Survey of the Solar System

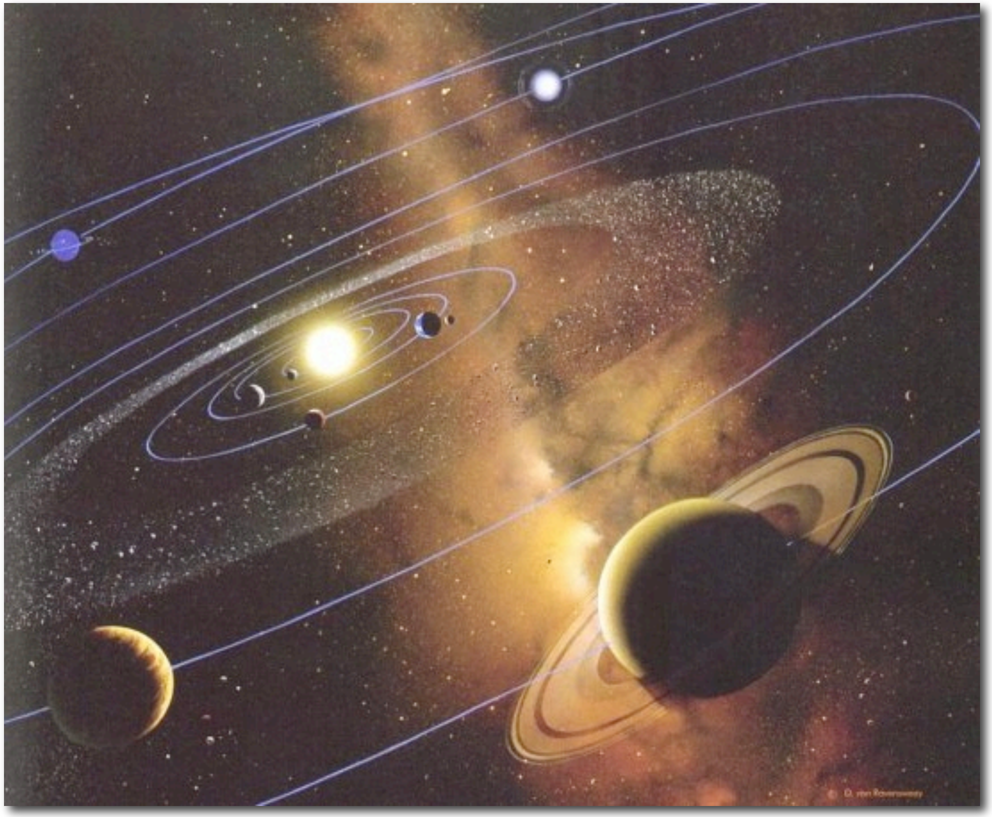
The Sun

Giant Planets

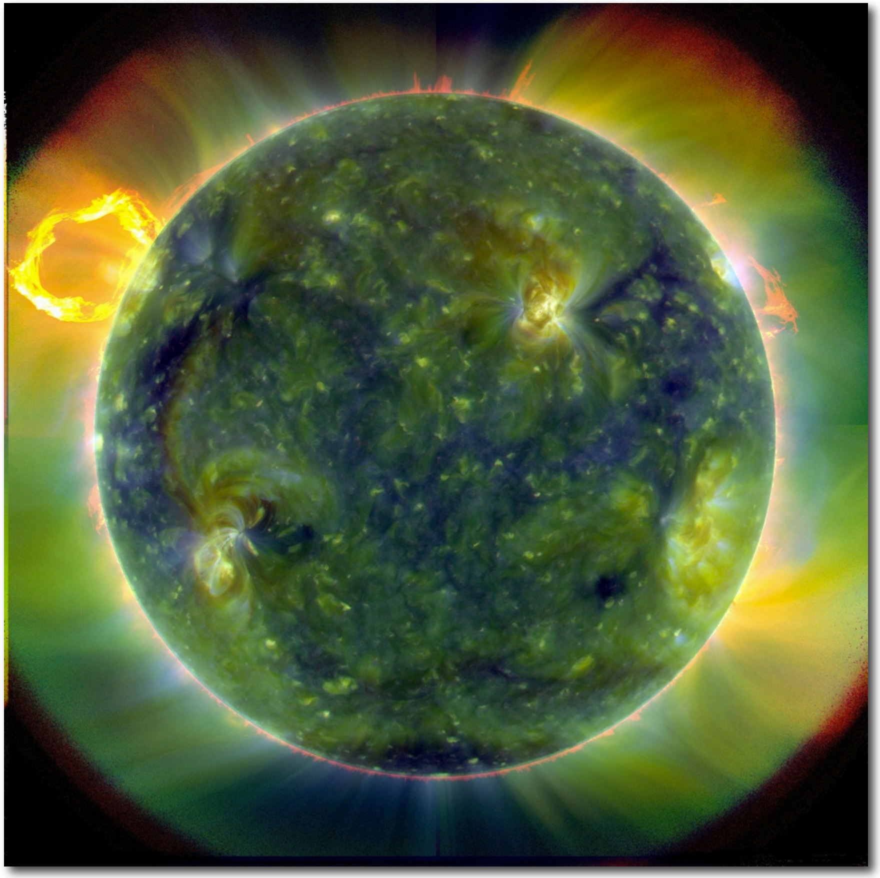
Terrestrial Planets

Minor Planets

Satellite/Ring Systems



The Sun



First light SDO -- 2010

Mass, $M_\odot$ ~ 2×10^{30} kg

Radius, $R_\odot$ ~ 7×10^{8} m

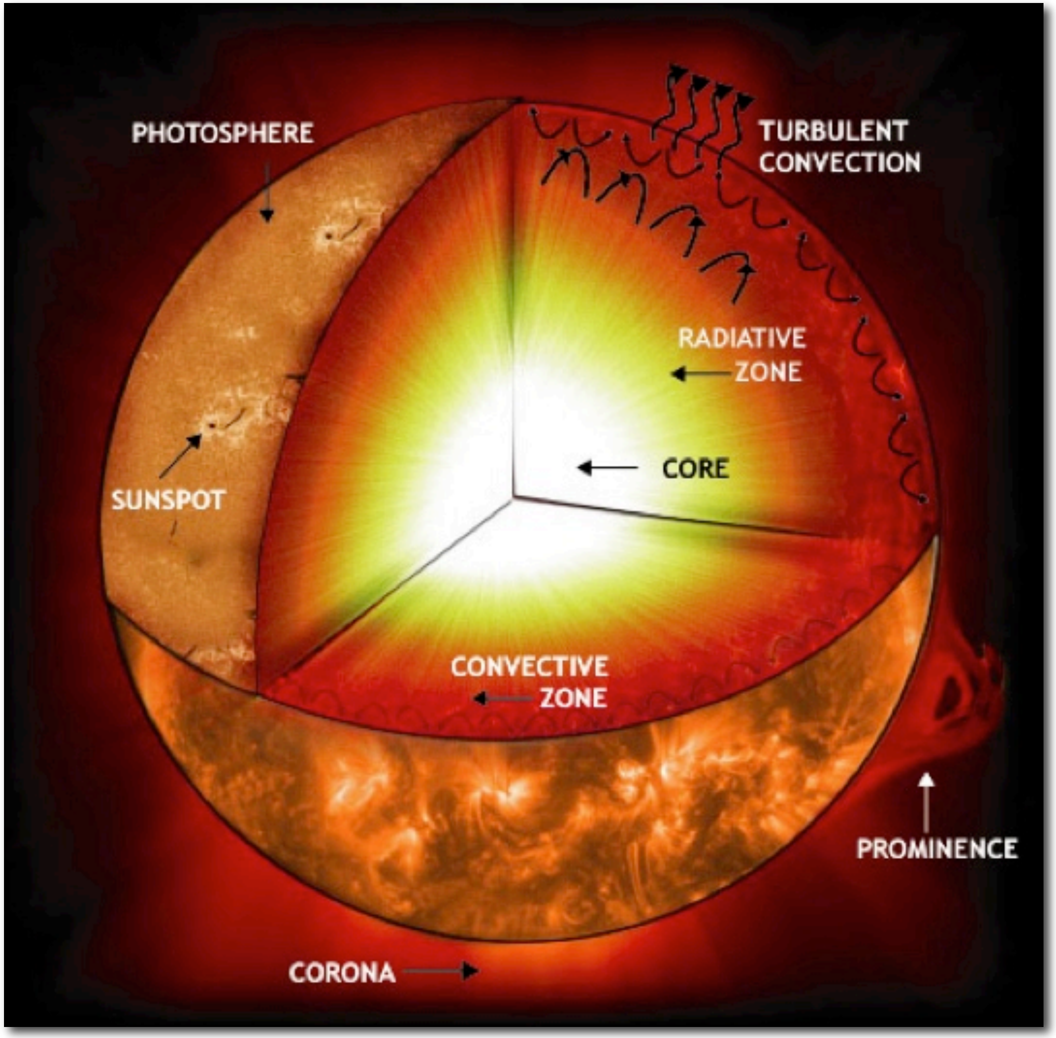
Surface Temperature

~ 5800 K

Density ~ 1.4 g/cm^3

Solar Structure

- Core:
  $r < 0.3\ R_\odot$
- Radiative Zone:
  $0.3\ R_\odot < r < 0.7\ R_\odot$
- Convective Zone:
  $r > 0.7\ R_\odot$
- Photosphere:
  'Surface' of the sun
- Corona:
  Solar Atmosphere



$R_\odot \sim 7 \times 10^8$ m $\sim 110 \times R_\oplus$

Core: Nuclear Fusion

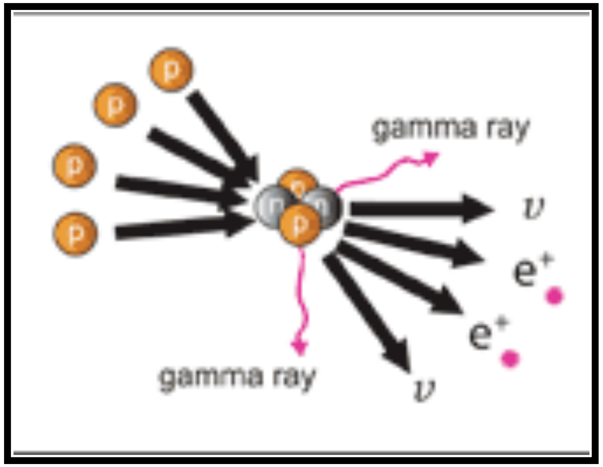
$^{1}H + {}^{1}H \rightarrow {}^{2}H + e^{+} + \nu_e$

$e^{-} + e^{+} \rightarrow 2\,\gamma$

$^{2}H + {}^{1}H \rightarrow {}^{3}He + \gamma$

$^{3}He + {}^{3}He \rightarrow {}^{4}He + {}^{1}H + {}^{1}H$

