

Today's Topics

Wednesday, October 7, 2020 (Week 7, lecture 21) – Chapters 11.

Icy Gas Giants

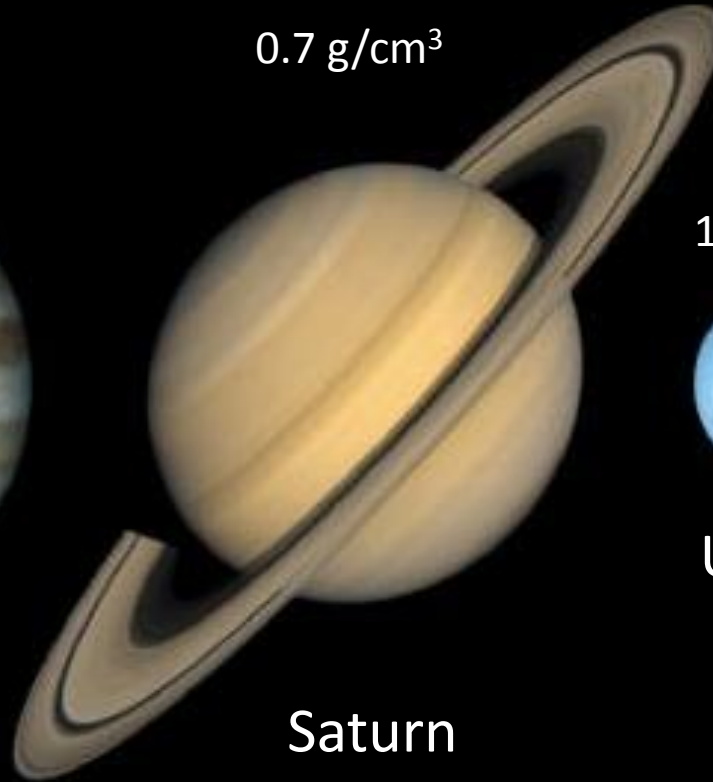
- A. Density & gases
- B. Internal structure
- C. Atmospheric structure
- D. Magnetosphere
- E. Tidal locking: how it works

Icy Gas Giant Planets



1.3 g/cm³

Jupiter
5.2 AU



0.7 g/cm³

Saturn
9.5 AU



1.3 g/cm³

Uranus
19 AU



1.6 g/cm³

Neptune
30 AU

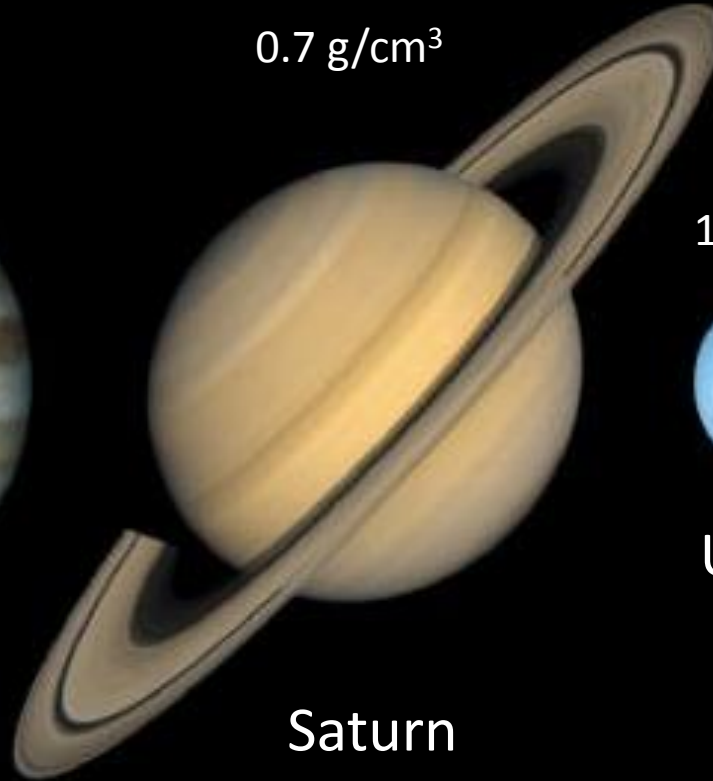
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*Pale Blue: methane gas
absorbs red light.*

[OpenStax: Astronomy]

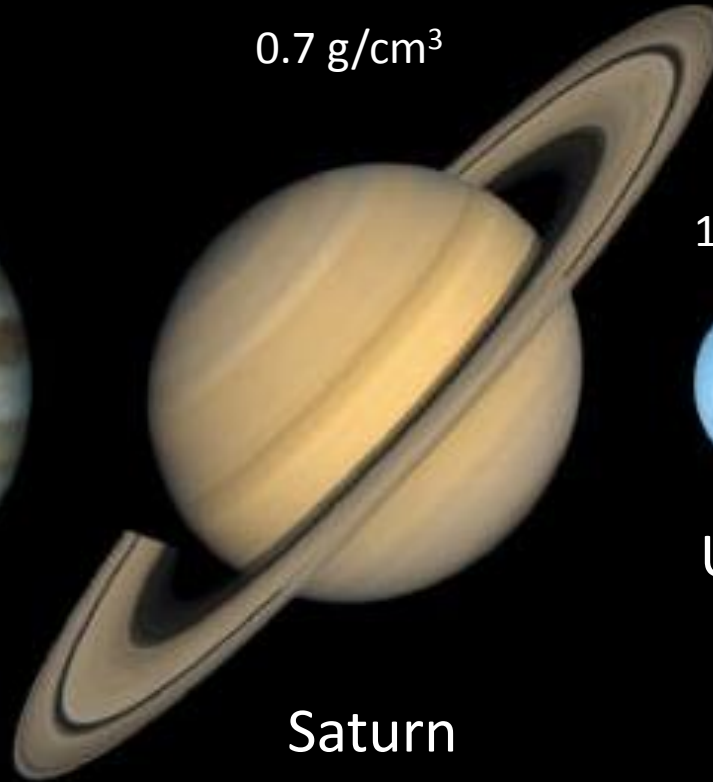
White ammonia (NH_3) clouds, red-ish ammonium hydrosulfide (NH_4)HS clouds
Hydrogen and helium are basically colorless.

