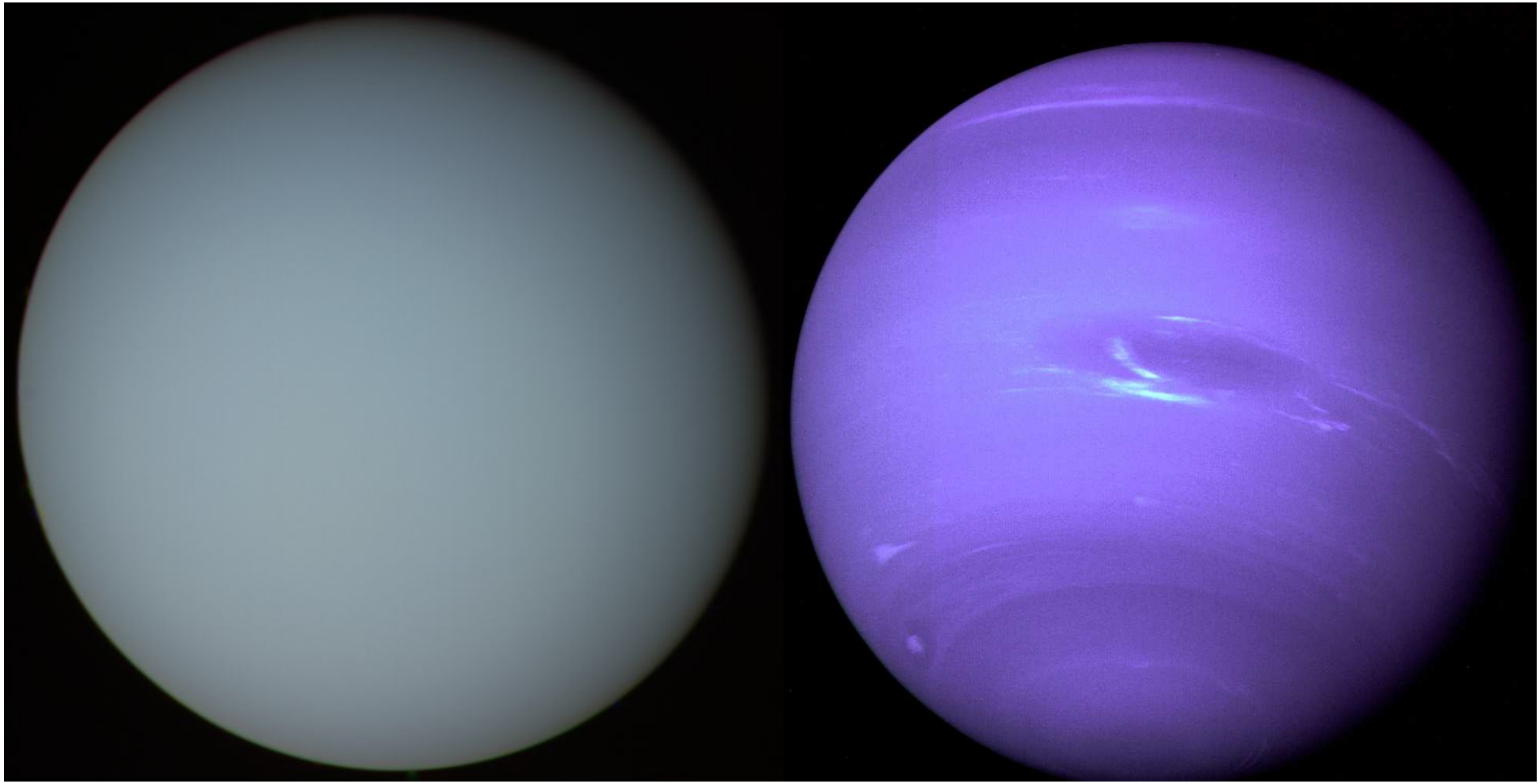


“Uranus & Neptune, The Ice Giants”

What We Will Learn Today

- How & When were Uranus & Neptune discovered?
- How are the interiors and weather on these planets?
- Why is Neptune as “warm” as Uranus?
- What are their moons and rings like?
- What is special about Triton, Neptune’s moon?
- How are these worlds unique in the SS?