Proton-Proton Chain



Overall Reaction:

$4\,^{1}H + 2e^{-} \rightarrow {}^{4}He + 2\nu_e + 6\gamma$

$\Delta E = [4(1.007825u) – 4.002603u]*[931MeV/u]$

$\Delta E = 26.7\ MeV$

Solar Structure

The Radiative Zone is a region of highly ionized gas where the energy transport is primarily by photon diffusion where photons are absorbed and re-emitted.

At the base of the Convection Zone, lower efficiency of photon diffusion leads to thermal gradients where convection becomes the dominant mechanism for energy transport.

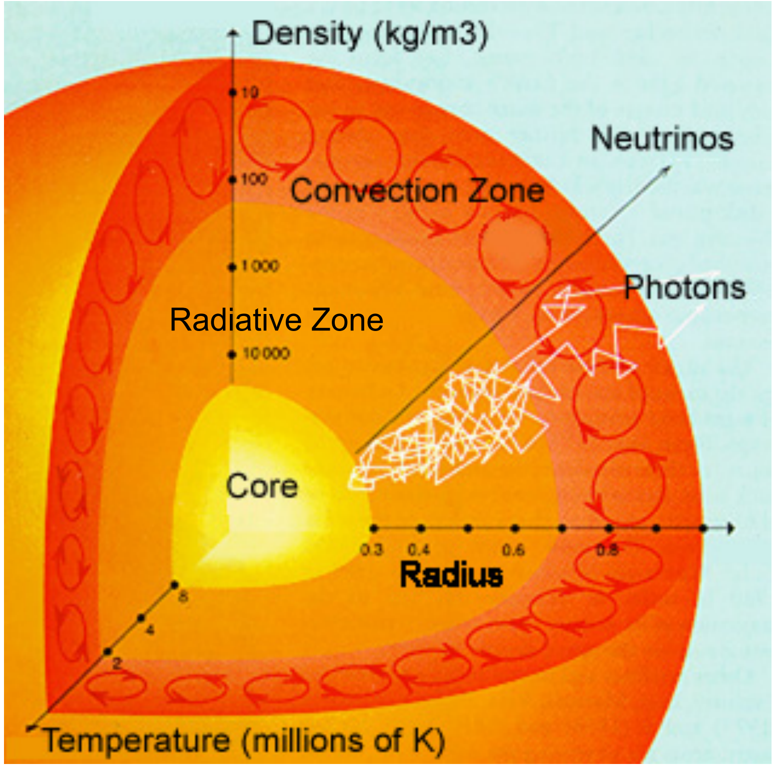
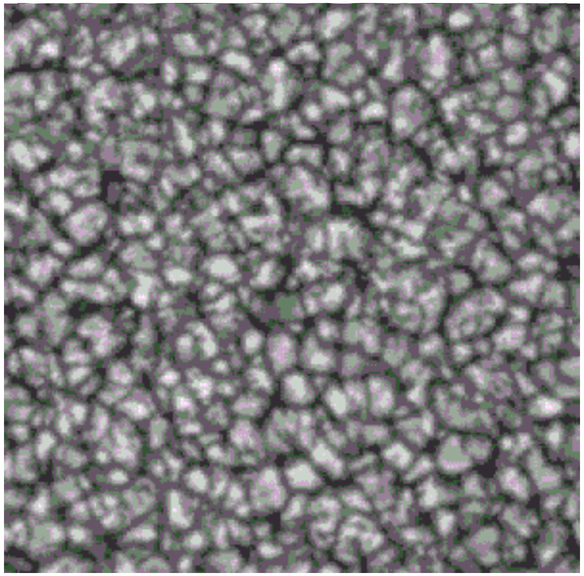


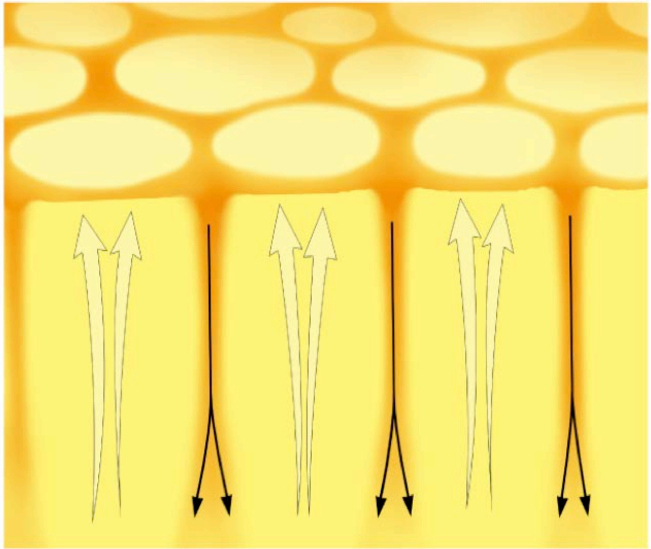
Image modified from: UCB's Center for Science Education

Solar Structure

In the Photosphere the plasma becomes transparent to the optical spectrum, allowing for the escape of most of the electromagnetic energy reaching that layer. Hence, the Photosphere is the visible ‘surface’ of the sun.