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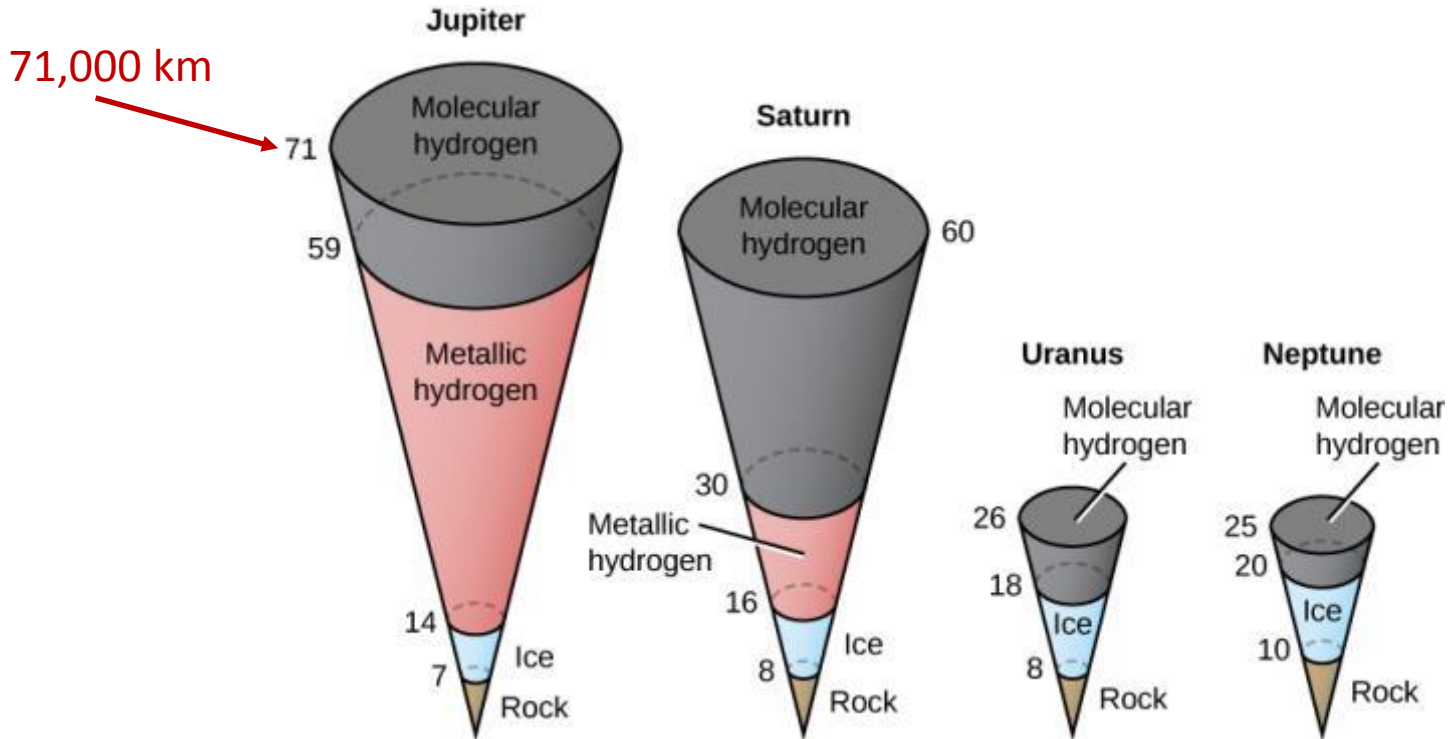
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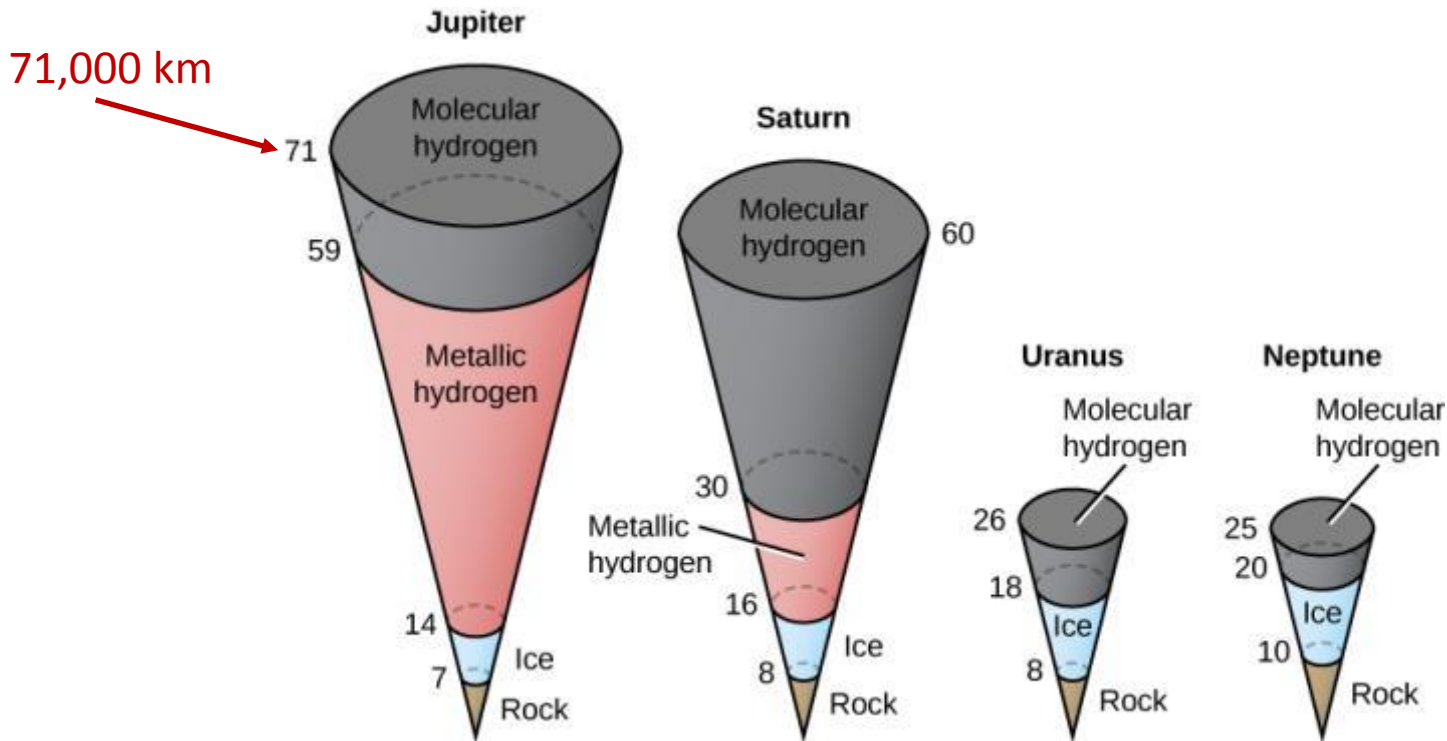
Icy refers to the molecules made of light elements that condensed beyond the “frost line.”
Gas refers to the thick layer/atmosphere of gas enveloping these planets.