Planet Details

Property	Uranus	Neptune
Semi-major axis	19.2 AU	30.1 AU
Size (radius)	4.0 R_{Earth}	3.9 R_{Earth} Smallest Jovian
Mass	14.5 M_{Earth}	17.1 M_{Earth}
Average density	1.32 g/cc	1.64 g/cc
Composition	H, He, H-compounds	H, He, H-compounds
Cloud-top Temp	60 K	60 K As “warm” as Uranus!
Moons	> 27	> 13
Orbital period	84 years	165 years
Rotation period *	-17.3 hours Retrograde	16 hours
Axis tilt	97.9º Most extreme	29.6º
Orbital inclination	0.77º	1.77º
Orbital eccentricity	0.046	0.010

* Measured based on rotation of magnetic field lines

Uranus & Neptune's Discovery

- First planets discovered using a telescope
- Uranus discovered in 1781 by William & Caroline Herschel
  - Although faintly visible to naked-eye, does not "wander" as much due to its long 84 year orbit
  - Discovered during a survey of the skies
- Careful observations of Uranus shows deviation in path vs. Newton's laws
- Adams & Leverrier independently predicted influence on Uranus from an unseen eighth planet
- Neptune discovered in 1846 by Galle based on Leverrier's prediction of its position!

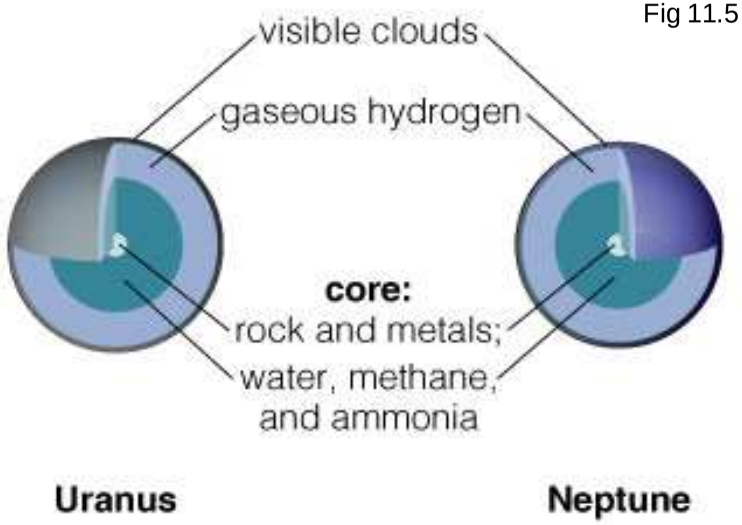
Formation of Uranus & Neptune

- Similar to Jupiter and Saturn, core of about 10 M_{Earth} formed from hydrogen compounds
- Accreted much smaller atmosphere
  - Orbit around the Sun is much bigger
  - Accretion slower as a result
  - Solar wind blew away gas into interstellar space
  - Stopped planet formation, leaving Uranus and Neptune less massive

Interior of Uranus & Neptune

- No liquid or metallic hydrogen
  - Not enough pressure
- Rock & metal core
  - Larger than Jupiter & Saturn as it is not weighed down by a large atmosphere
- Hydrogen compound layer
  - Differentiated over rock & metal core unlike Jupiter & Saturn
- Gaseous hydrogen
- Visible clouds
- Uranus
  - Cooled off and dull (as expected)
- Neptune
  - Internal heat source!
  - Perhaps due to ongoing contraction
    - Like which other planet?

