



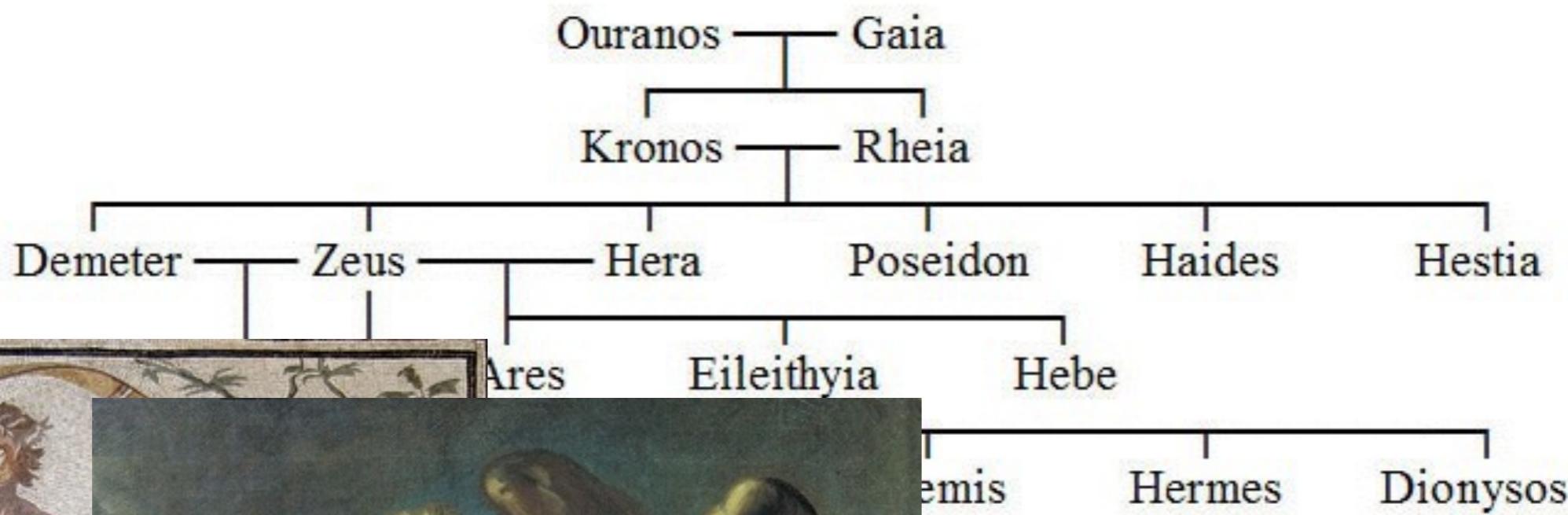
Astronomy

with your host:



**Lecture 12:
Uranus/Neptune**

Coop





Uranus

$r \sim 4 r_E$

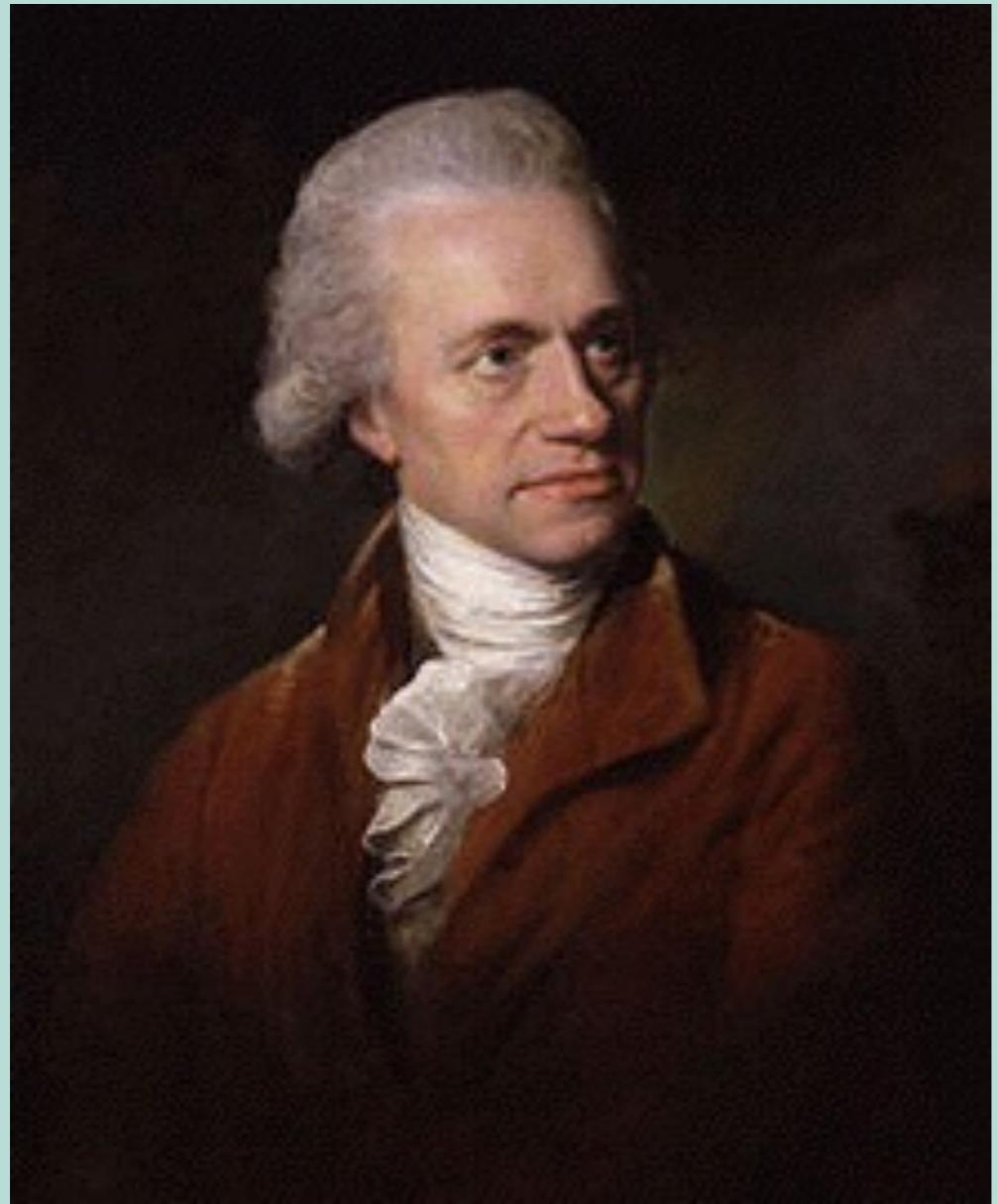
$m \sim 14.5 m_E$

density ~
 1300 kg/m^3

$d \sim 19.2 \text{ AU}$

Uranus and some of its moons



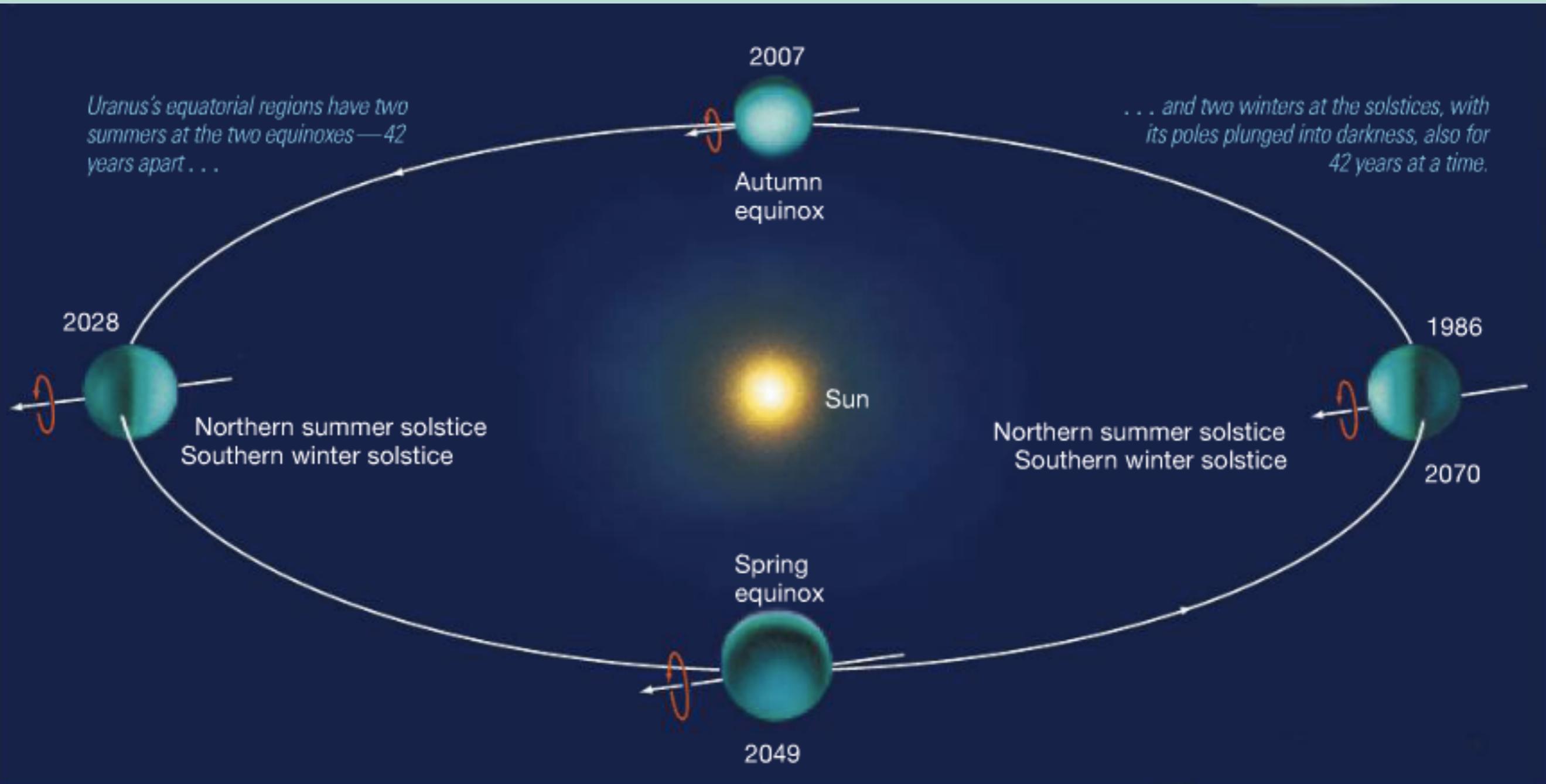


William Herschel

b. Hanover 1738
d. Slough, UK 1822

- Discovered Uranus (1781)
- Discovered Oberon (Uranus), Enceladus (Saturn), Titania (Uranus) and Mimas (Saturn)
- Discovered Infrared Radiation!