Internal Structure of Jovian Planets



[OpenStax: Astronomy]

Internal Structure of Jovian Planets

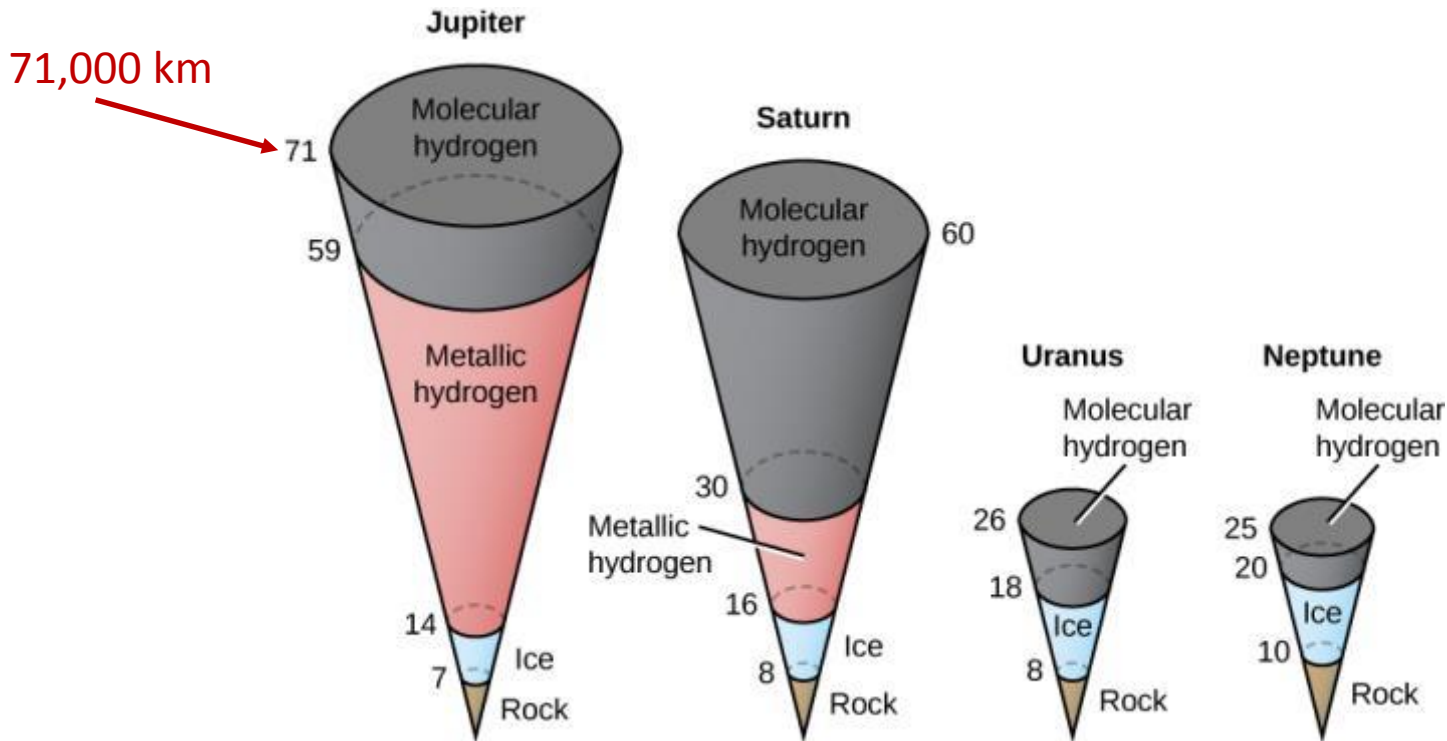


[OpenStax: Astronomy]

Outer/Visible Atmosphere

- **Jupiter** and **Saturn** are composed primarily of **hydrogen (H₂)** and **helium (He)**.
 - H₂ / He by volume: Jupiter **89%** / **10%**, Saturn **96%** / **3%**.