Fig 11.5



Atmosphere & Weather

- ~ 84% H, 14% He, 2% CH_4
- Methane condenses into "snow flakes" less than 100 km below the cloud tops
  - Gives the blue color
  - Methane gas above absorbs red light
  - Methane clouds reflect blue light
- Why is Neptune bluer?
  - Uranus has smog-like layer due to its extreme seasons
  - Scatters blue light before reaching clouds

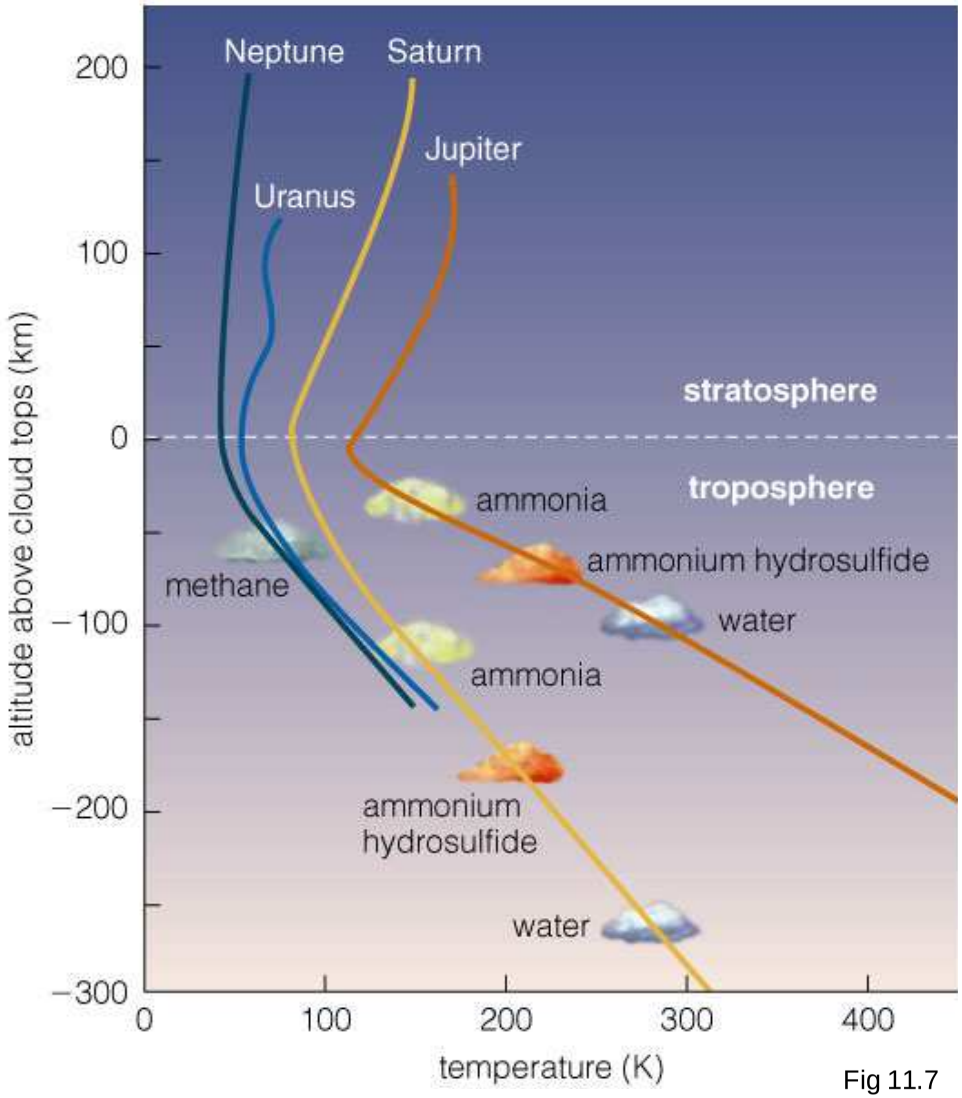


Fig 11.7

Winds & Weather

- Uranus
  - Voyager 2 saw no bands or clouds in 1986
  - Subsequent HST and AO observations reveal storms brewing
  - Perhaps due to changing seasons NH seeing Sunlight after 42 years!
- Neptune
  - Banded atmosphere with storms and clouds
  - Great Dark Spot
    - Lasted only about 6 years