Below the photosphere the plasma is so dense that we can not see through it, but evidence of the convection zone are visible as ‘granules’.

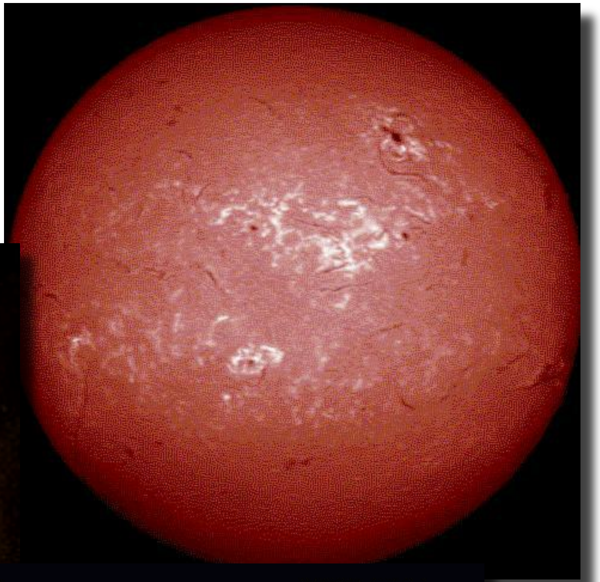


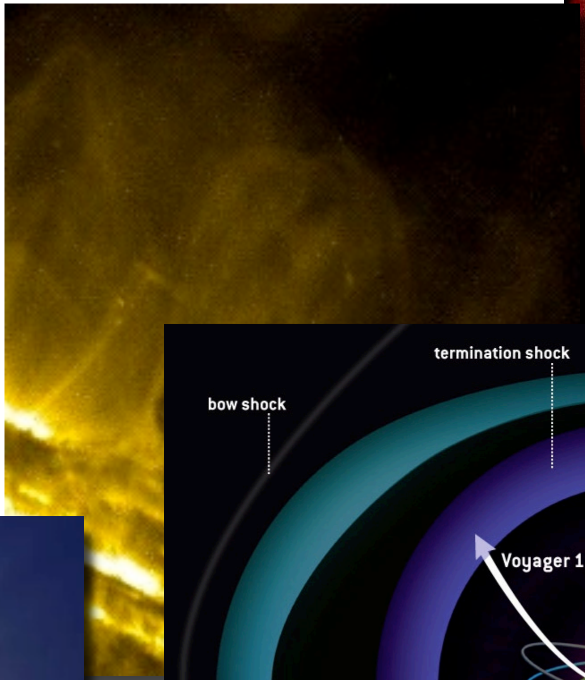
(a)

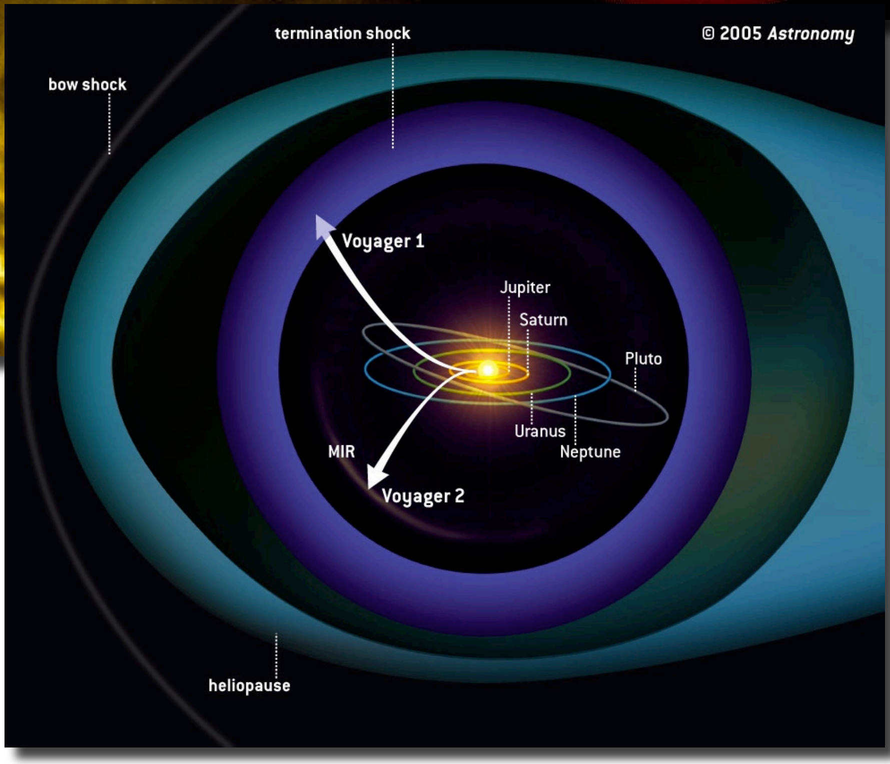
Solar Structure

The Solar Atmosphere:

- Photosphere
- Chromosphere
- Transition Zone
- Corona
- Heliosphere







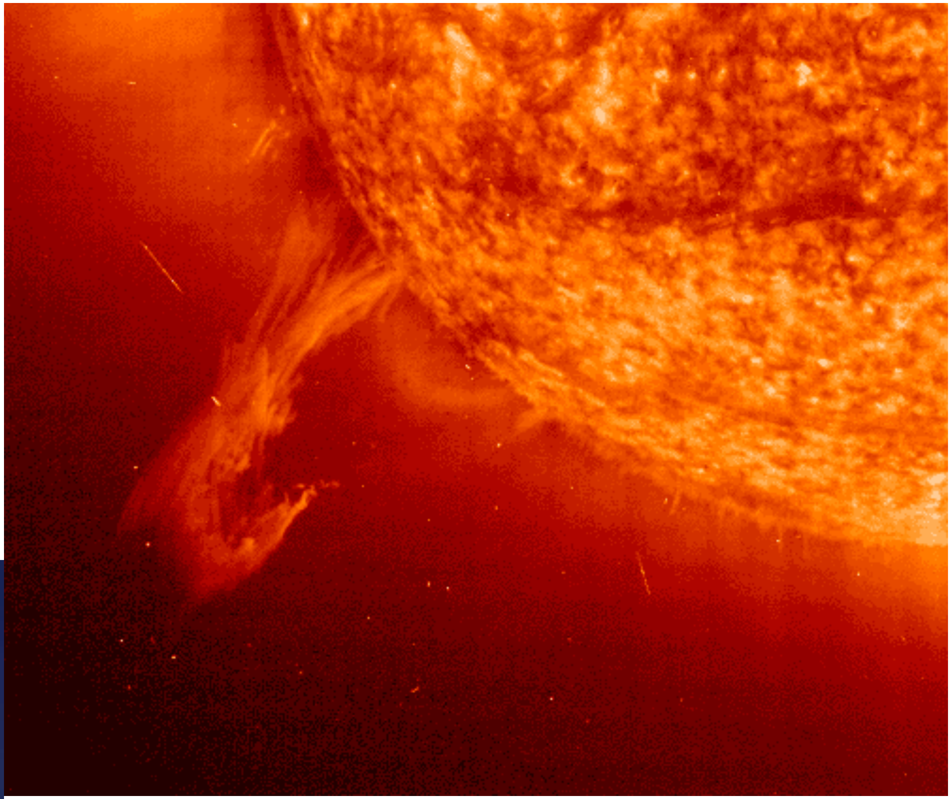
Solar Wind

(at 1 AU)