Internal Structure of Jovian Planets

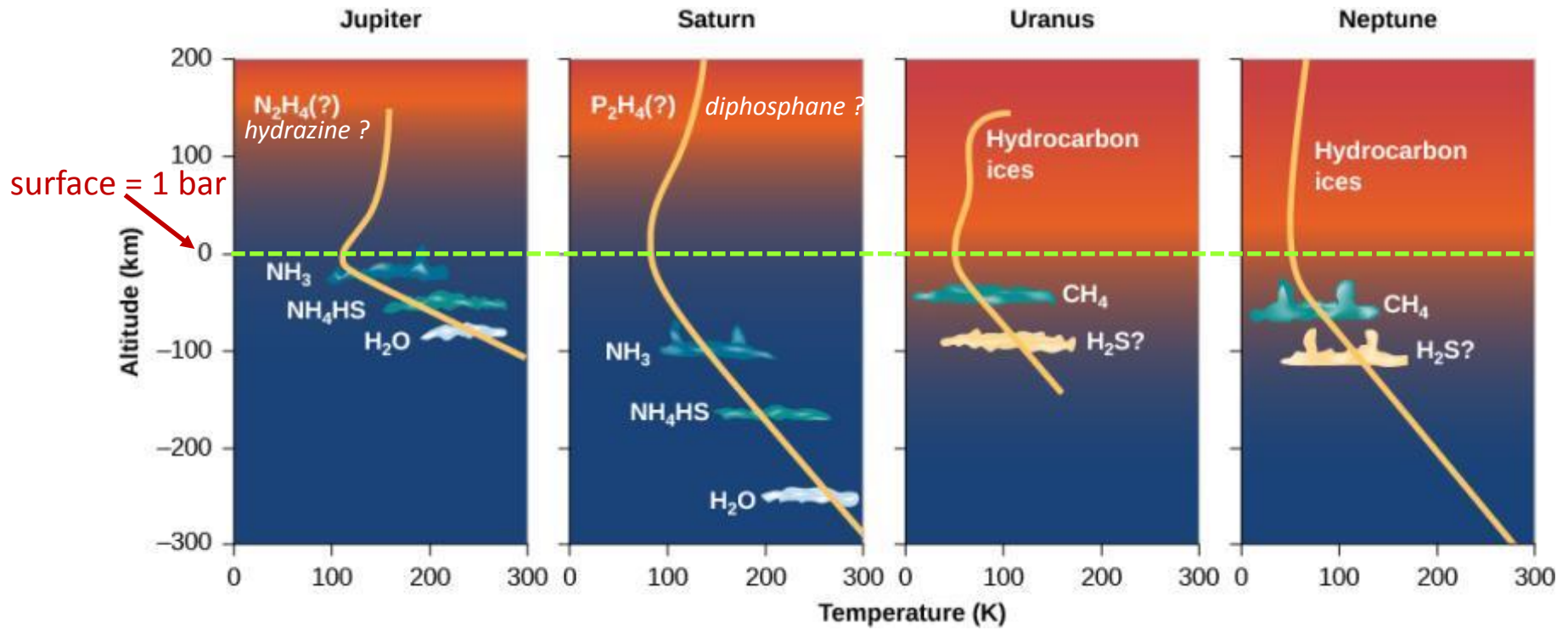


[OpenStax: Astronomy]