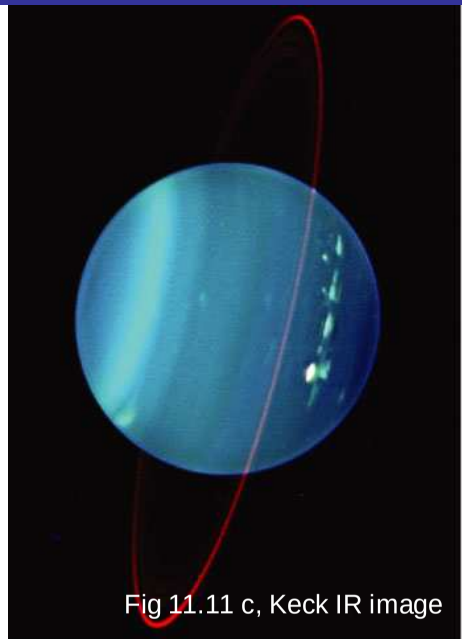


Fig 11.11 c, Keck IR image

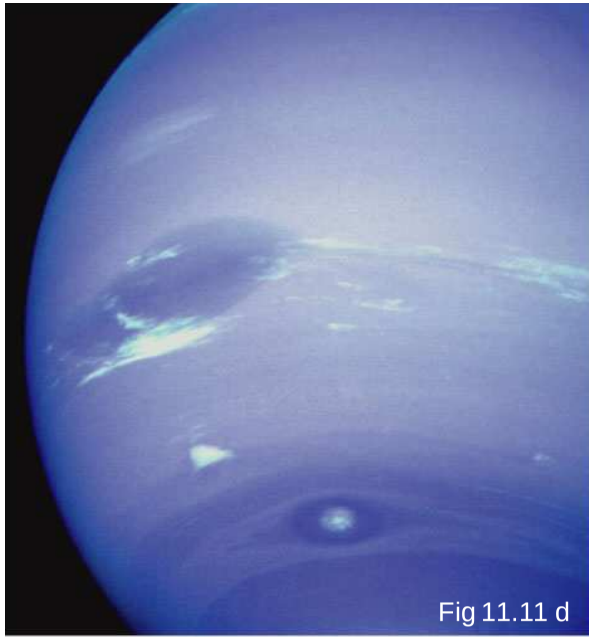


Fig 11.11 d

Magnetic Fields

- Moderate sized magnetosphere despite weak field
  - Liquid core of metals and hydrogen compounds generate magnetic field
  - Weaker solar wind pressure allows moderate sized magnetosphere
- Both magnetic axes are very tilted with respect to rotation axes
  - Don’t know why