Density ~ 5-10 cm^{-3}

Speed ~ 450 km/s

Magnetic field ~ 6 nT



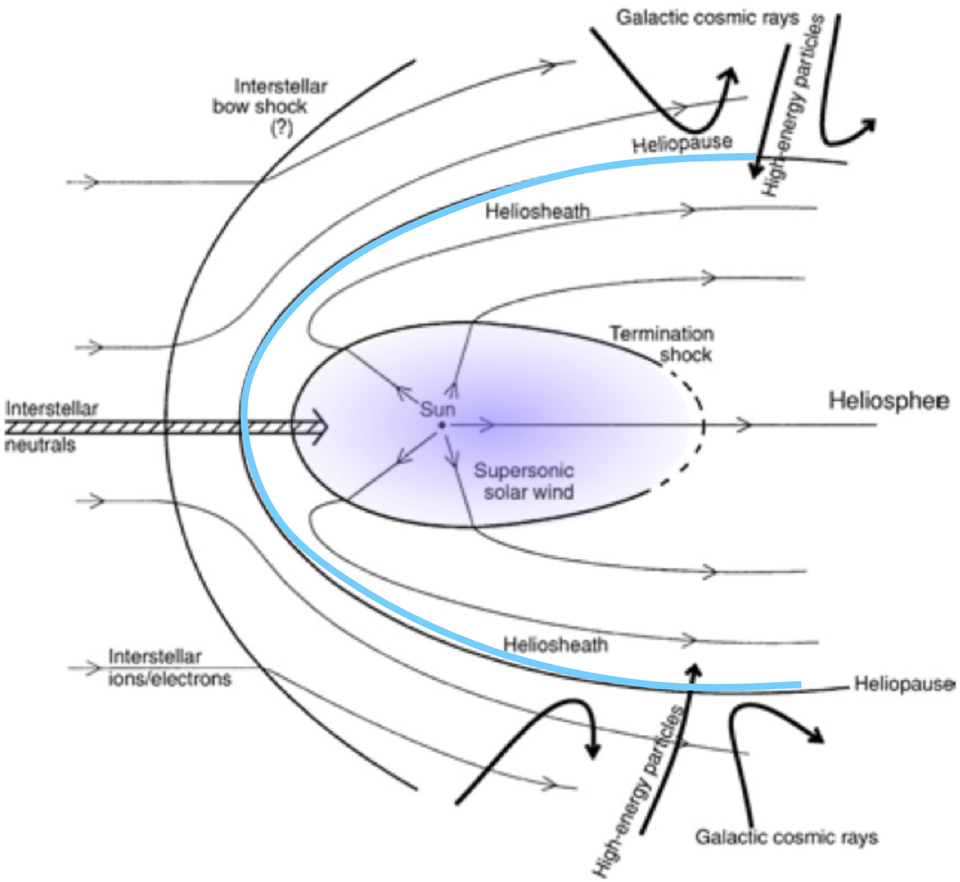
Temperature ~ 10^5 K

Sonic Mach ~ 10

Alfvén Mach ~ 4

Outermost Solar Atmosphere

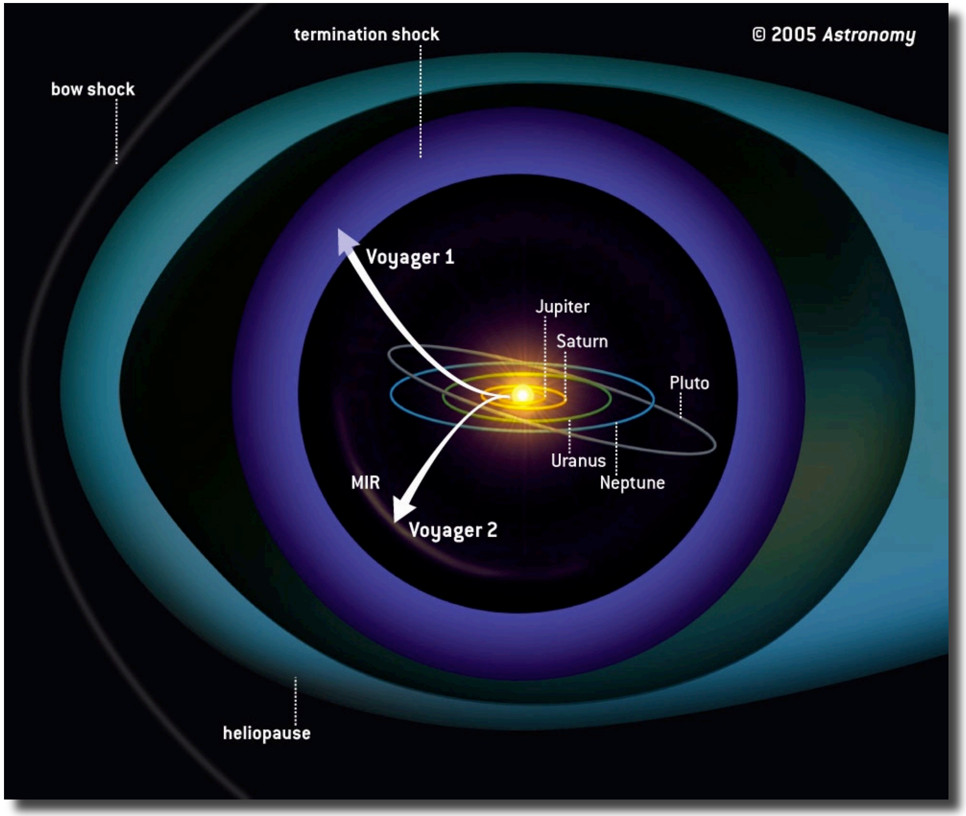
Termination Shock - Heliopause - Interstellar Bow Shock



- At the heliopause the solar wind merges with the interstellar medium, forming the boundary of the heliosphere (the radial extent of the solar atmosphere).
- Neutrals in the interstellar medium are unaffected by the solar wind and pass directly into the solar system, enabling relative speed determination.

Outermost Solar Atmosphere

Termination Shock - Heliopause - Interstellar Bow Shock



The termination shock marks the inner edge of the heliopause. This boundary is in dynamic pressure balance between the solar wind and interstellar medium is characterized by a slowing of the solar wind (variable due to the solar cycle).

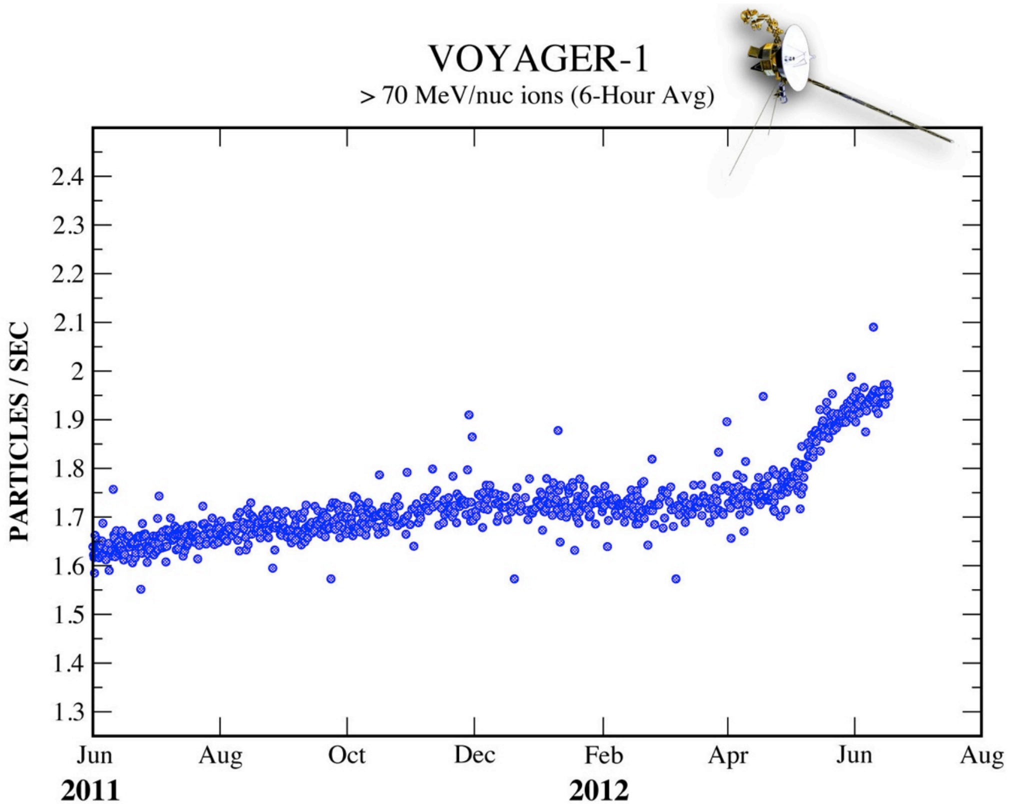
Both Voyagers 1 and 2 are believed to have crossed the termination shock.