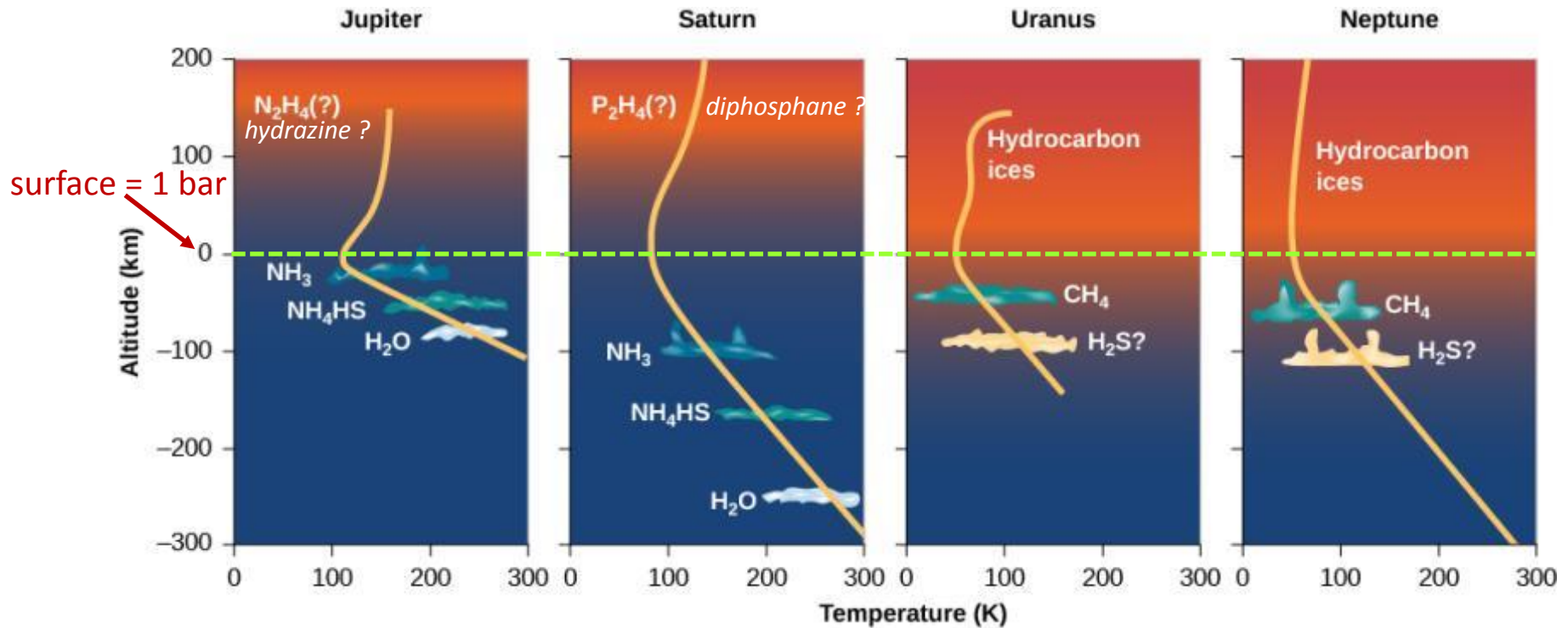
Outer/Visible Atmosphere

- **Jupiter** and **Saturn** are composed primarily of **hydrogen (H₂)** and **helium (He)**.
 - H₂ / He by volume: Jupiter **89%** / **10%**, Saturn **96%** / **3%**.
- **Uranus** and **Neptune** are largely **hydrogen** and **helium**, but also include **methane gas (CH₄)**, **water ice**, and **ammonia ice**.
 - H₂ / He / CH₄ by volume: Uranus **83%** / **15%** / **2%**, Neptune **80%** / **19%** / **1.5%**.

Atmospheric Structure



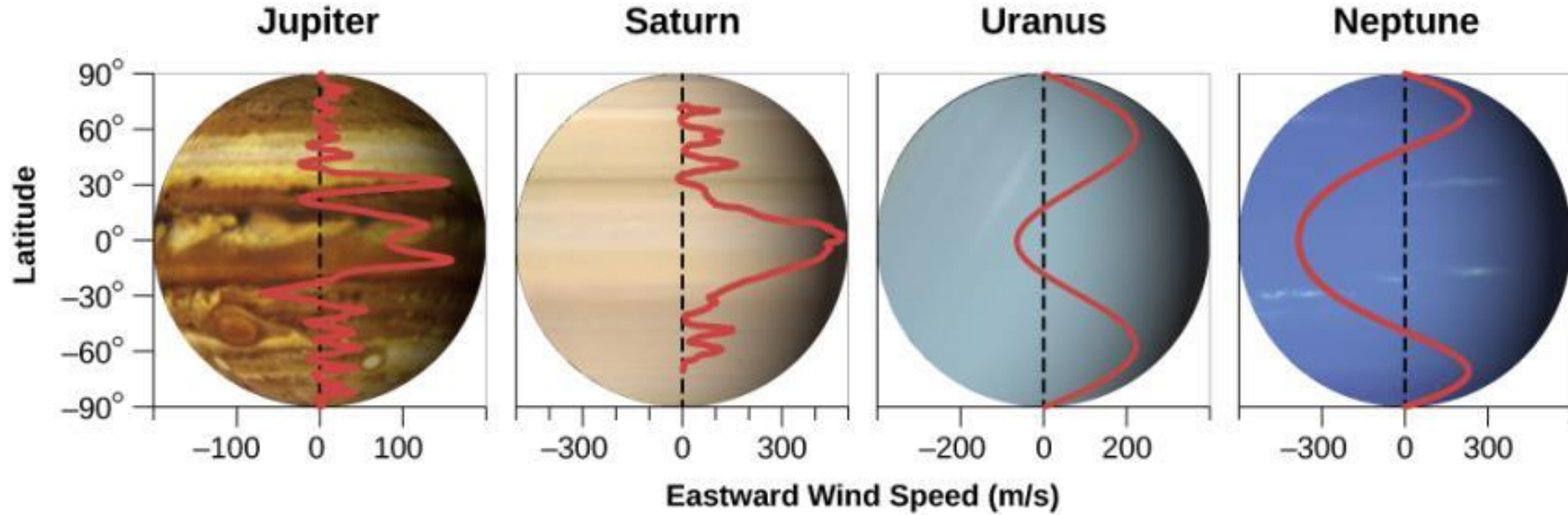
Atmospheric Structure



- The “**surface**” (1 bar) **temperature** drops from Jupiter through Neptune.
- The **temperature increases** as one penetrates **deeper** into the atmospheres.
- **Cloud composition** depends on altitude, i.e. temperature.
- **Jupiter’s temperature** increases relatively quickly with depth.