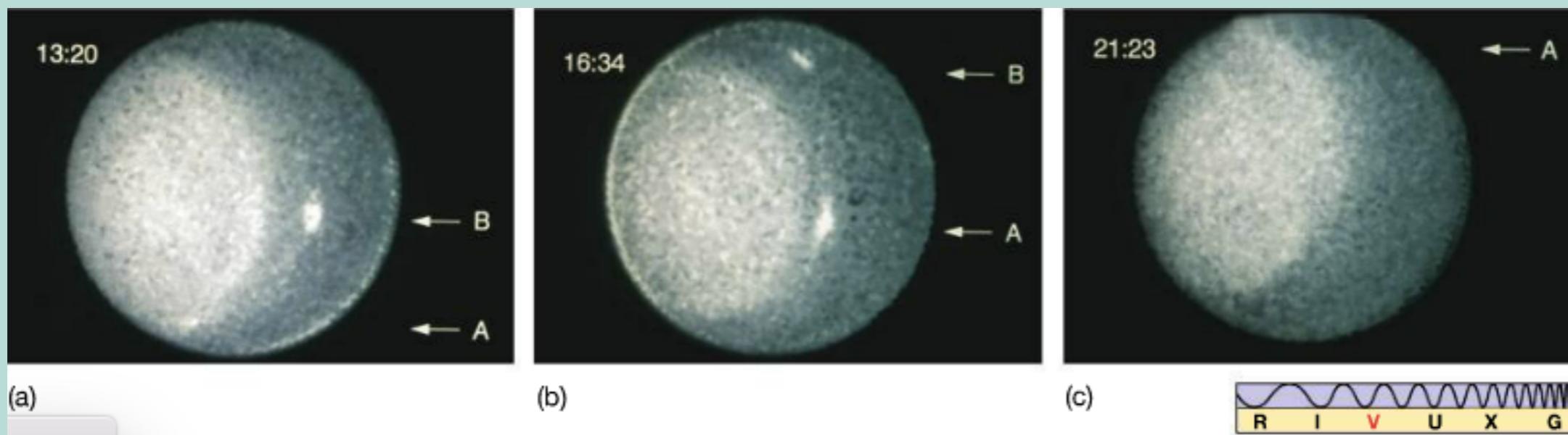
- Was found the good old fashion way. Looking around.
- Originally wanted to name Uranus “George’s Star”
 - First planet discovered in over 2000 years!



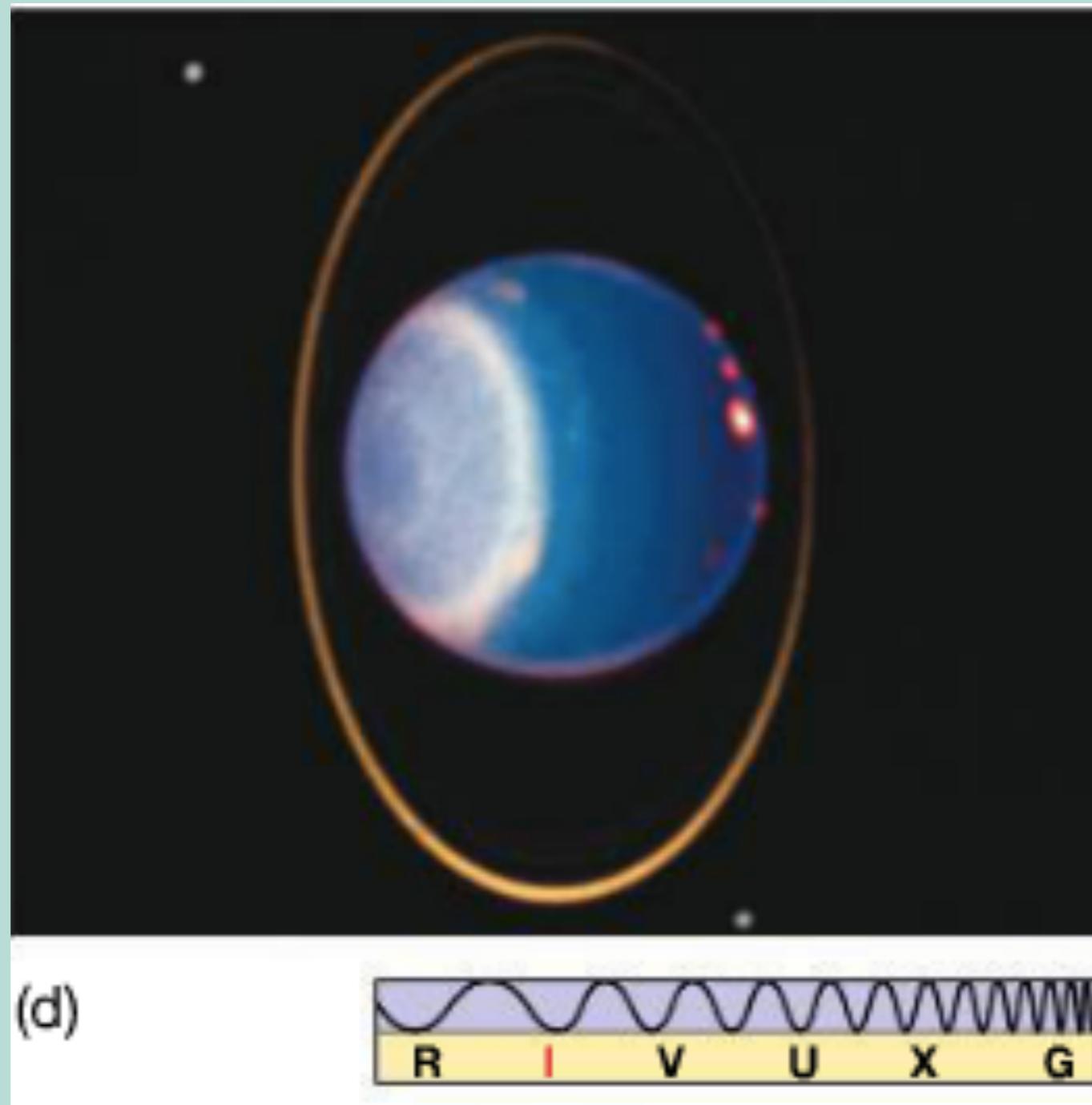
Rotation axis tilted 98 degrees!

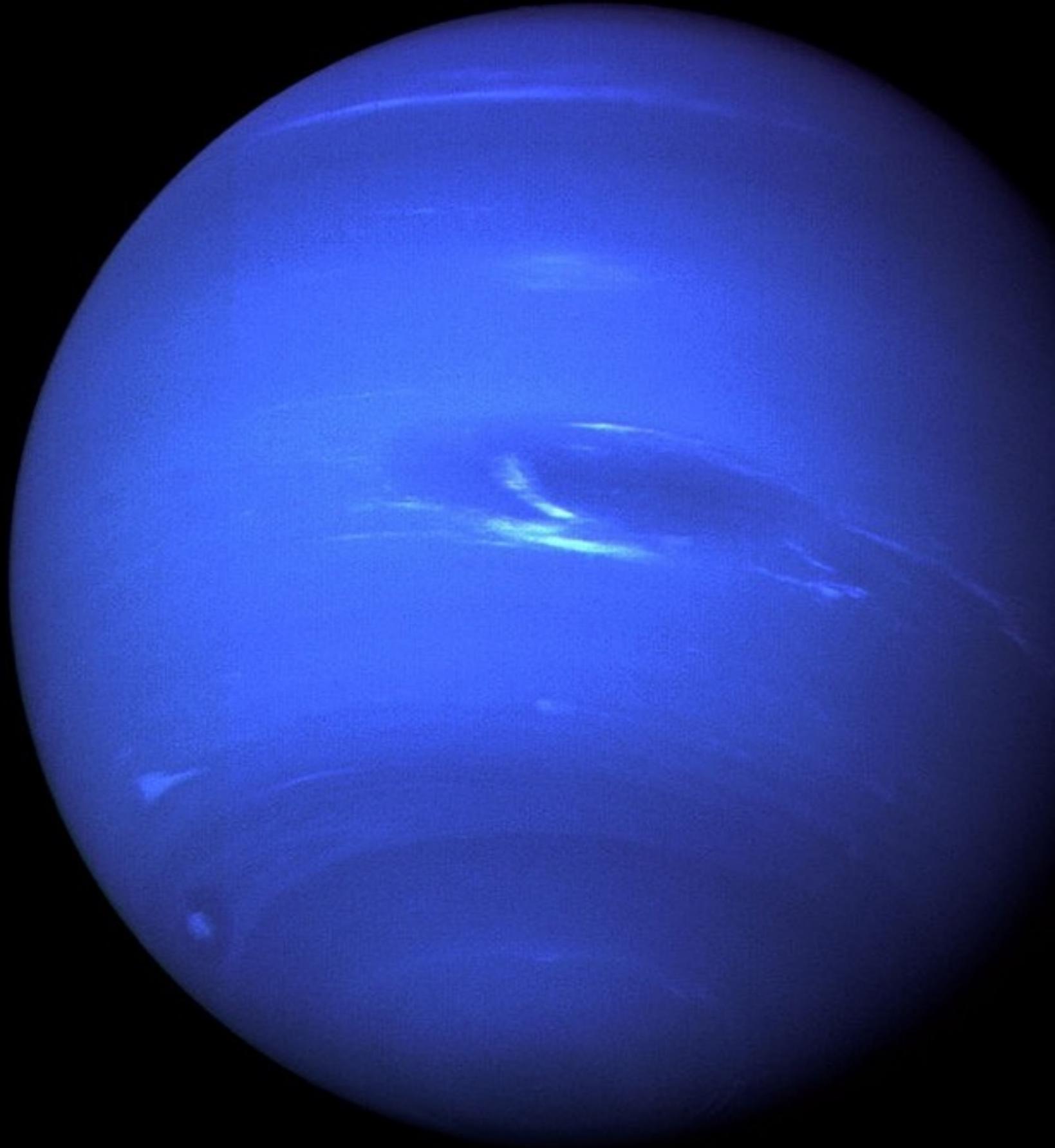
- Origin of tilt: unknown!
- One day ~17.2 hours
- Atmospheric differential rotation, but this time faster at the poles!