2004- Voyager 1 @ 94 AU (solar max)

2007 Voyager 2 multiple crossings @ ~84 AU (solar min)

Outermost Solar Atmosphere: Update

Termination Shock - Heliopause - Interstellar Bow Shock



2012- Voyager 1 @ 120 AU

Just this year Voyager 1 indicated that it finally 'cleared' the Solar System and has ventured into interstellar space!

How do we know?

http://science.nasa.gov/science-news/science-at-nasa/2012/21jun_finalfrontier/

Non-Sun Material

Terrestrial Planets

Giant Planets

Asteroids

Minor Planets

Comets

Ring Systems

Satellites

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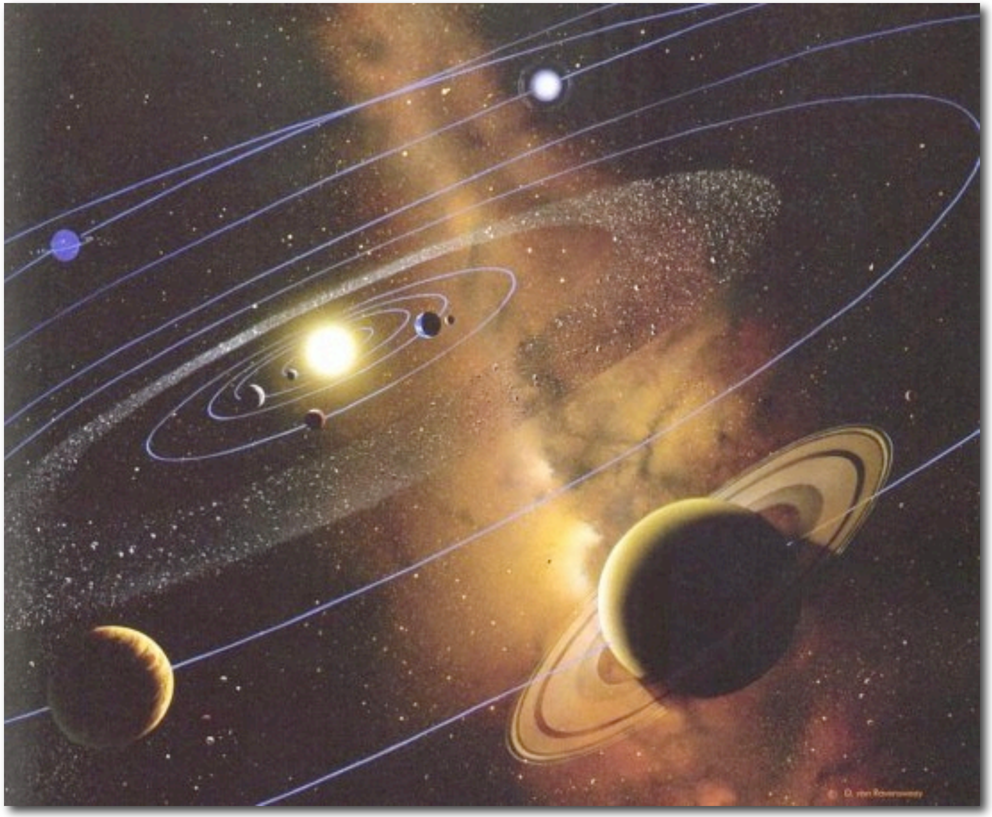
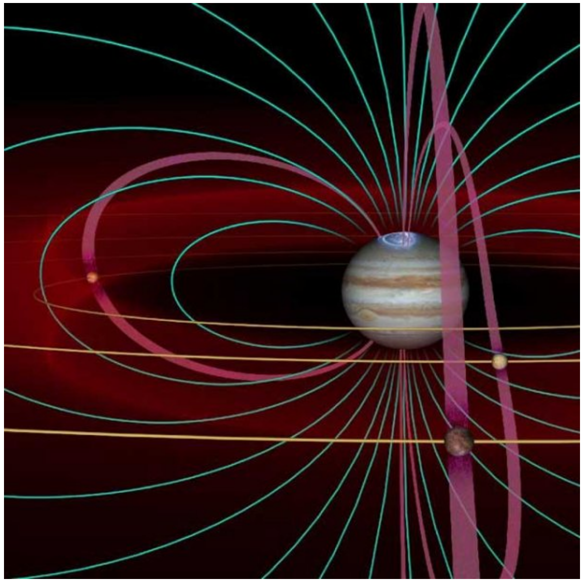