Atmospheric Wind

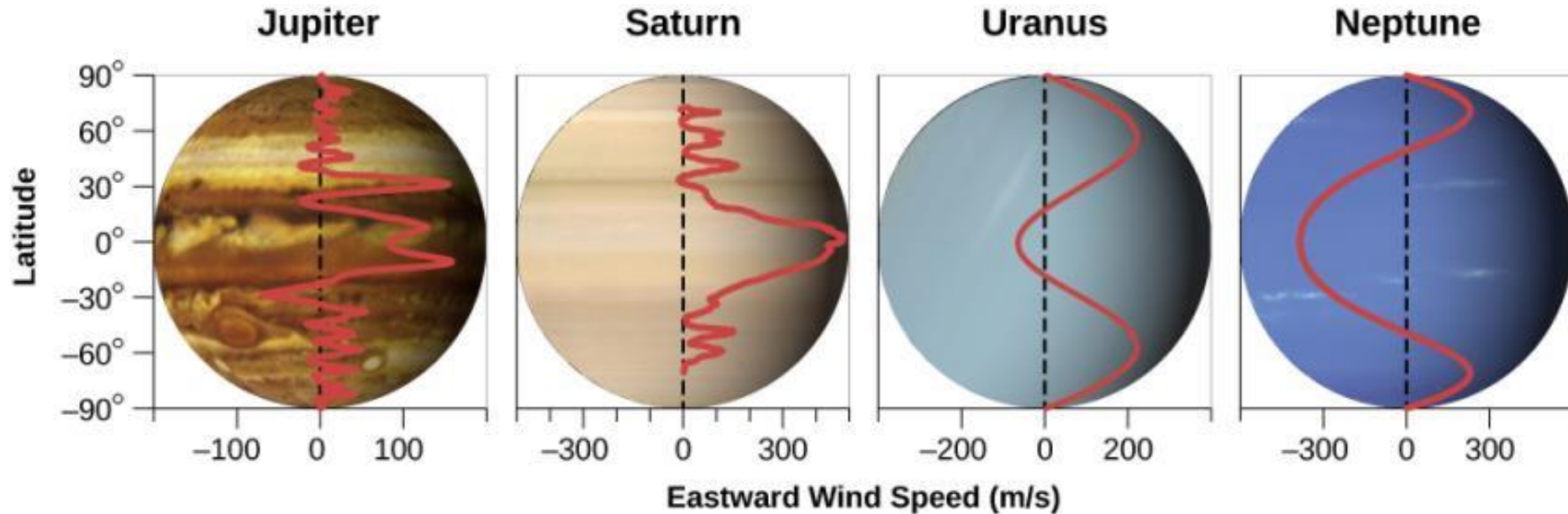
[OpenStax: Astronomy]



positive wind speed = same direction as planet rotation

Atmospheric Wind

[OpenStax: Astronomy]



positive wind speed = same direction as planet rotation

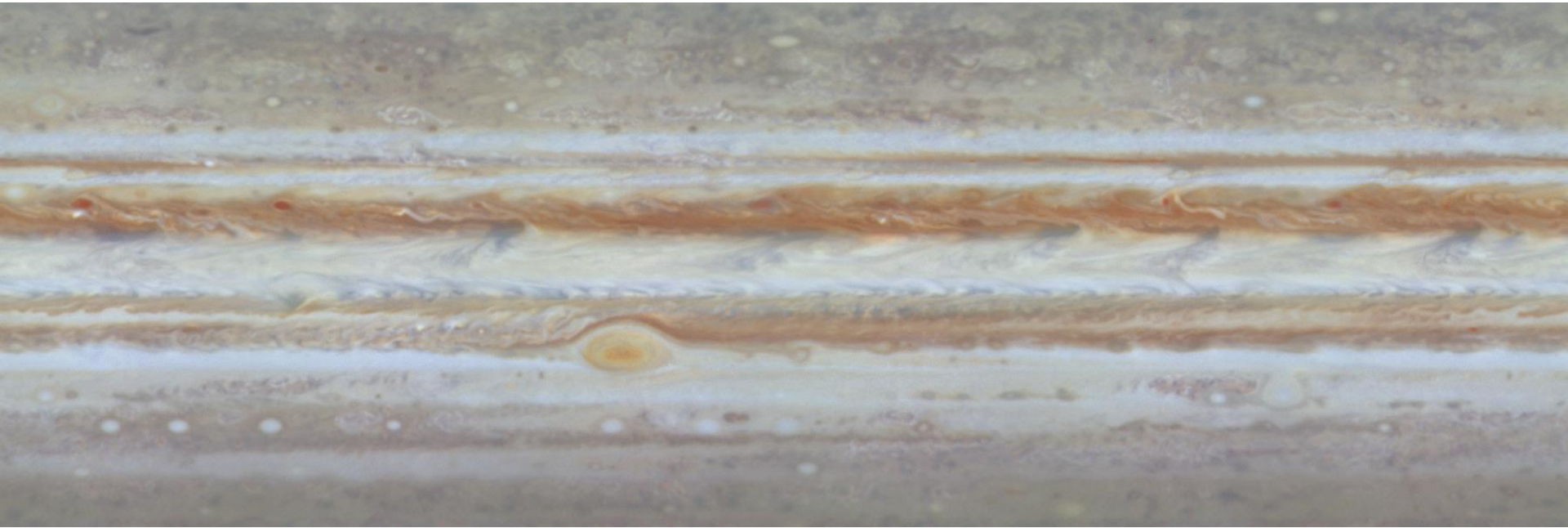
- Winds tend to be **mostly in the direction of rotation** of the planet's core.
- Wind direction and strength is **strongly dependent on latitude**.
- **Saturn's** equatorial winds reach **1800 km/h** (500 m/s).
- **Neptune** can have winds as high as **2100 km/h** (supersonic!).