Turbulent Cloud Structure



Uranus in the IR





Neptune

$r \sim 3.9 r_E$

$m \sim 17.1 m_E$

density ~
1600

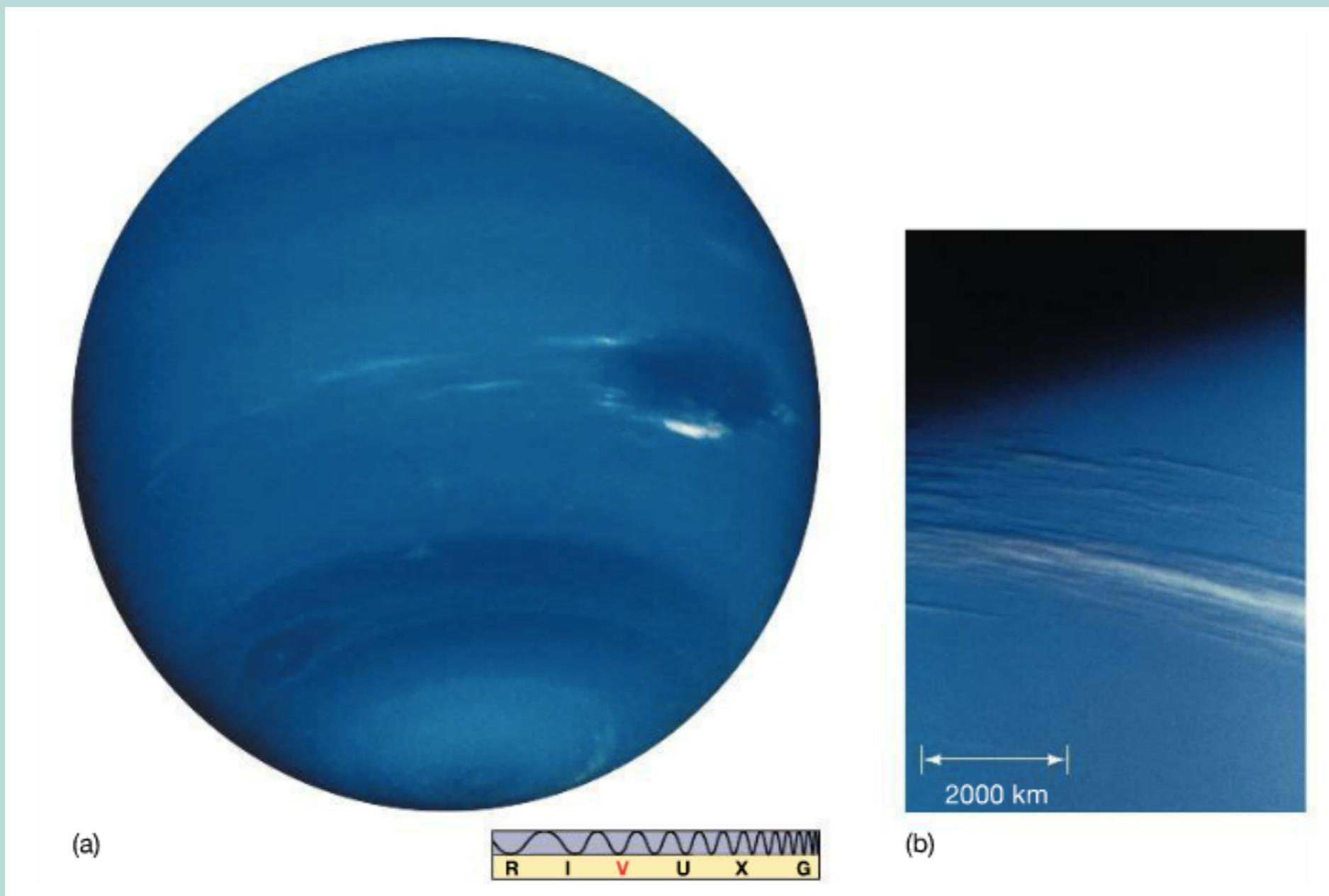
$d \sim 30.1 \text{ AU}$

- The presence of Neptune was inferred from its gravitational perturbation of Uranus's orbit: Dark Matter!
- The planet was “Discovered” mathematically by John Adams and Urbain Leverrier (1845) and eventually found by Johan Galle
- Orbital period of 163.7 years! (about how long we’ve known about Neptune)

Neptune and its Moons

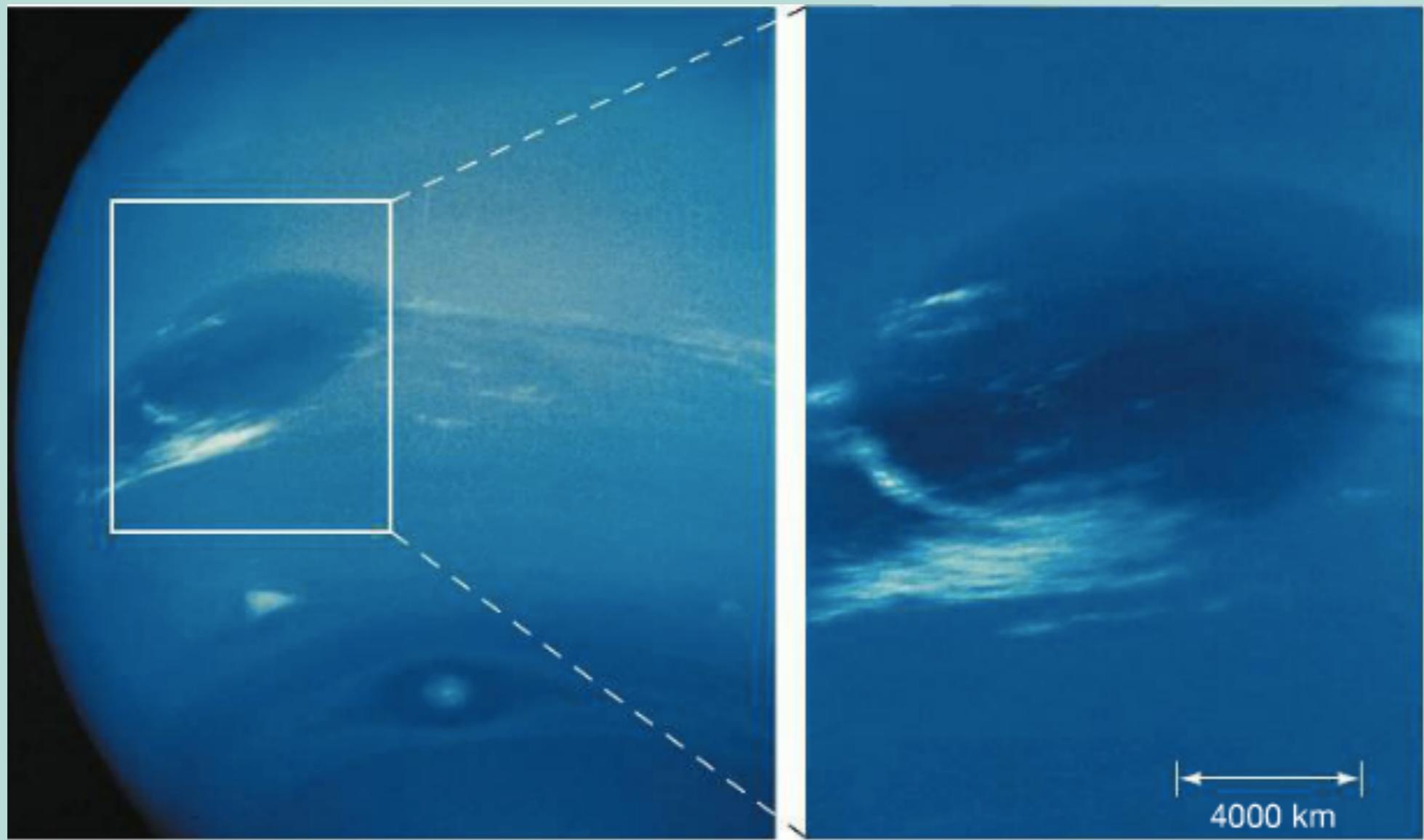


Cloud Streaks

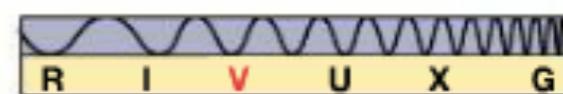


- The interior rotates once every 16.1 hours, but the rotation period of the atmosphere is 17.3 hours. Neptune is unique among Jovian planets in this regard ($T_{\text{atmos}} > T_{\text{interior}}$)
- Axis of rotation inclined 29.6 degrees (similar to 27 degrees for Saturn)