Giant Planets



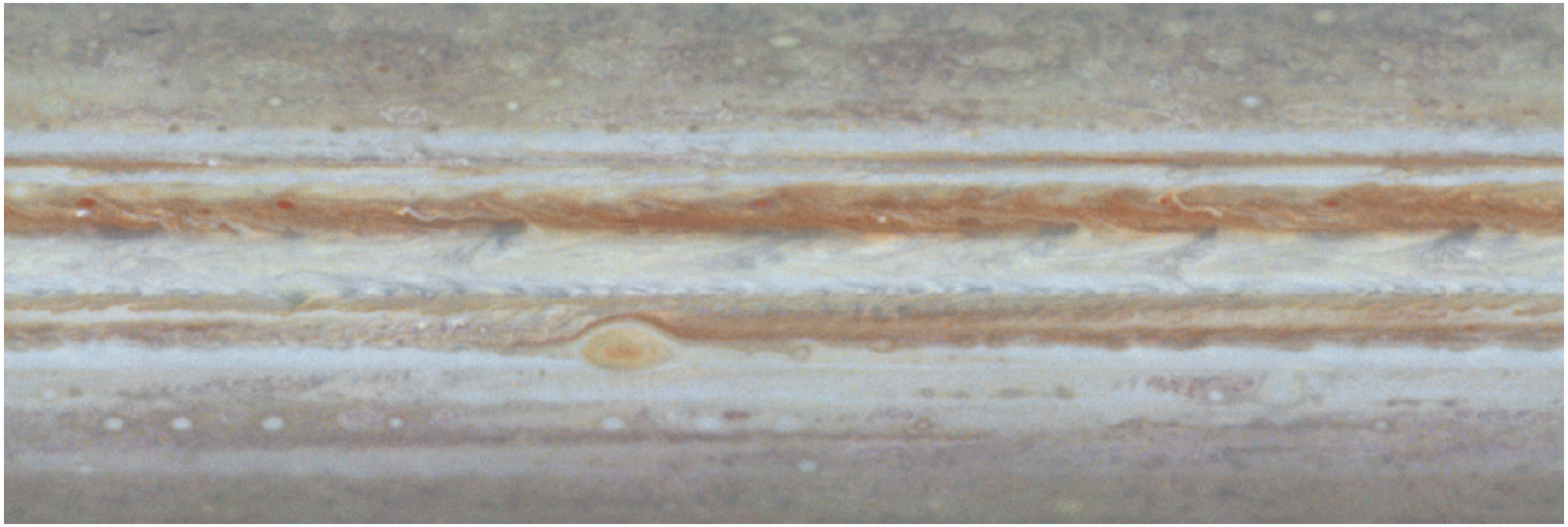
Gas Giants: Jupiter

Mass ~ 1.900 x 10^{27} kg

Radius ~ 71500 km

Orbit ~ 5.2 AU

Rotation ~ 10 hr



Giant Planets

Gas Giants: Jupiter

Composition mostly H & He, but
with a heavy element core
~ 3% of total mass

Strong Atmospheric Dynamics

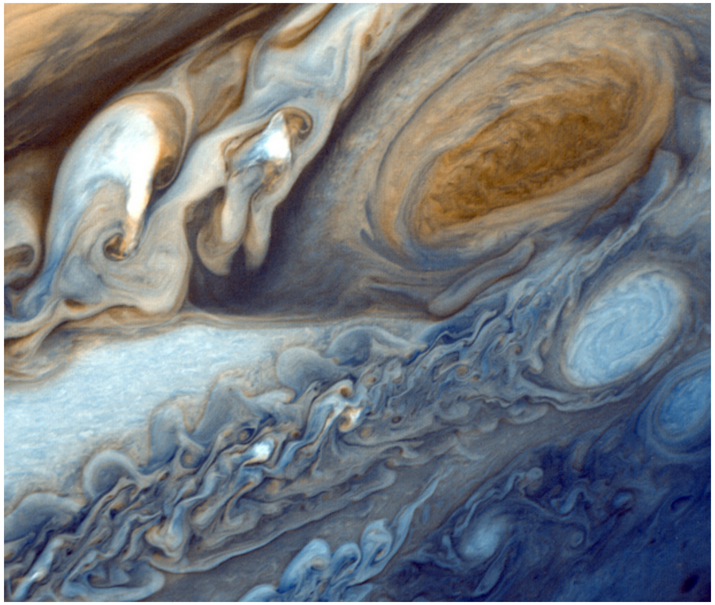
Several large satellites

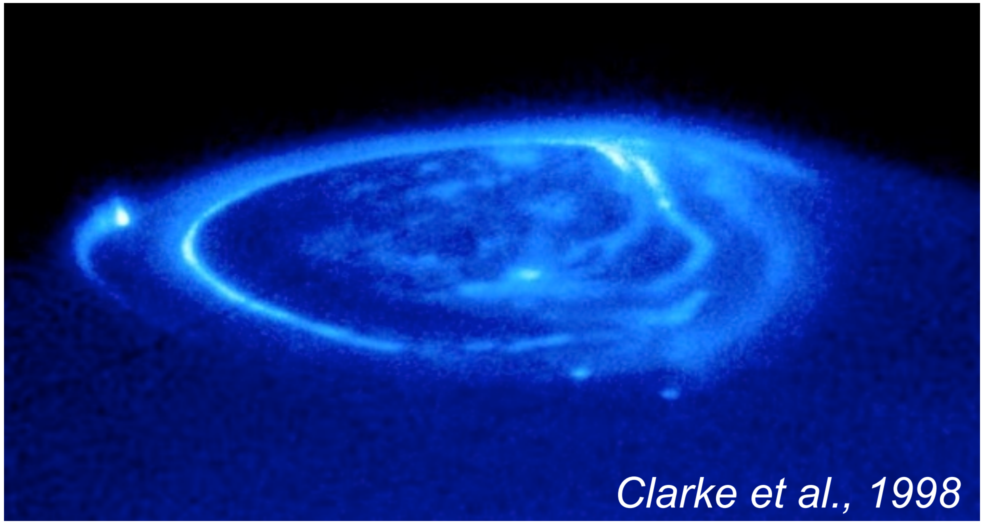
Strong magnetic field

Thin Rings

Plasma Torus

Aurora





Clarke et al., 1998

Giant Planets

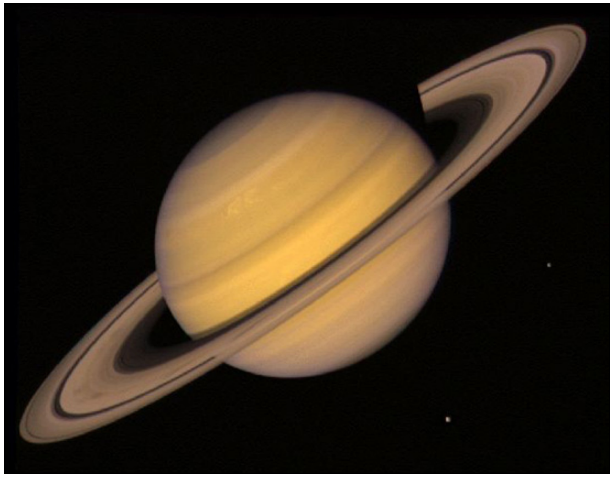
Gas Giants: Saturn

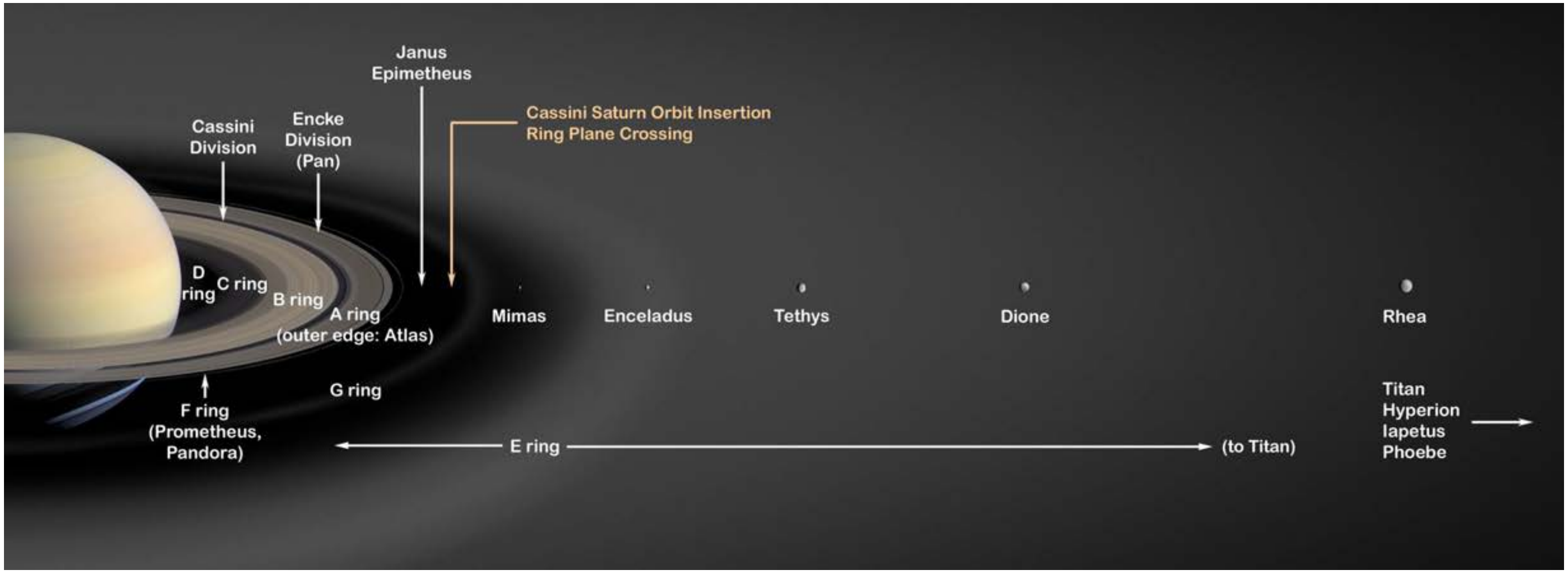
Mass ~ 5.7×10^{26} kg

Radius ~ 60300 km

Orbit ~ 9.5 AU

Rotation ~ 10.5 hr





Giant Planets

Gas Giants: Saturn