Jupiter Winds



[NASA: Voyager 1, duration = 1 Earth month, 1979]

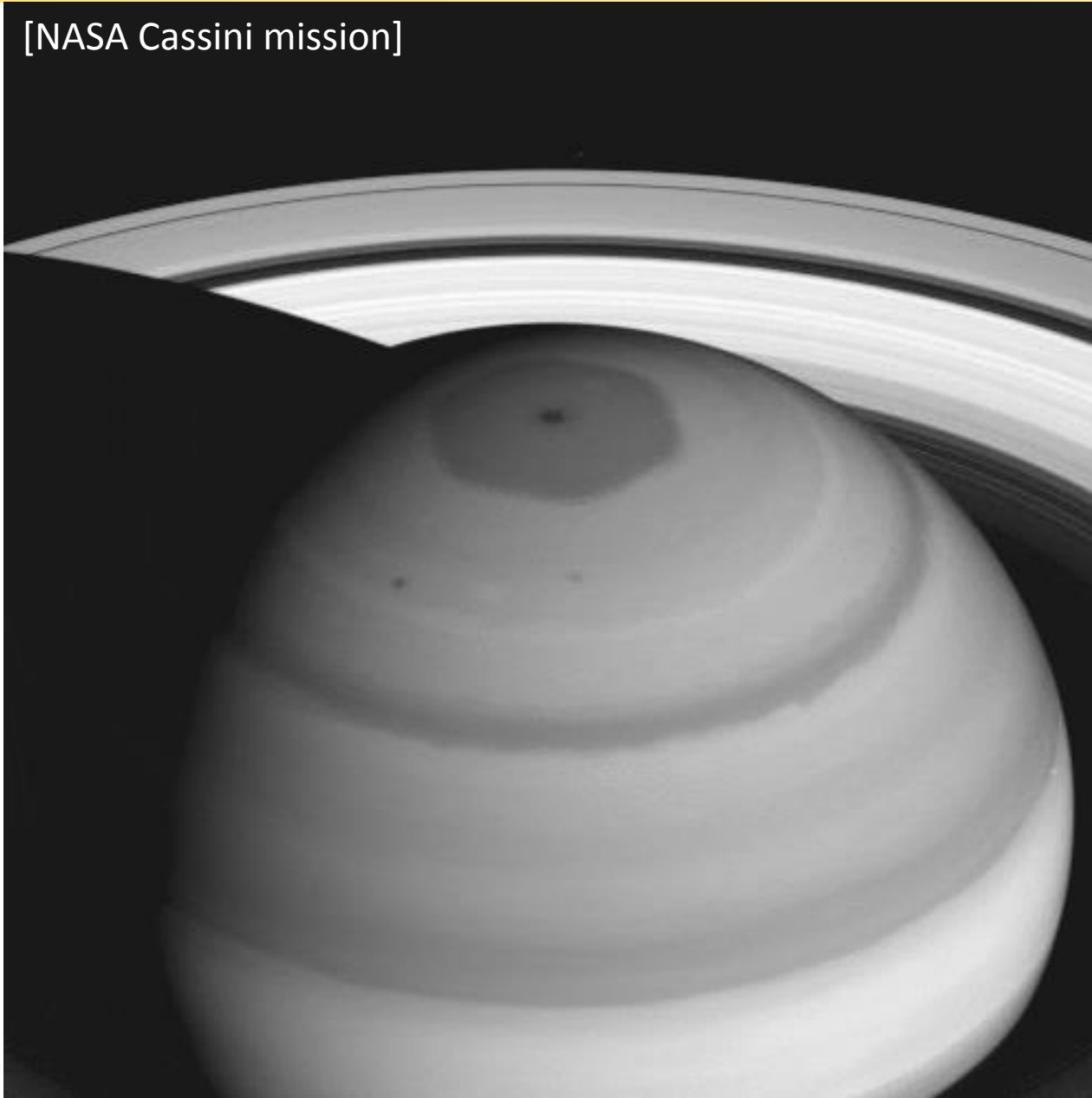
Jupiter Winds



[NASA: Cassini mission, duration=10 Earth days, 2000]

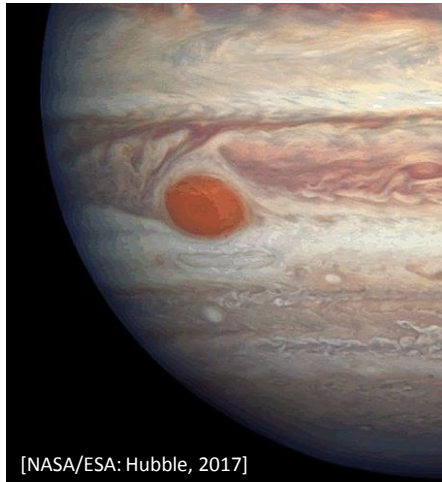
Saturn's Hexagon

[NASA Cassini mission]



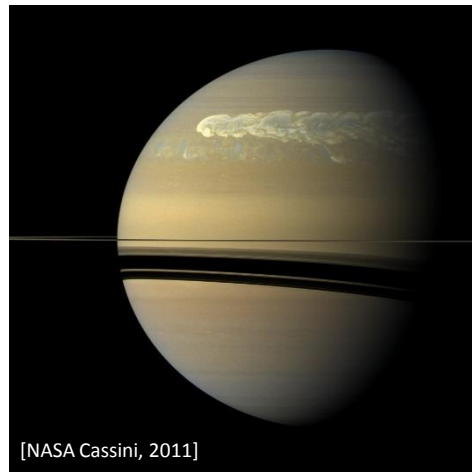
Storms

All of the gas giants have storms.