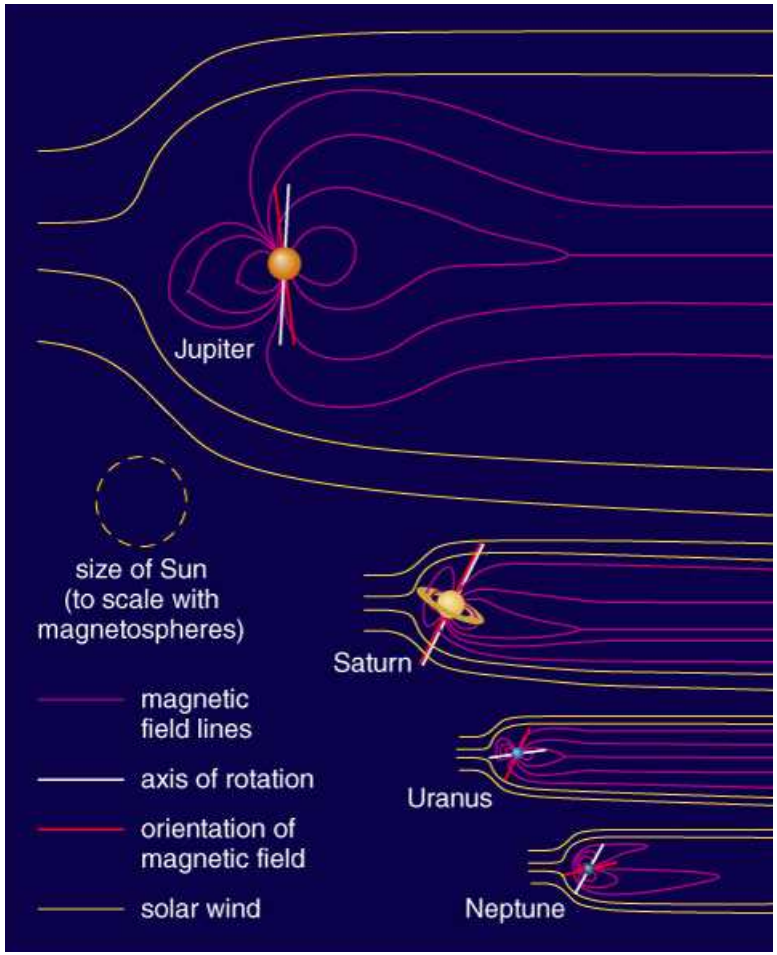


Fig 11.13

Uranus' Medium Sized Moons

- All named after Shakespeare's characters
- Made mainly of ices (water, methane, ammonia)
- Voyager flyby gave us information and raised questions
  - Ariel & Umbriel are virtual twins, but only Ariel shows evidence of volcanism & tectonics
  - Titania & Oberon are also similar size, but only Titania shows geological activity
- Miranda, the smallest, shows many tectonic features and relatively few craters
  - Perhaps due to past tidal heating

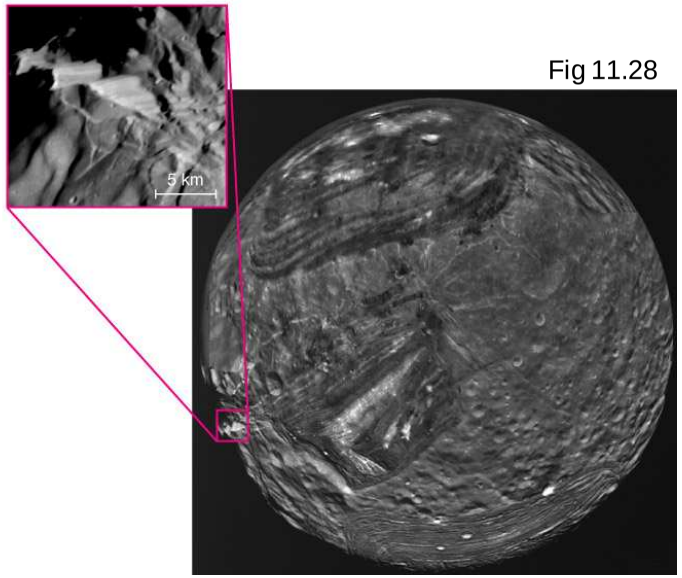
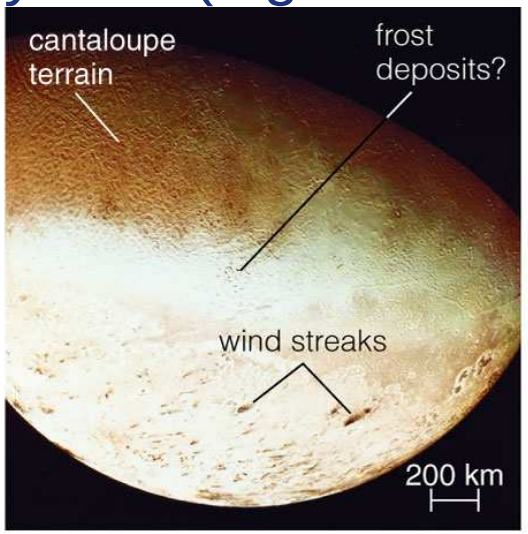