The Great Dark Spot



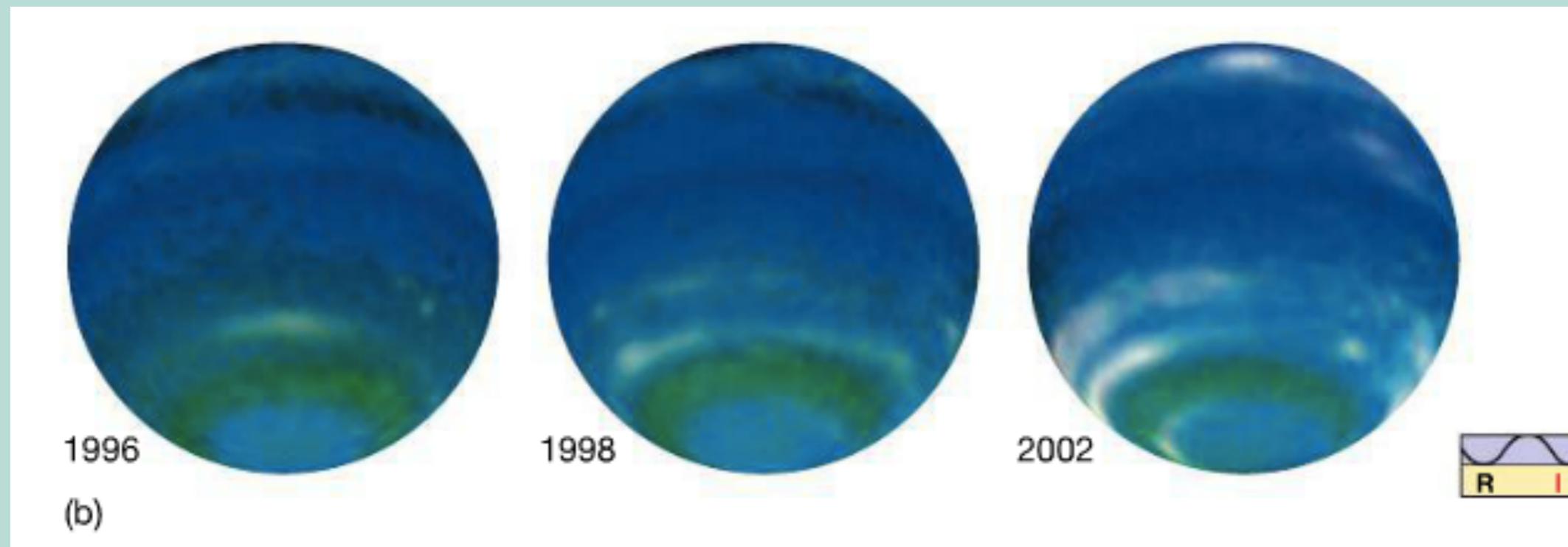
(a)



Neptune is crazy violent.

- Earth sized storms are the ‘rule’ more than the ‘exception’.
- Wind speeds have been clocked up to 1500 km/h!!
(Mach .5)

Neptunian Weather



No Spot!

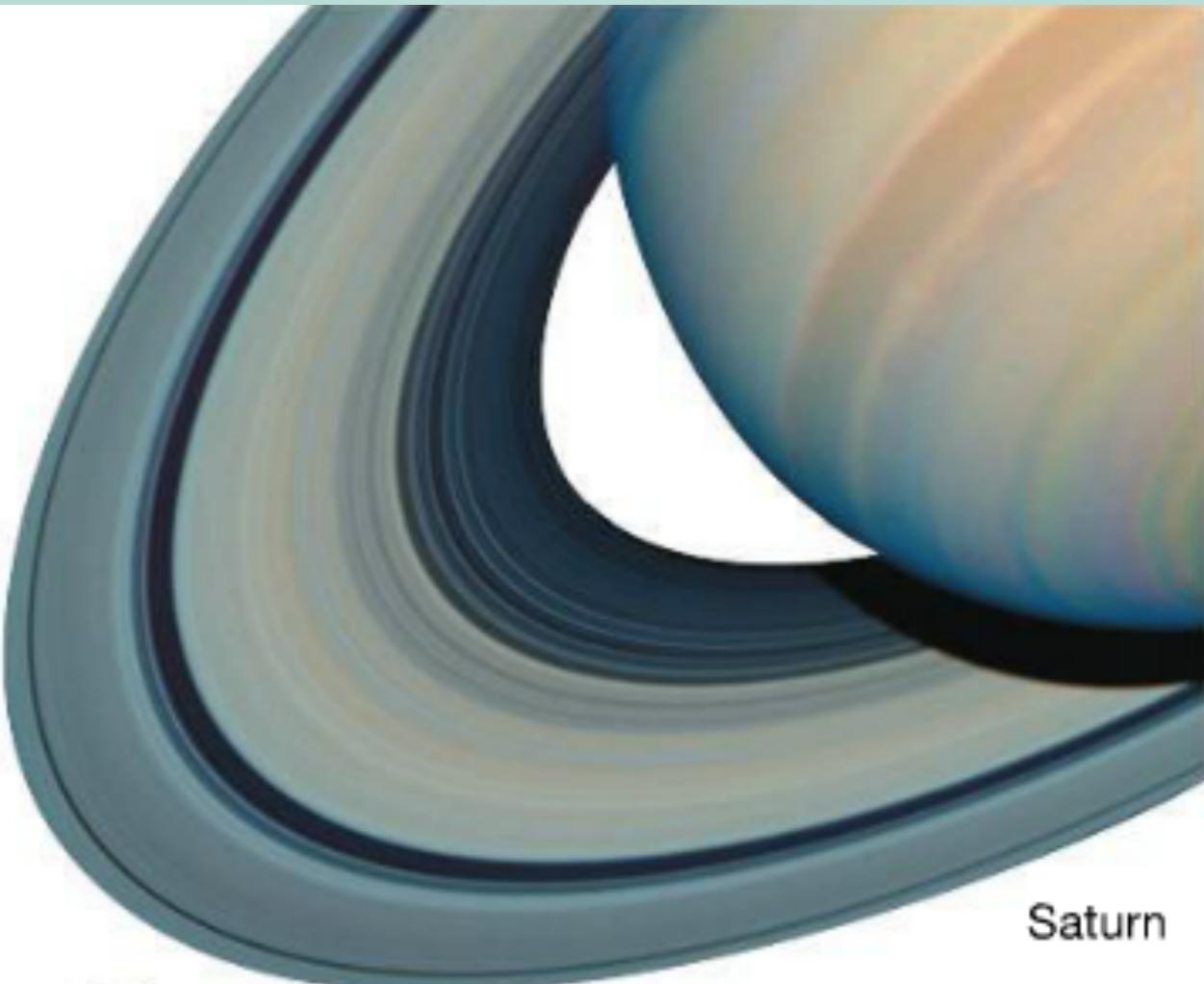
Uranian and Neptunian Atmospheres

- ~84% molecular hydrogen, ~14% Helium for both
- Methane ~3% for Neptune and ~2% for Uranus (methane responsible for bluish hue)
- Ammonia freezes at 70K (between the cloud tops of Saturn/Jupiter and Uranus/Neptune) So very little in outer planets' atmospheres

- Uranus has no internal heat source but Neptune does! The source is likely the same as Jupiter: left over heat from formation.
- Recall, Neptune is more massive and has more methane to keep it insulated