Composition mostly H & He, but with a heavy element core ~ 10% of total mass

Strong Atmospheric Dynamics

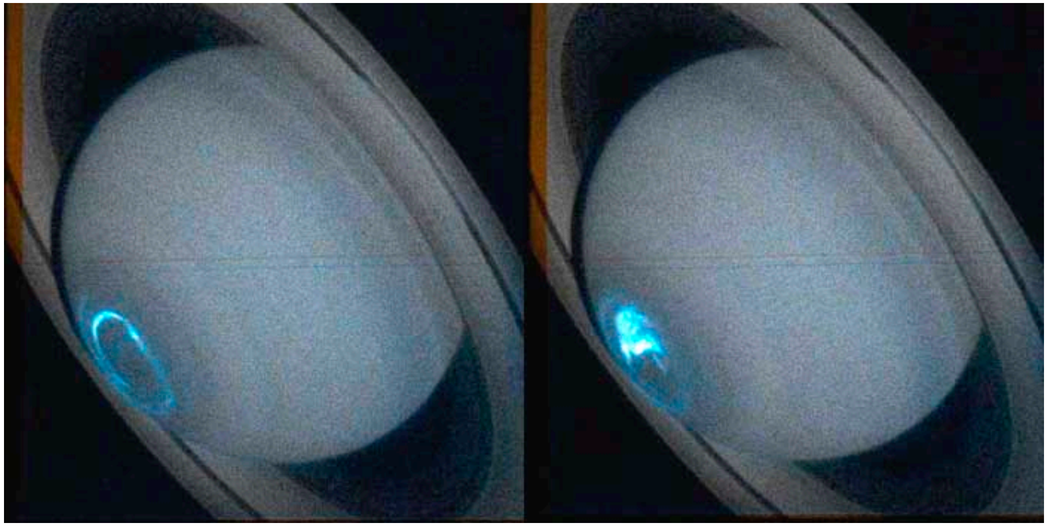
Several satellites

Strong magnetic field

Complex Rings

Neutral Cloud

Aurora



Clarke et al., 2005

Giant Planets

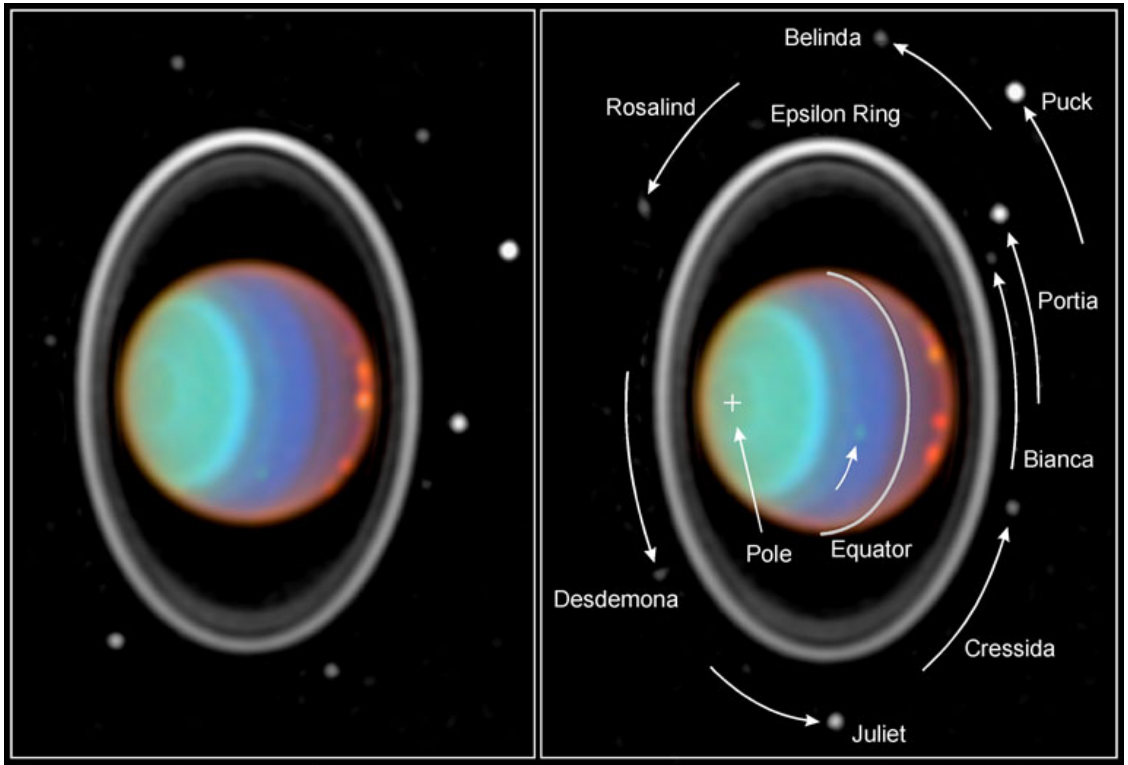
Ice Giants: Uranus

Mass ~ 8.7×10^{25} kg

Radius ~ 25600 km

Orbit ~ 19.2 AU

Rotation ~ -17.4 hr



Uranus • July 28, 1997 HST • NICMOS

PRC97-36a • November 20, 1997 • ST ScI OPO

E. Karkoschka (University of Arizona Lunar & Planetary Lab) and NASA

Giant Planets

Ice Giants: Uranus

Composition mostly H_2O, NH_3, & CH_4, but with a small rocky core

Strong Atmospheric Dynamics

Several satellites

Strong off-axis magnetic field

Several Thin Rings

Aurora ??   -- Yes!