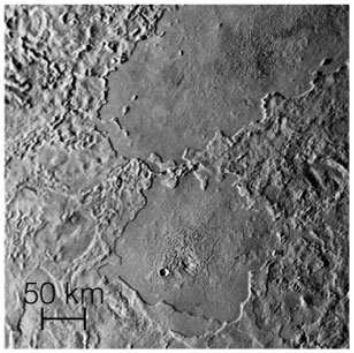
Fig 11.28

Neptune's Captured Moons

- Many retrograde orbits, high inclinations
  - Captured asteroids
- Triton is the largest captured object in the Solar System
  - Coldest world in the solar system (high albedo)
  - Once orbited the Sun as a KBO
  - Larger than Pluto
  - Retrograde orbit
  - Spiraling into Neptune
  - Will cross Roche Limit in about 100 million years
  - Evidence of past geological activity
    - Past eccentric orbit caused tidal heating



Triton's southern hemisphere as seen by *Voyager 2*.



This close-up shows lava-filled impact basins similar to the lunar maria, but the lava was water or slush rather than molten rock.

Fig 11.29

Rings

- Uranus' rings are tipped over
  - Photo from HST in IR
- Neptune rings picture was taken by Voyager

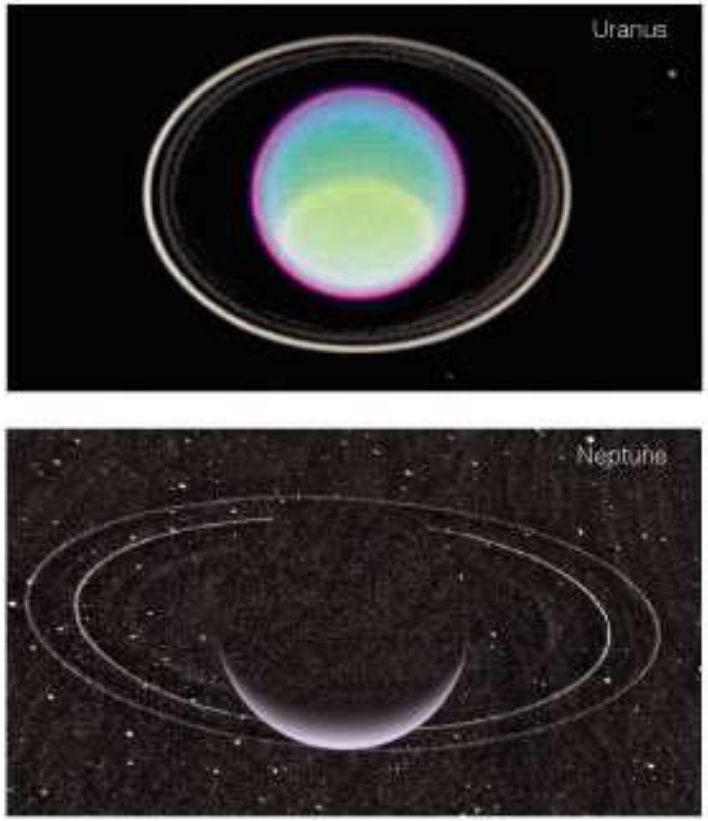


Fig 11.34

Unique Features of Uranus

- First SS planet to be discovered with a telescope
  - Farthest naked eye planet, but not recognized as a planet
- The most tilted planet
  - Moon and rings are like bulls-eye from the Sun/Earth
  - Most extreme seasons
  - 42 years of day and 42 years of night!
- The only gas giant to have no internal heat source

Unique Features of Neptune

- As warm as Uranus despite greater distance from the Sun
  - Internal heat source
- Largest captured moon
  - Retrograde orbit
- Many moons with wacky orbits
  - Captured KBOs
- Triton is coldest world in the Solar System
  - 35 K, -238 ^{o}C, -396 ^{o}F
- Smallest gas giant planet

Voyager Movies