Jupiter



Saturn



Uranus

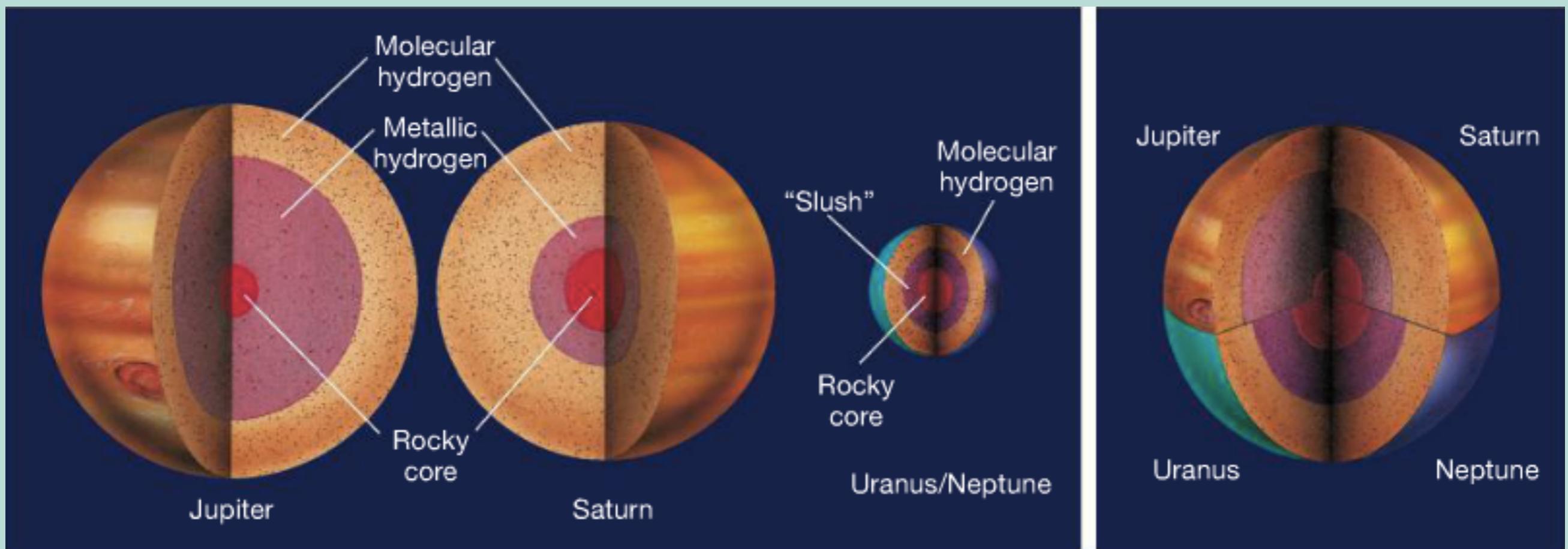


Earth

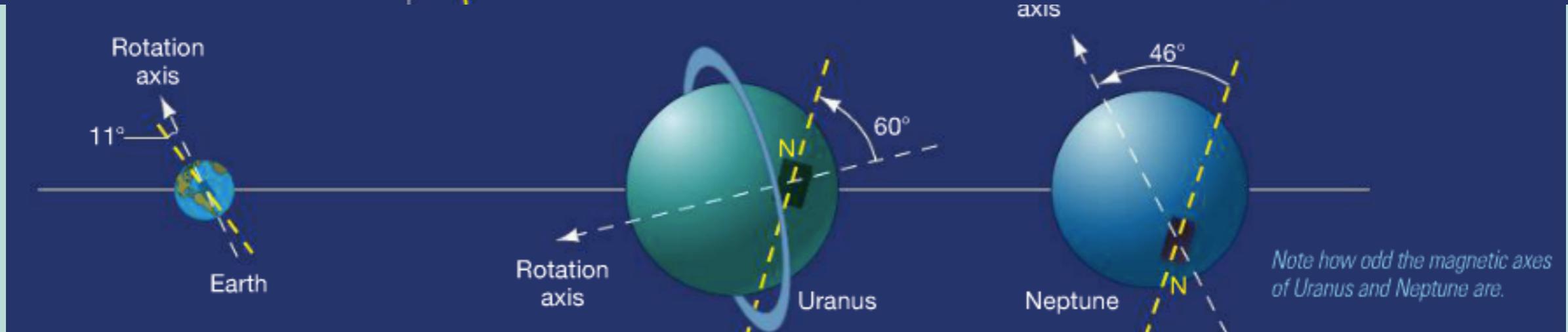
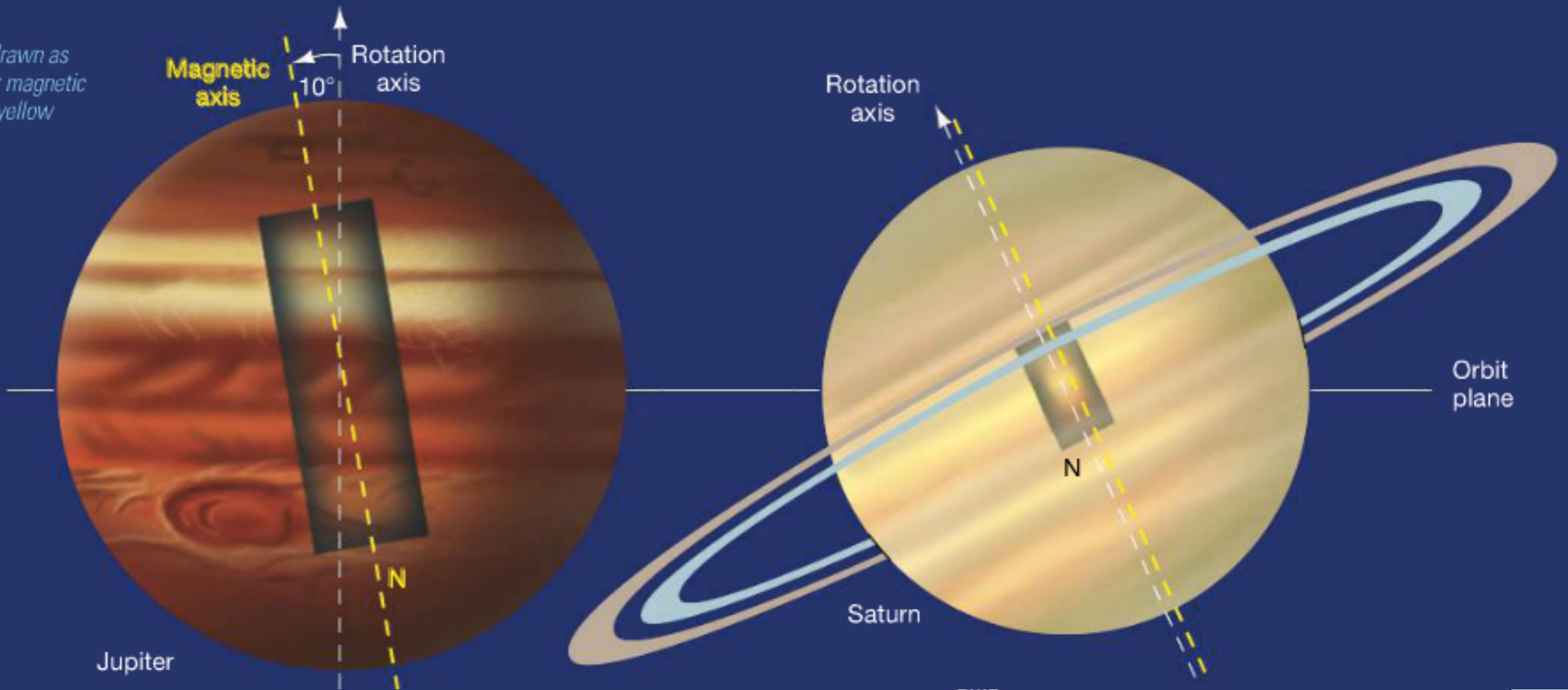


Neptune

Interior Comparison



Rotation axes are drawn as white dashed lines; magnetic axes are drawn as yellow dashed lines.



Magnetic and Rotational Axes

- The axes are misaligned in Neptune and Uranus with respect to the rotation axis and also its center isn't centered on the planet, uncommon in typical "dynamo" theories of a conductive liquid core.
- Nothing is certain, but this could be due to the fact that at the temperature and pressures of these outer jovian cores, hydrogen doesn't transition into its metallic state.
- What creates the magnetosphere instead could be a "slush" of water and ammonia (frozen and sunk out of the atmosphere) which would create a much more complicated field.

Uranus: 27 moons
 Neptune: 13 moons

TABLE 13.1 The Major Moons of Uranus and Neptune*

Name	Distance from Planet (km)	Distance from Planet (planetary radii)	Orbital Period (days)	Size (longest diameter, km)	Mass** (Earth/Moon masses)	Density (kg/m ³)	Density (g/cm ³)
Miranda (U)	130,000	5.08	1.41	480	0.00090	1100	1.1
Ariel (U)	191,000	7.48	2.52	1160	0.018	1600	1.6
Umbriel (U)	266,000	10.4	4.14	1170	0.016	1400	1.4
Titania (U)	436,000	17.1	8.71	1580	0.048	1700	1.7
Oberon (U)	583,000	22.8	13.5	1520	0.041	1600	1.6
Proteus (N)	118,000	4.75	1.12	440			
Triton (N)	355,000	14.3	-5.88 [†]	2710	0.292	2100	2.1
Nereid (N)	5,510,000	223	360	340	0.0000034	1200	1.2

(> 300 km)

The appearance, structure, and history of Titania and Oberon seem similar to those of Saturn's moon Rhea.



Oberon

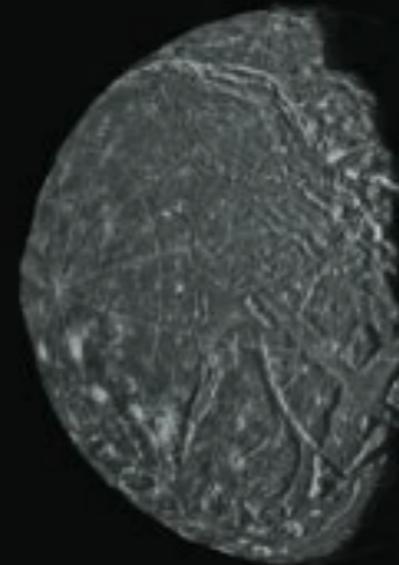


Miranda



Nereid

Earth's
Moon



Ariel



Proteus



Umbriel

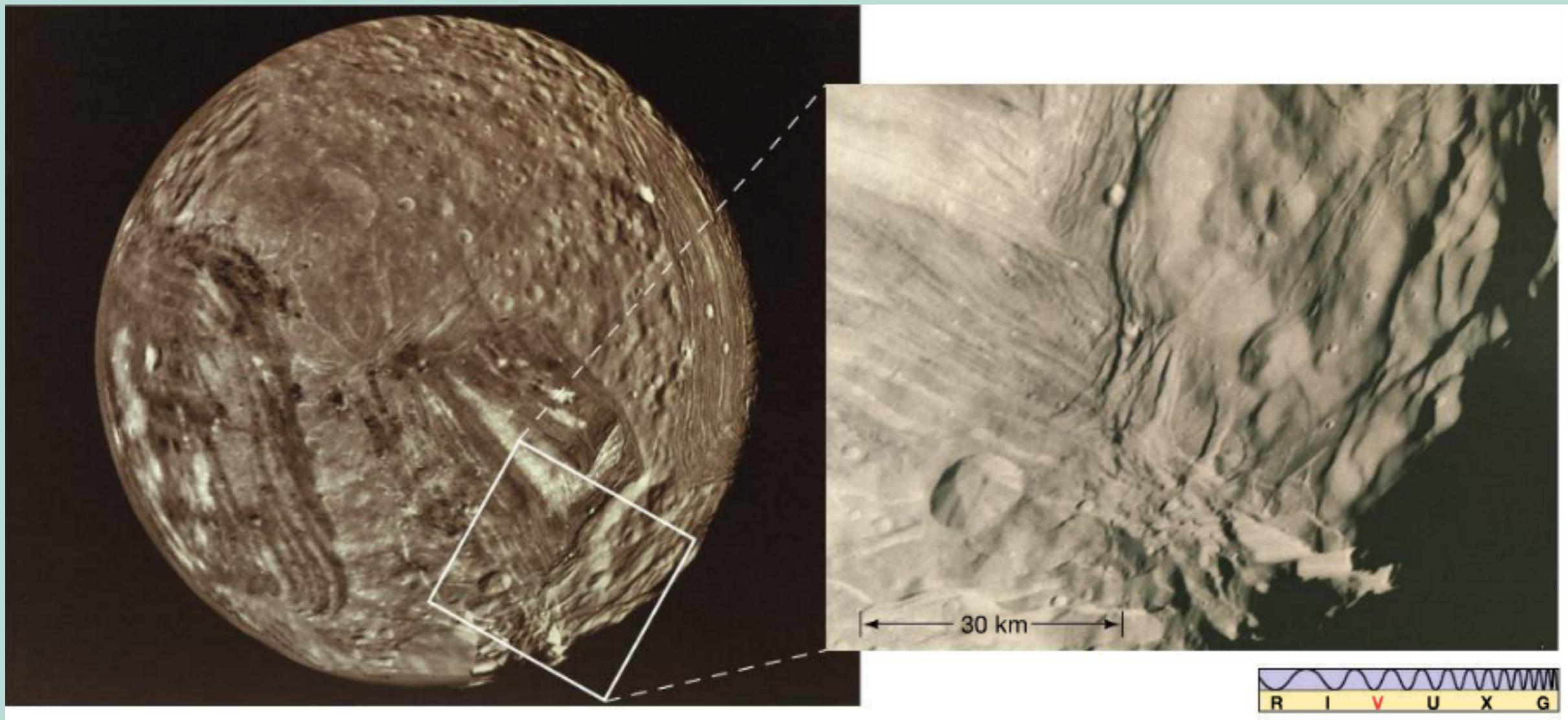
Umbriel is one of the darkest bodies in the solar system.



