

The Outer Planets*



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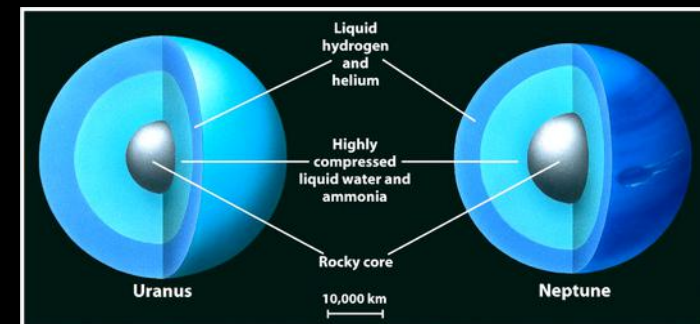
Basic information (U, N, P)

Density (avg, g/cm^3):	1.3	1.6	1.8
Distance from Sun (avg, AU):	19	30	40
Orbital Period (years):	84	165	249
Rotation Period (equatorial):	~17h	~16h	~6 days
Albedo:	0.30	0.29	0.72
Moons (2018):	27	14	5
Tilt of rotational axis:	98°	30°	118°
Equatorial diameter (x Earth):	~4	~4	~0.20

Exploring the Outer Planets

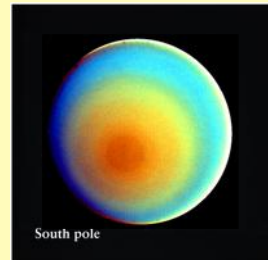
- *none* are *easily* visible without a telescope
- **Uranus** found *accidentally* by **Herschel** (1781)
- **Neptune** *predicted* by **LeVerrier** (1846)
- **Pluto** *photographed* by **Clyde Tombaugh** (1930)
- **Voyager 2** flybys NASA
Uranus (1986), **Neptune** (1989)
- **New Horizons** flyby of **Pluto** (2015) NASA

Interior Structure



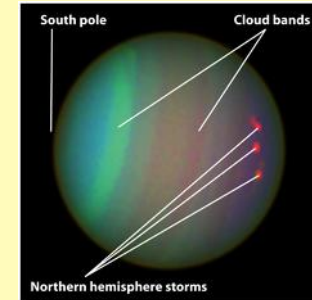
Uranus (“God of the Night Sky”)

- almost named *“Georgium Sidus”* (George's Star)
- renamed for **Saturn's father**
- **only planet with Greek name**
- **rotational axis tilted $\sim 98^\circ$**
- **only moves $\sim 4^\circ$ per year**

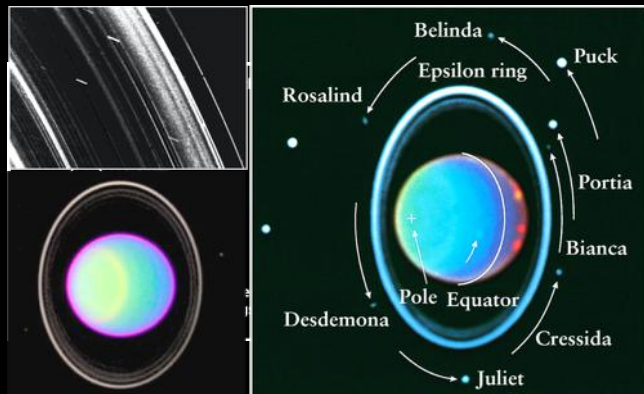


Atmosphere

- temp: 55 K (-218°C)
- dominated by **H, He**
- some **methane**
- **very cold: NH_3 , H_2O** precipitated into interior; with **little solar energy**
 \Rightarrow bland appearance
- **relatively high density** \sim like **Jupiter**
- **formed elsewhere & migrated?**



Rings



- discovered during a 1977 occultation

CLICKER: Why was Uranus not identified as a planet much earlier?

- (a) *it moves very slowly compared to the stars*
- (b) *the greenish color makes it difficult to spot*
- (c) *extreme tilt makes viewing impossible*
- (d) *it is only visible with very large telescopes*

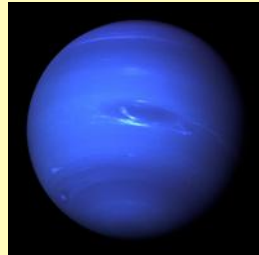
© GEMANIS

Neptune (“God of Sea”)

- co-discovered? (*LeVerrier/Adams*) via *predictions* made due to *observed deviations* in *Uranus' orbit*

- same size as *Uranus*, but *20% more massive*

- *emits more energy* than it *receives*



Atmosphere

- temperature: *55 K (-218° C)*

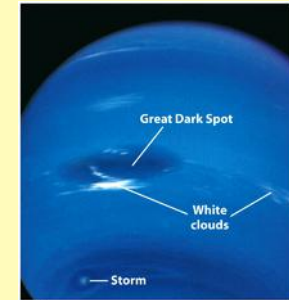
- *same as Uranus*

Q: Why is this unusual?

