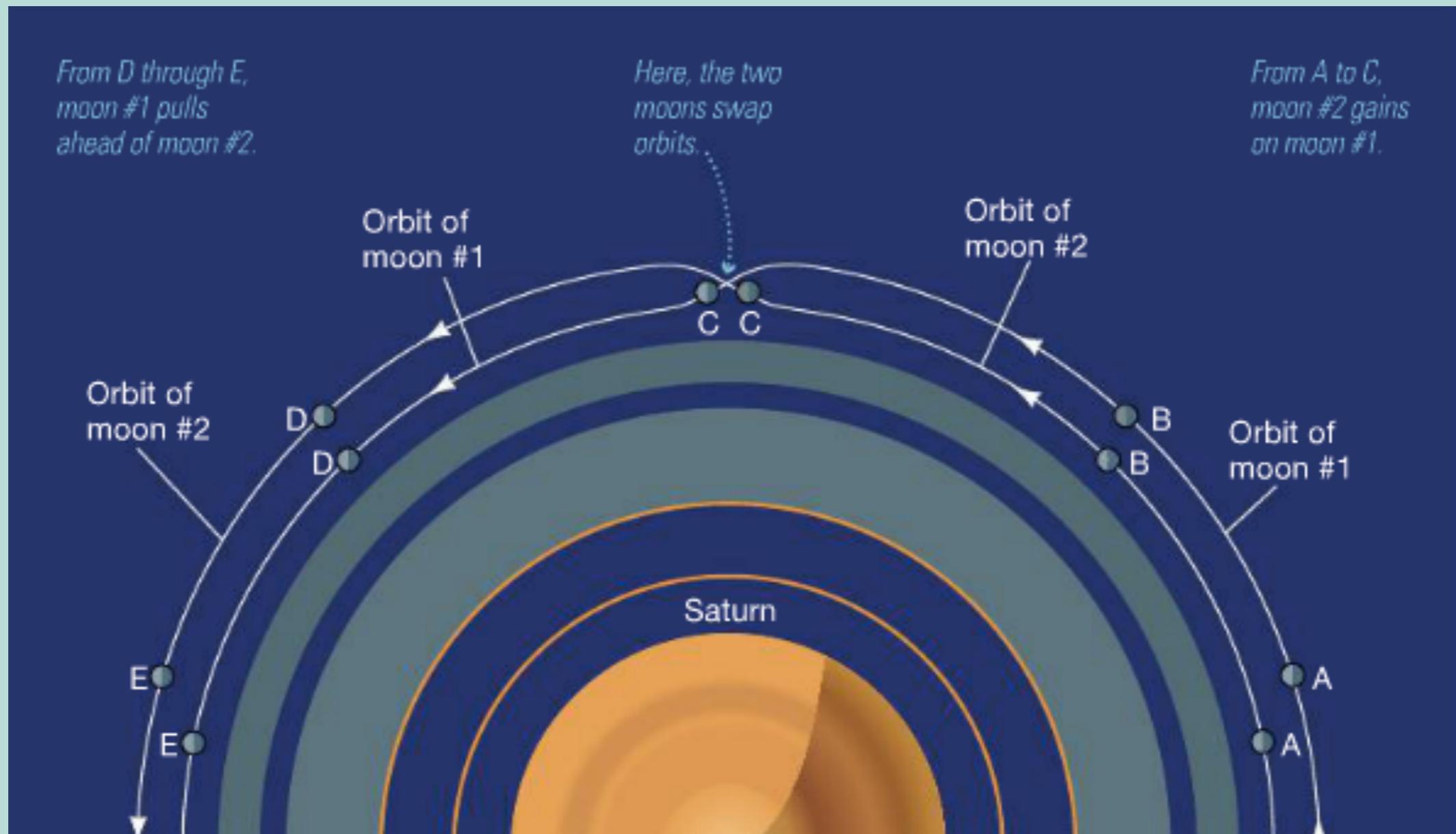
Enceladus



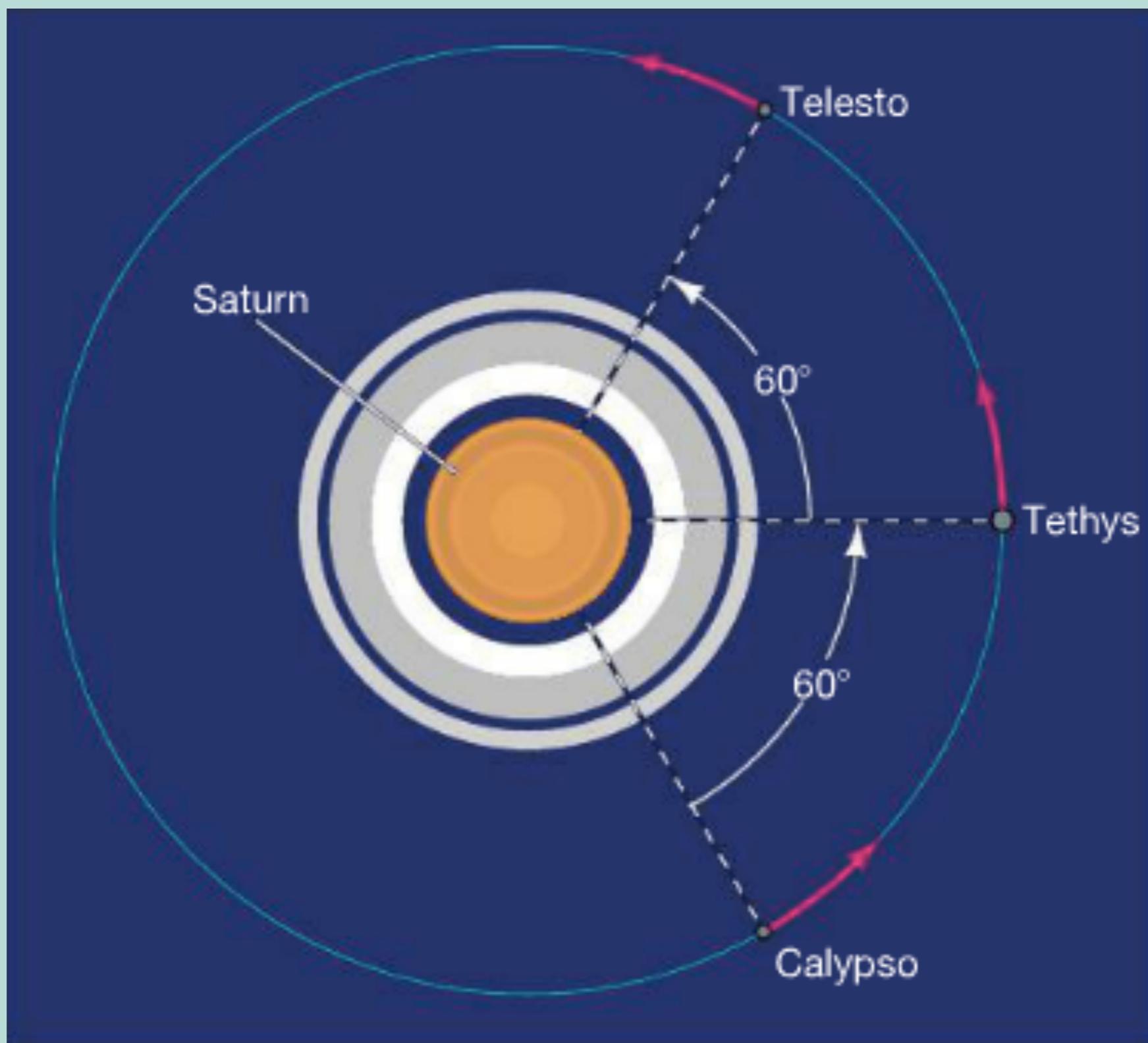