Titania

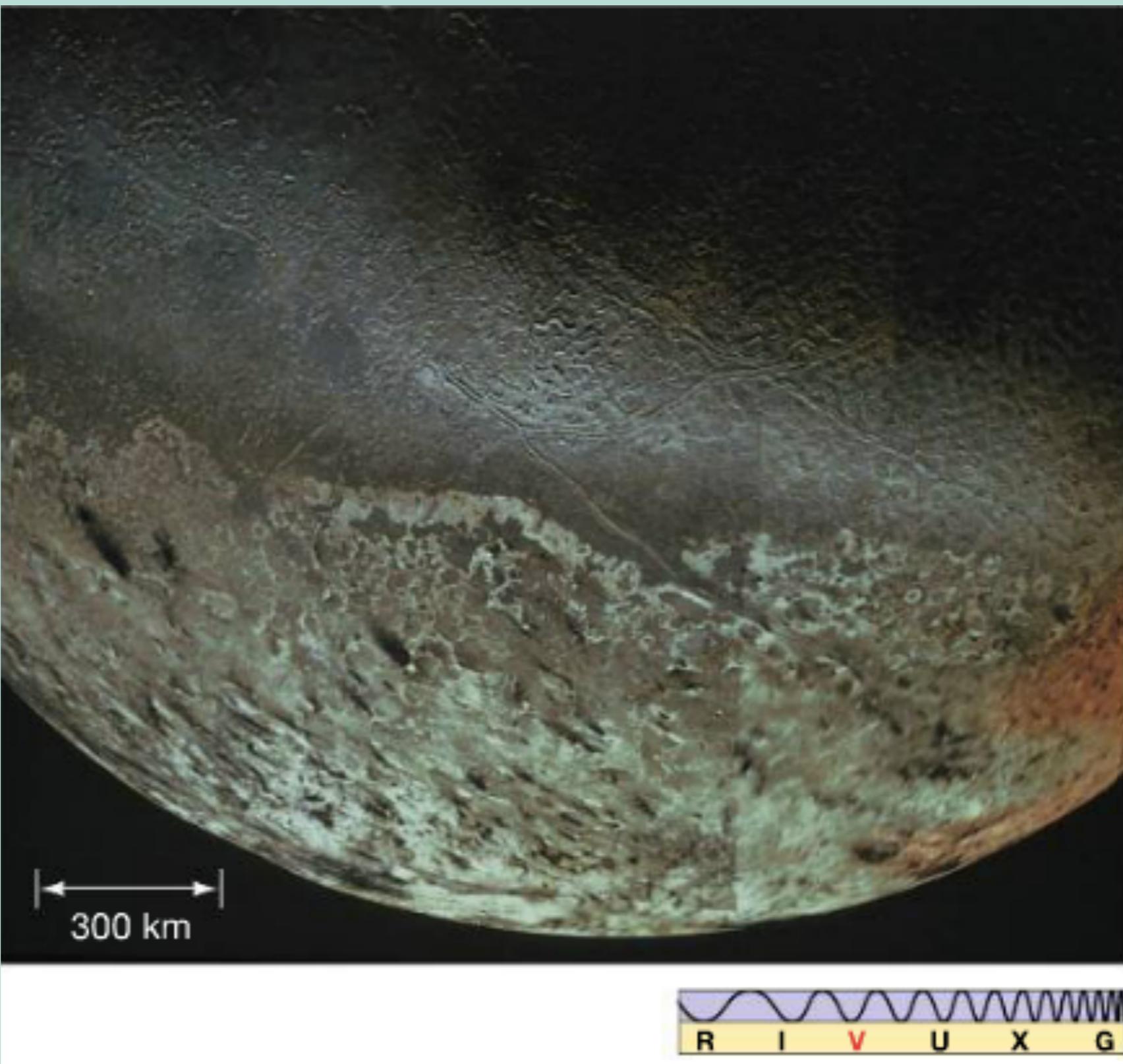
- Bodies in the outer solar system tend to be sootier than the inner (radiation darkening, possible reason)

Miranda: A glitch in the Matrix



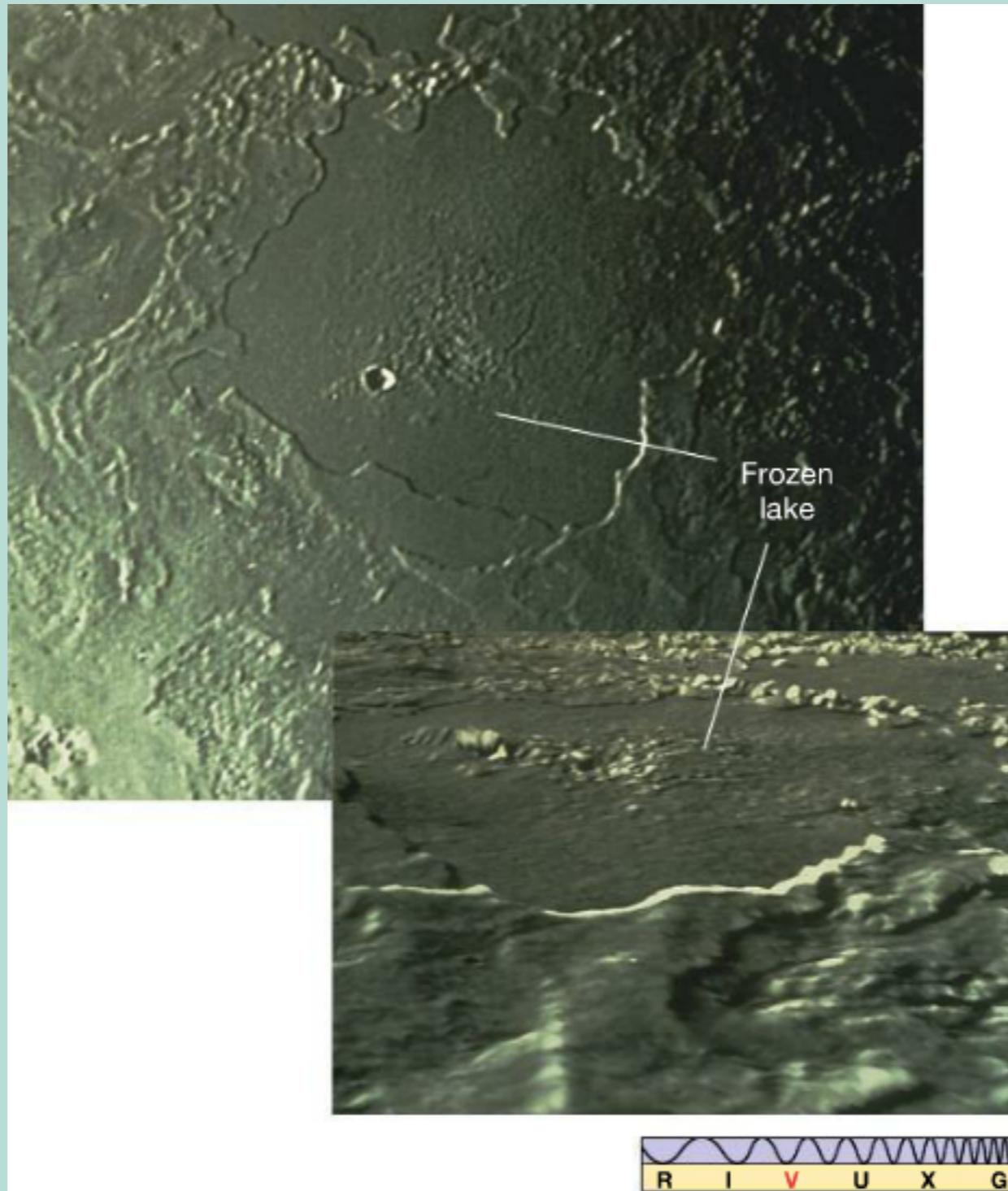
Smashed apart and reformed?

Triton



- Only large moon in a retrograde orbit
- 16th largest thing in the solar system! (half Europa-ish)
- Nitrogen Frost caps (37 K)
- Captured?