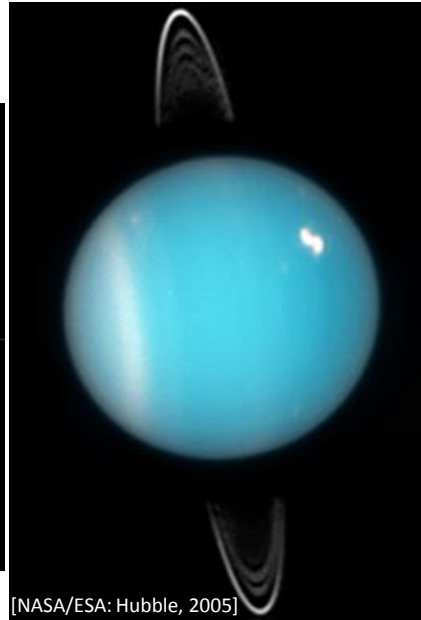
[NASA/ESA: Hubble, 2017]

- “Great red spot”
- *Composition unknown.*
 - *Existed since 1600/1800s.*
 - *Currently shrinking.*



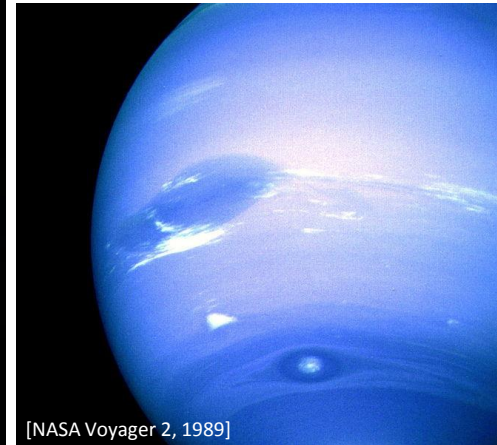
[NASA Cassini, 2011]

- “great white spot”
- *Periodic (27-30 years)*
 - *First seen in 1876.*



[NASA/ESA: Hubble, 2005]

Uranus clouds



[NASA Voyager 2, 1989]

- “Great dark spot”
- *Winds up to 2100 km/h*
 - *No longer visible*

Magnetospheres

- All of the icy gas giant have magnetospheres.
- The magnetospheres of Jupiter and Saturn are thought to be supported by their **metallic hydrogen layer/core**.
 - Jupiter and Saturn have the strongest & largest magnetospheres of all the planets.
 - Magnetic axis is somewhat tilted with respect to rotation axis (like Earth).

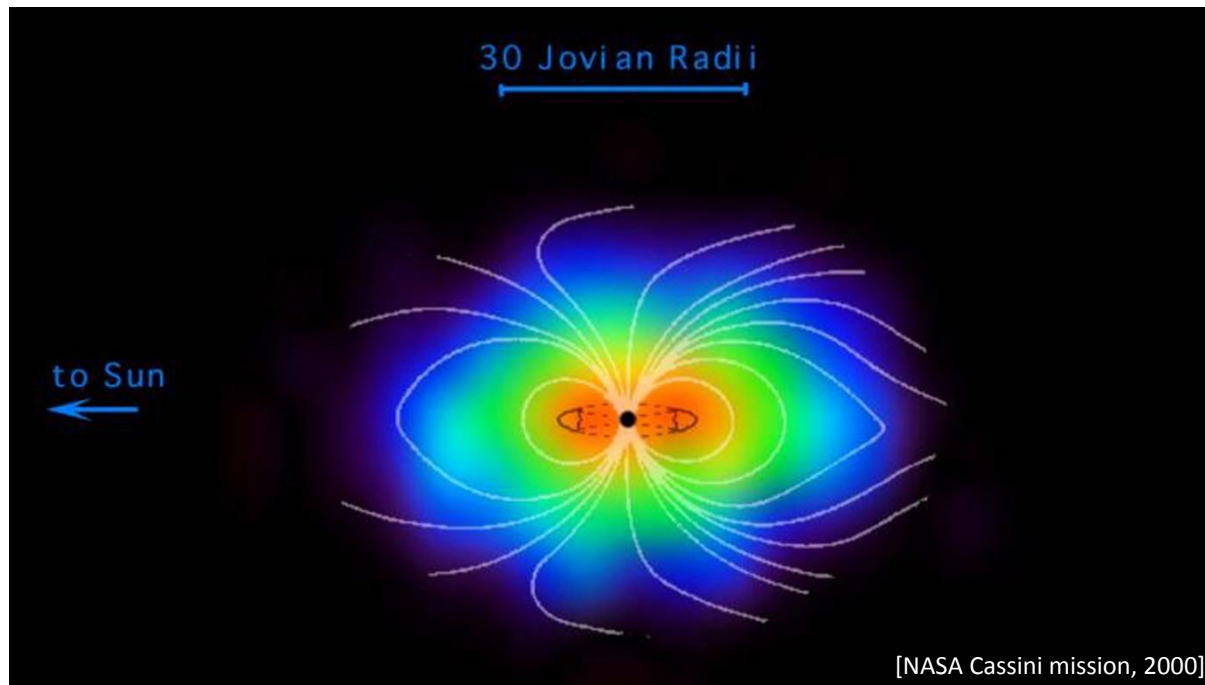


Image of ions and neutral atoms in Jupiter's magnetosphere.

*- The ions and atoms are fed by the **moon Io**.*

*- Jupiter's magnetosphere is **huge**: it has 2-3 times the angular size of the Moon.*

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 - Magnetic axis is somewhat tilted with respect to rotation axis (like Earth).
- The magnetospheres of Uranus and Neptune are thought to originate from a **thin shell of conducting fluid** (NH_3 , CH_4 , H_2O).
 - Uranus's and Neptune's magnetospheres look like they are produced **by two crossed bar magnets** (quadrupole character).
 - Magnetic axis is **strongly tilted** with respect to rotation axis and does NOT go through center of planet.
- Rotation period of magnetosphere define the **official rotation period** of planet.