99% reflective

Supplies E-ring with particles from tidally activated ice geysers

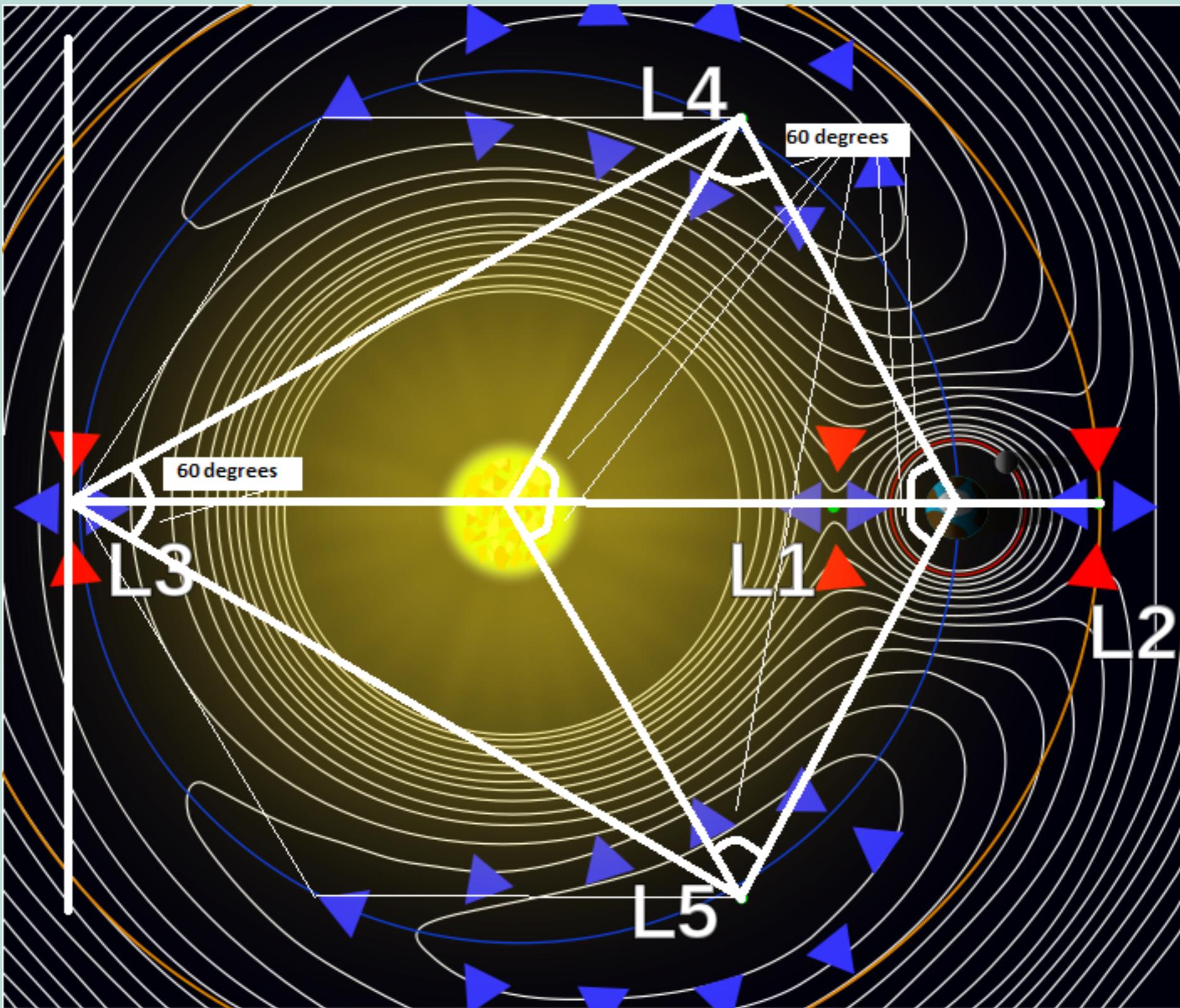
Orbit Dance



Joint Orbits