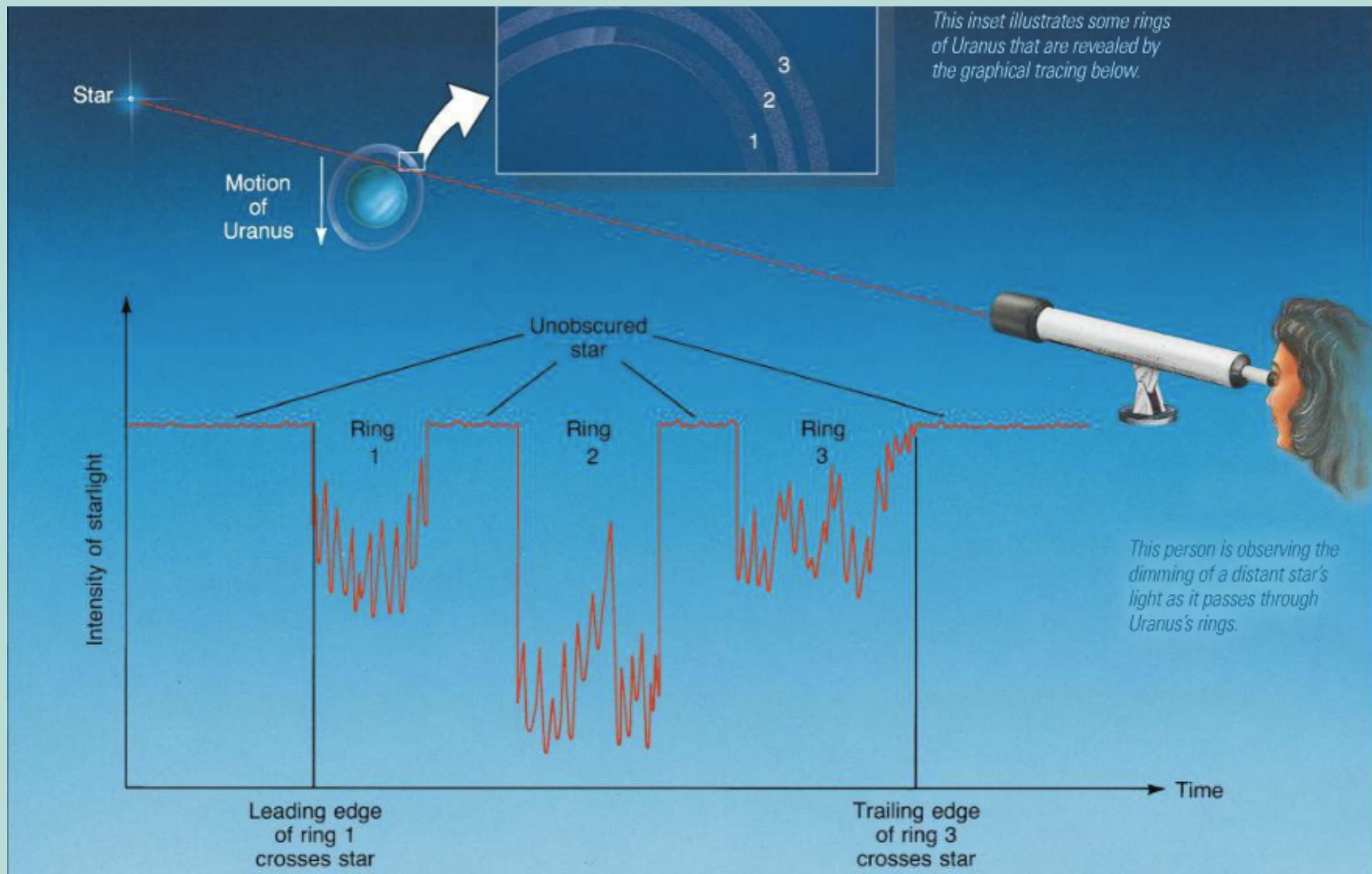
Water Lakes on Triton



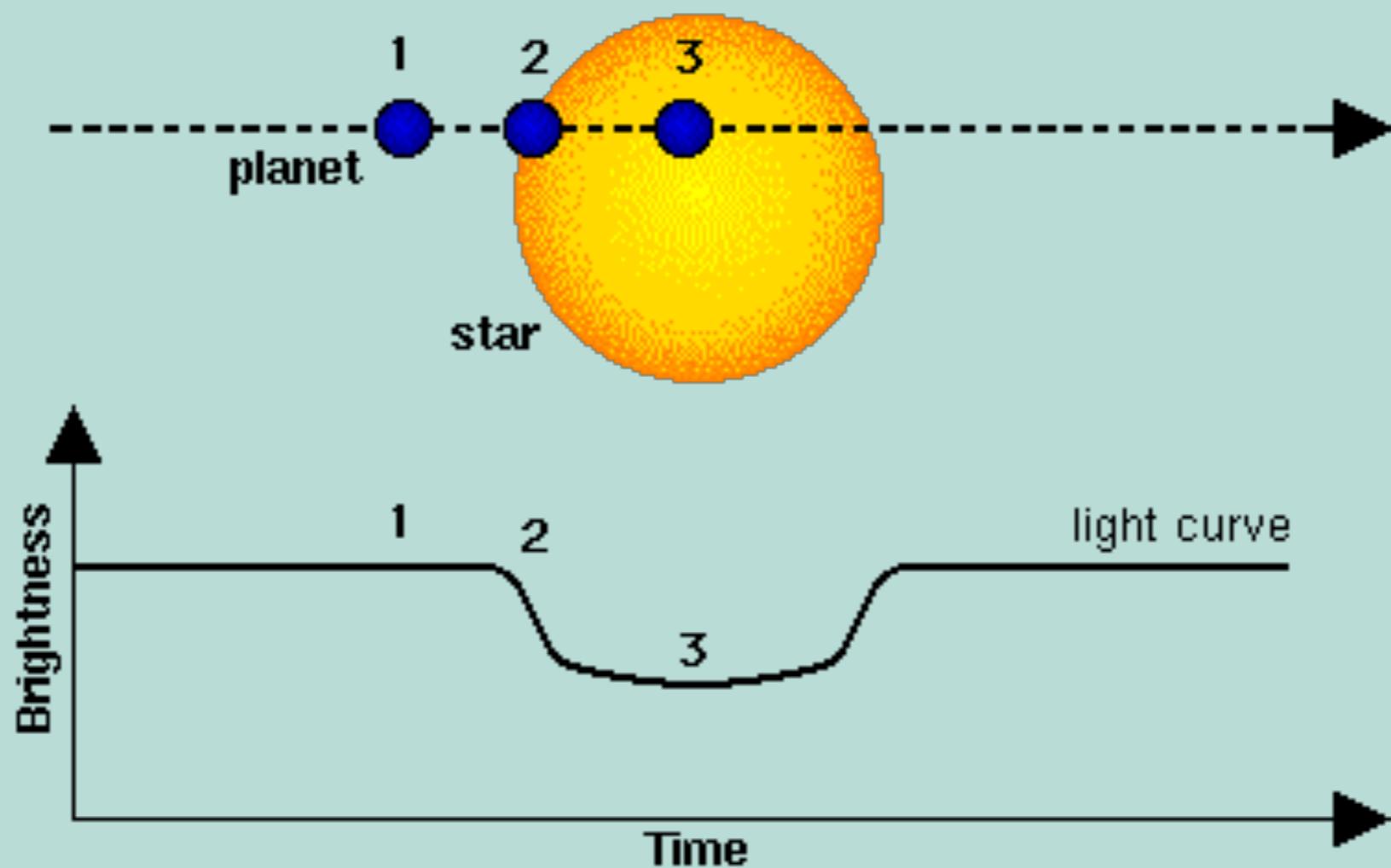
... and nitrogen geysers!

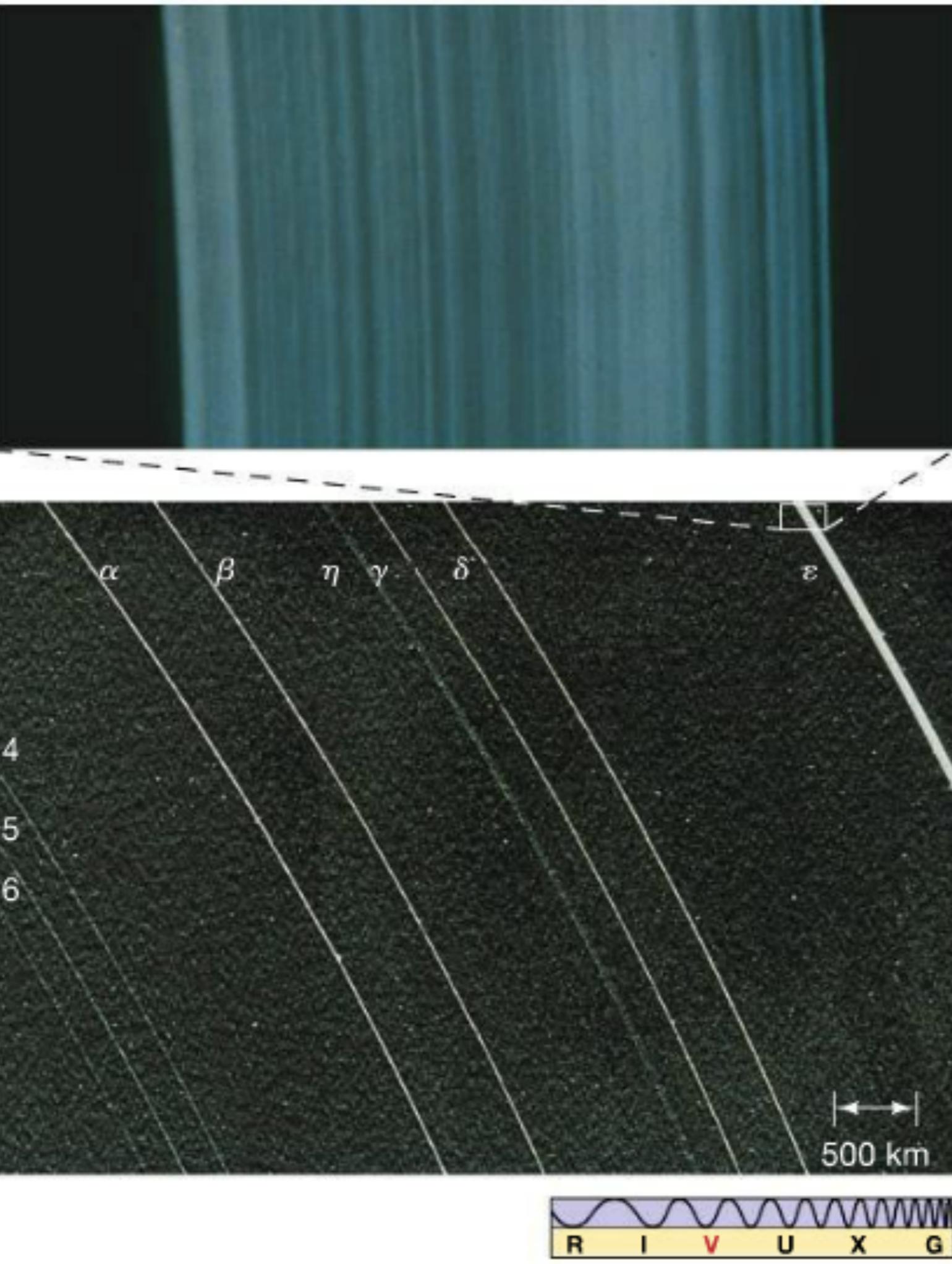
Triton's Spiral of Death. (~100 million years)