Giant Planets

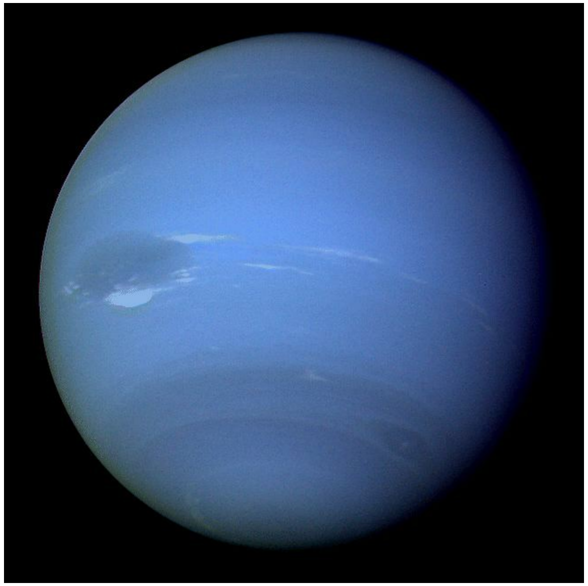
Ice Giants: Neptune

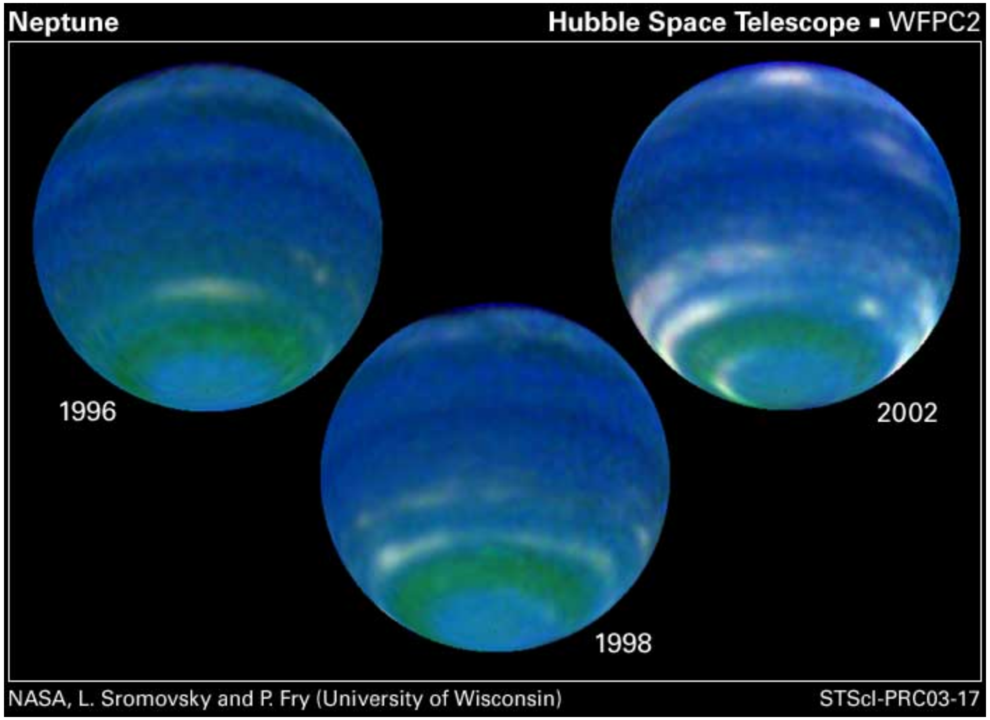
Mass ~ 1.02×10^{26} kg

Radius ~ 24800 km

Orbit ~ 30 AU

Rotation ~ 16.1 hr





Giant Planets

Ice Giants: Neptune

Composition mostly H_2O, NH_3, & CH_4, but with a small rocky core

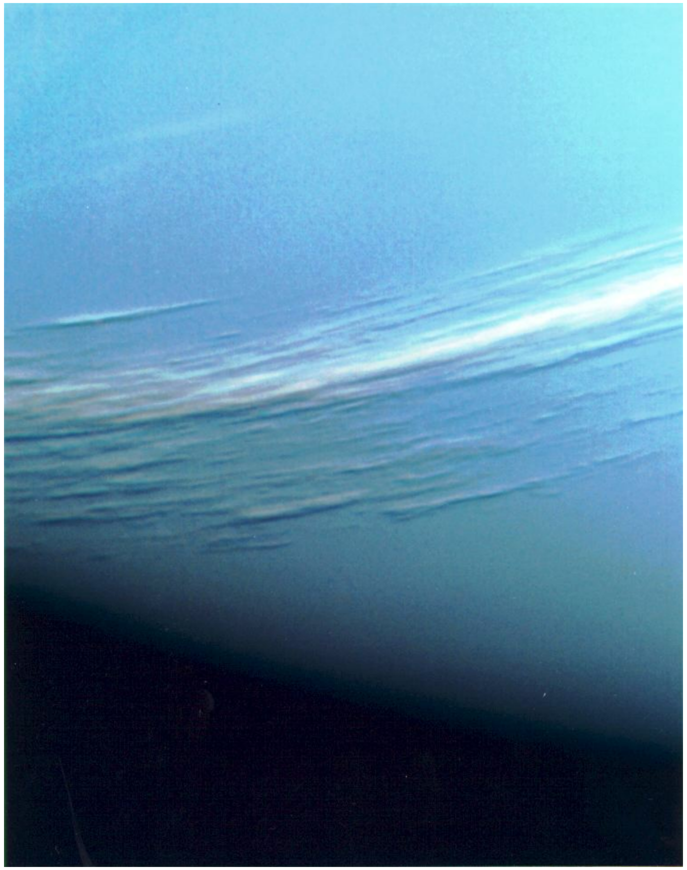
Strong & Seasonal Atmospheric Dynamics

Several satellites

Off centered/ off axis Magnetic field

Interesting Rings

Aurora ??



Voyager 2 encounter

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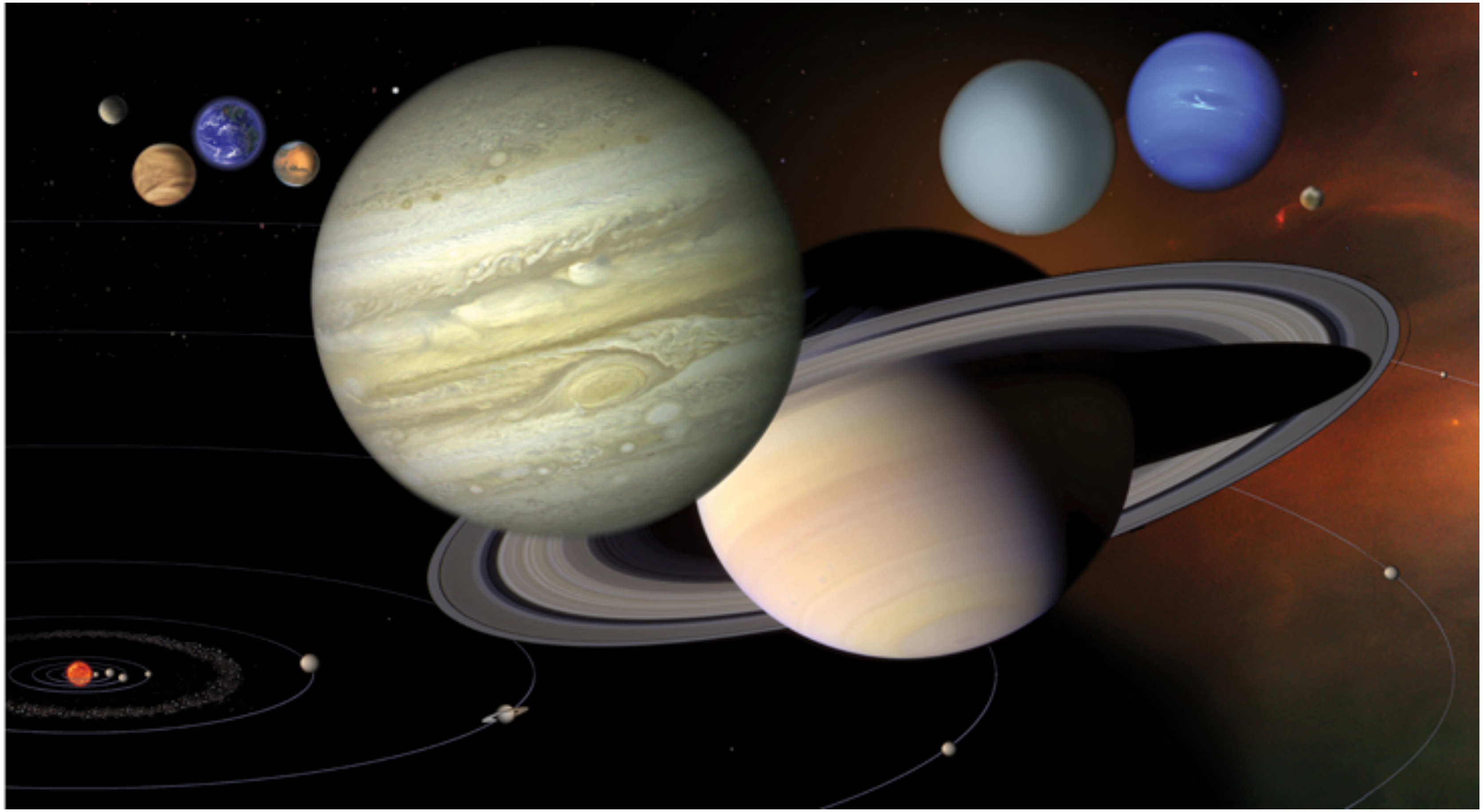
Weekend Assignment



The planets are shown with the correct relative sizes, and the correct relative orbital distances, though the sizes of the bodies are greatly exaggerated relative to the orbital distances.

Weekend Assignment: Launch

Tomorrow at 4:07am!

http://rbsp.jhuapl.edu/