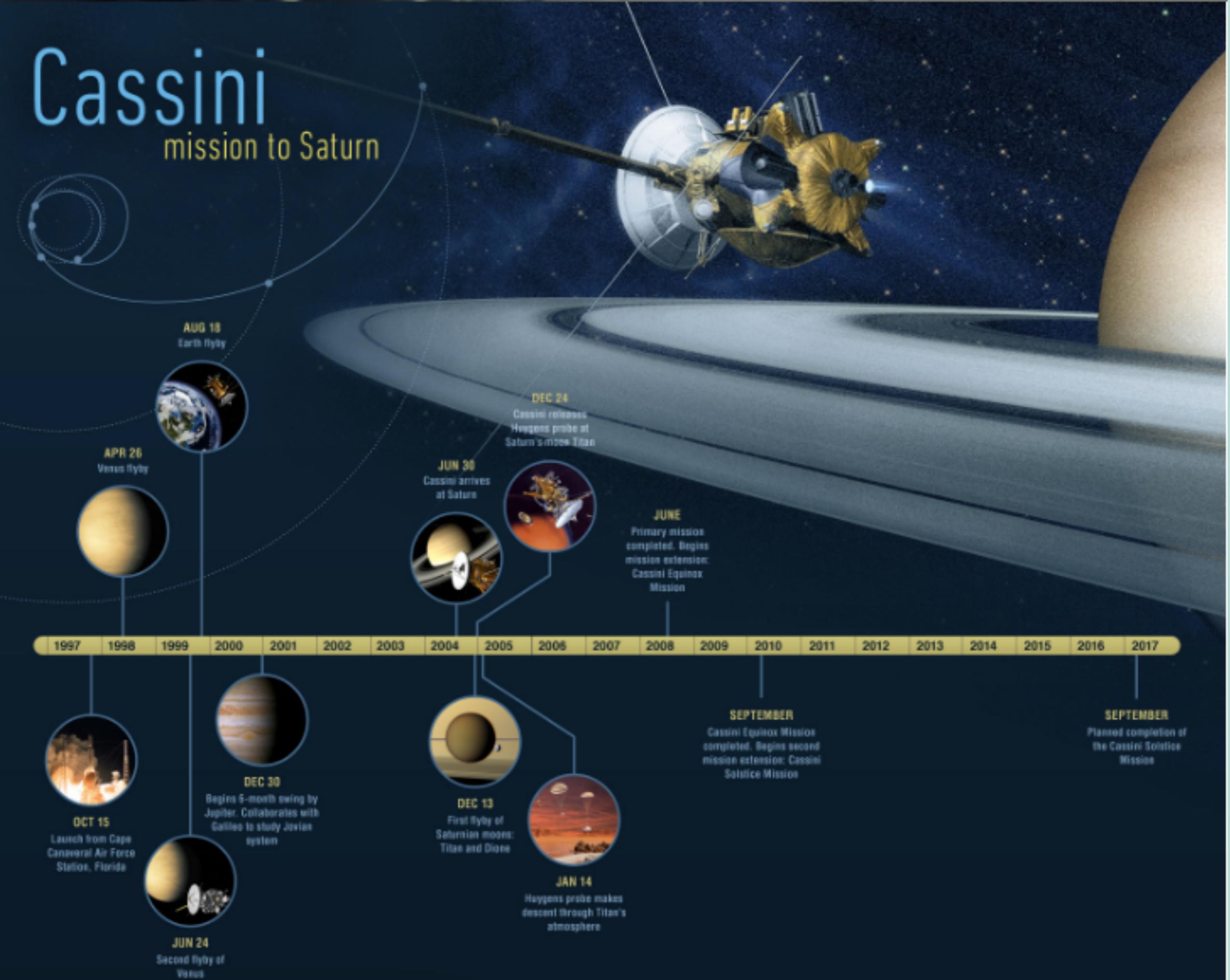


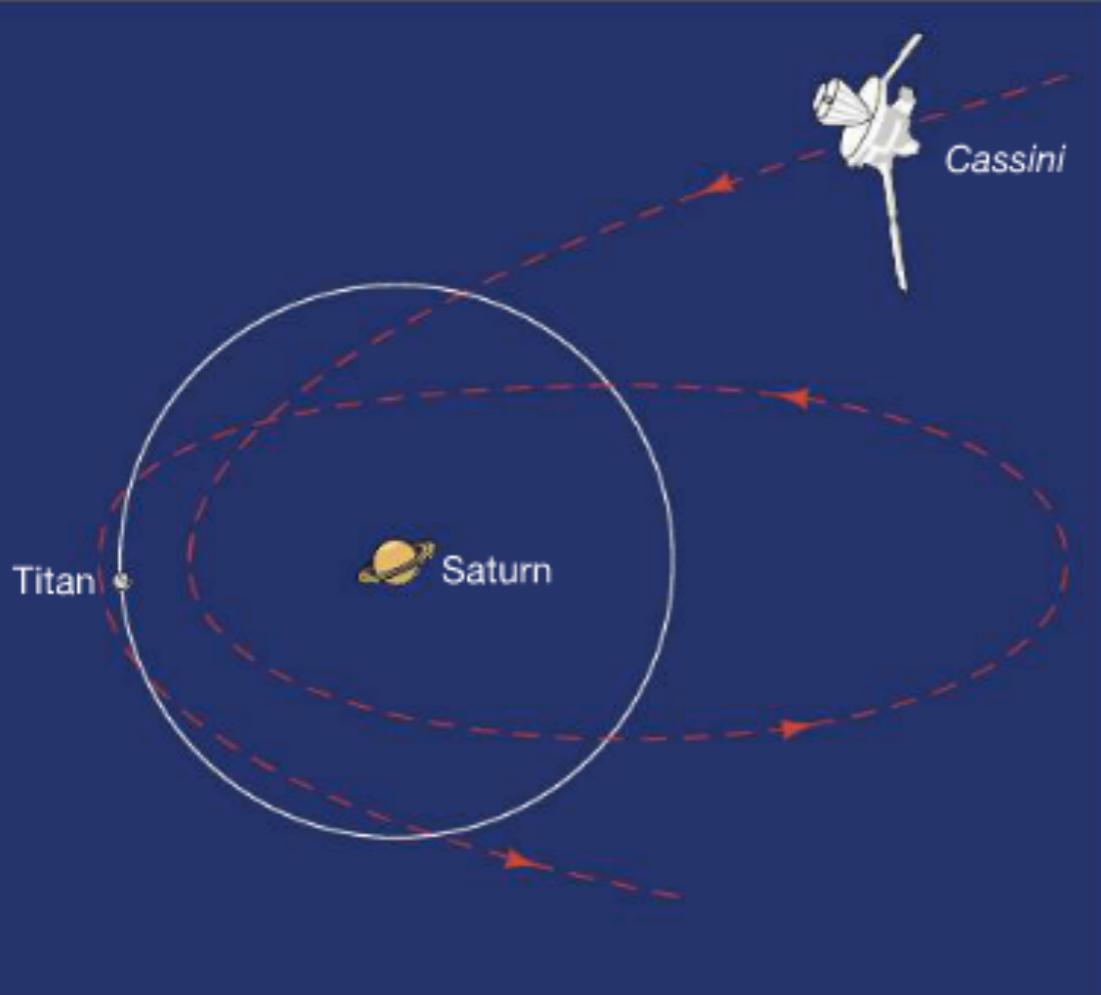
Lagrange Points



Cassini

mission to Saturn





Gravitational Slingshot