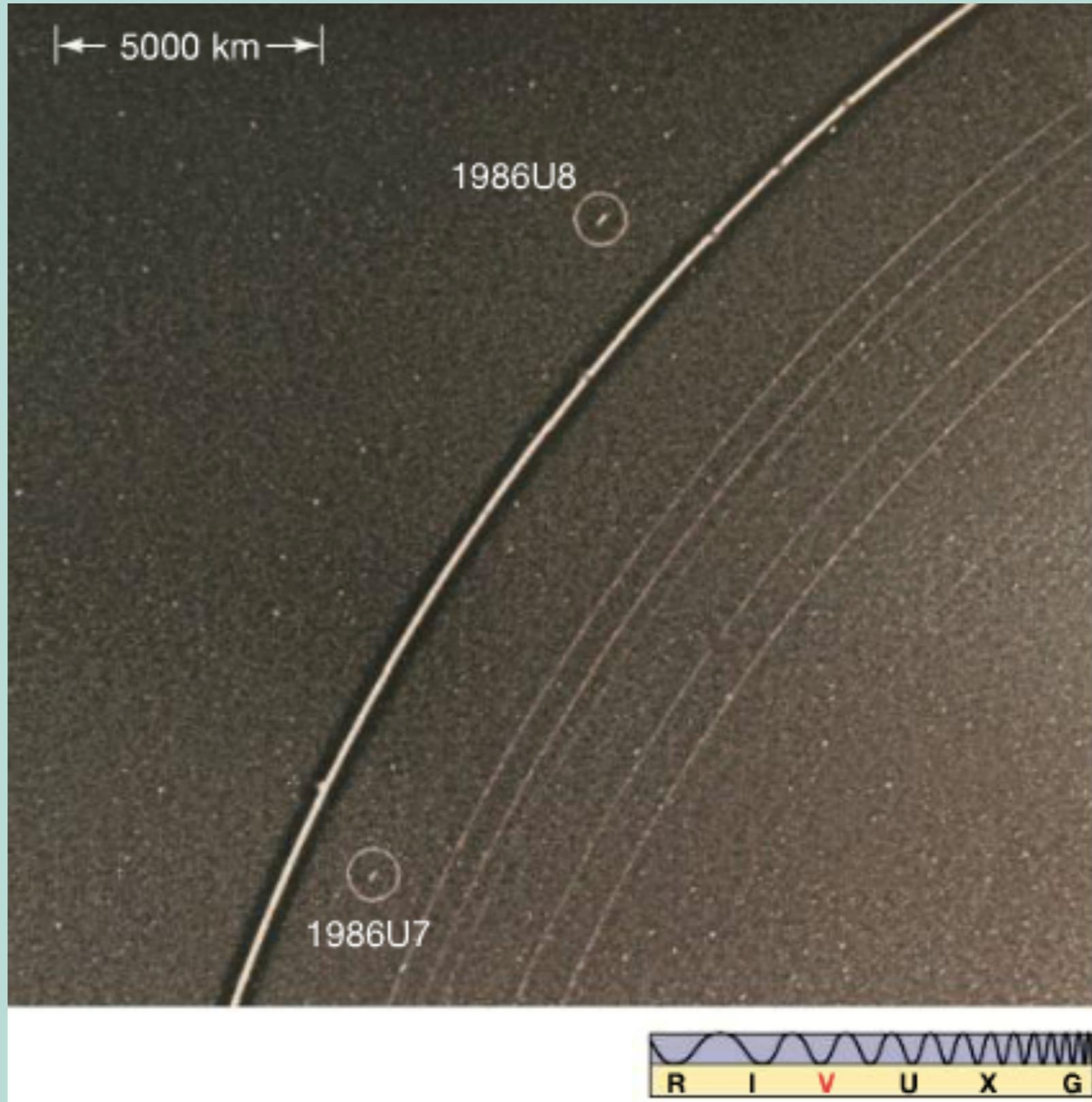


Same technique used to find Exoplanets!





'skinny'

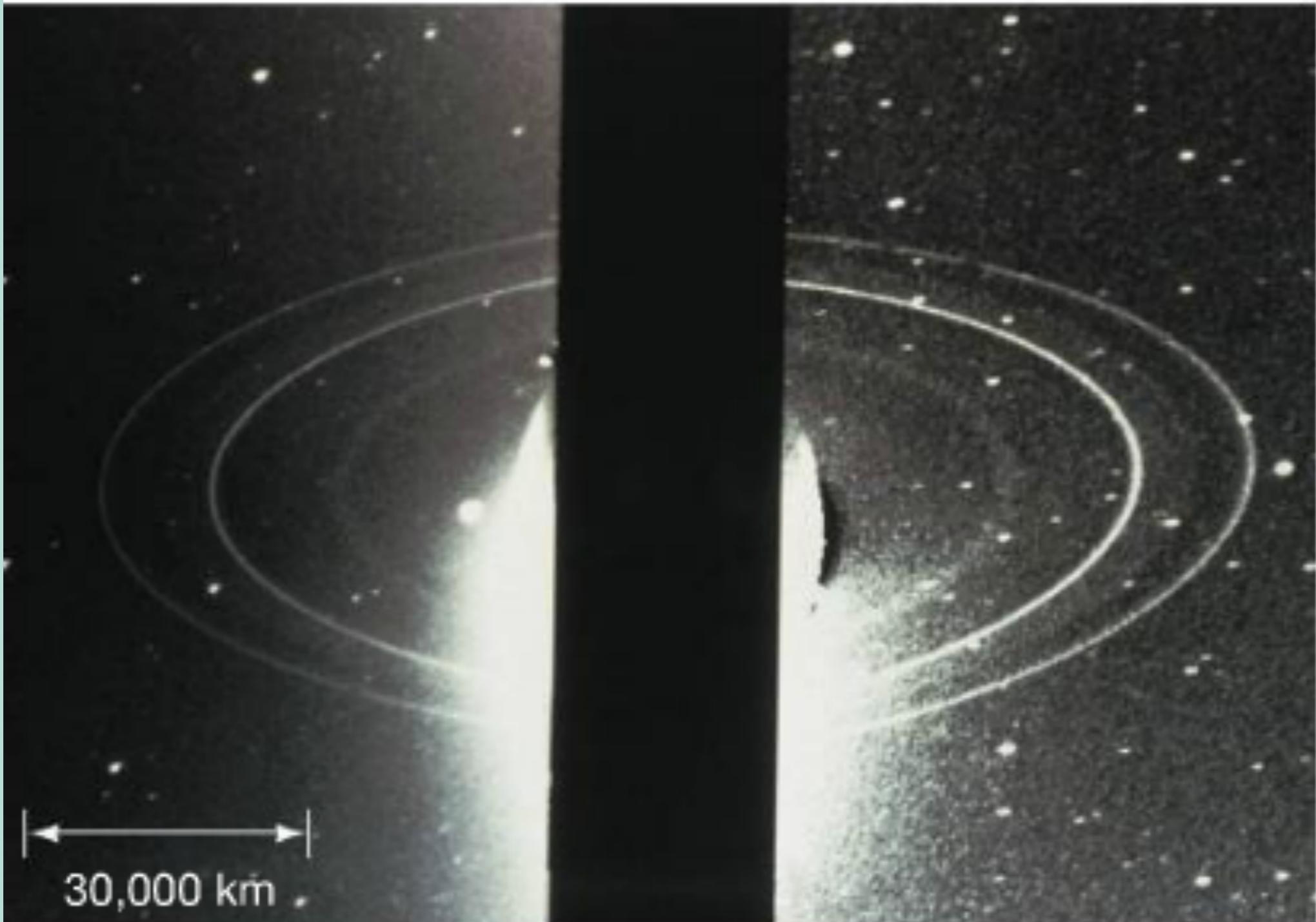


Uranus Sheppard Moons (the origin of the theory)

TABLE 13.2 The Rings of Uranus

Ring	Inner Radius (km)	Outer Radius* (planetary radii)	Width (km)
1986U2R	37,000	1.45	39,500
6	41,800	1.64	2
5	42,200	1.65	2
4	42,600	1.67	3
Alpha	44,700	1.75	4–10
Beta	45,700	1.79	5–11
Eta	47,200	1.83	2
Gamma	47,600	1.86	1–4
Delta	48,300	1.90	3–7
1986U1R	50,000	1.96	2
Epsilon	51,200	2.00	20–100

Neptune's Rings (long exposure)



Neptune Ring Data

TABLE 13.3 The Rings of Neptune

Ring	Inner Radius (km)	Outer Radius* (planetary radii)	Width (km) (planetary radii)
Galle (1989N3R)	40,900	1.65	42,900 1.73 2000
Leverrier (1989N2R)	53,200	2.15	100
Lassell (1989N4R)**	53,200	2.15	57,200 2.31 4000
Arago (1989N4R)**	57,200	2.31	100
Adams (1989N1R)	62,900	2.54	50