- *more mass* but *same size*
- **gravitational contraction** releases energy (like *Jupiter*)

Q: What effect will this have?

- ⇒ dynamic atmosphere with visible *belts & zones*
- winds of *1300+ kph*



Rings

December 8, 2004
ACS/HRC

Adams Ring

Leverrier Ring

Arcs

Image Credit: M. Showalter/SETI Institute

- complete but **dark** ring system: *Voyager 2*

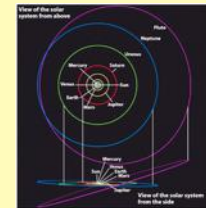
Pluto “God of the Underworld”

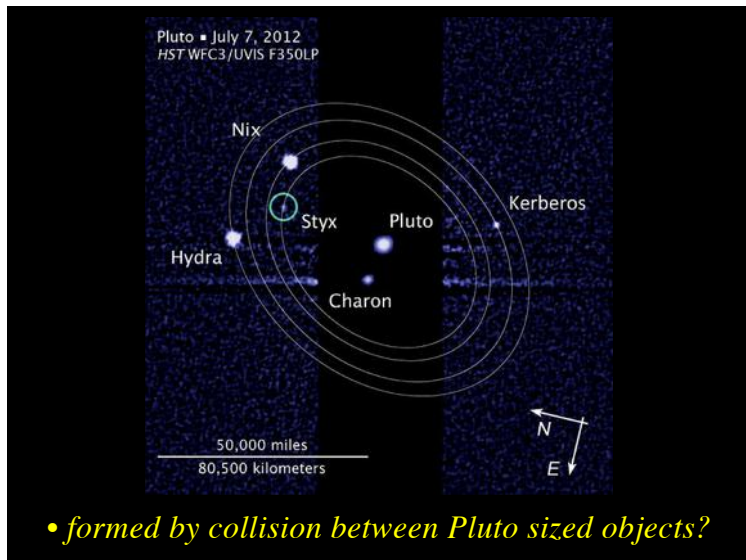
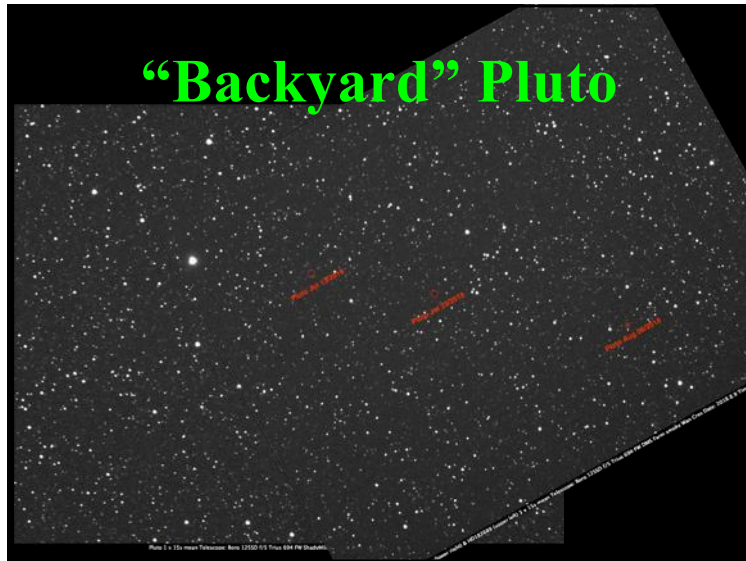
- named by English schoolgirl *Venetia Burney*

- *highly elliptical orbit* **crosses** orbit of *Neptune*; *orbital plane tilted 17°* wrt **ecliptic**

- **retrograde rotation**

- *Pluto's* moon *Charon* is *half* its size





TNO's & Kuiper Belt

- ~ 2000 objects *found* within ~100 AU (2018)

Largest known trans-Neptunian objects (TNOs)

2000km

A disk blocks out the bright light from the star...

100 AU

...thus revealing a faint disk (seen edge-on) of material around the star

- *similar* belts around other stars, (eg) *HD 139664*

