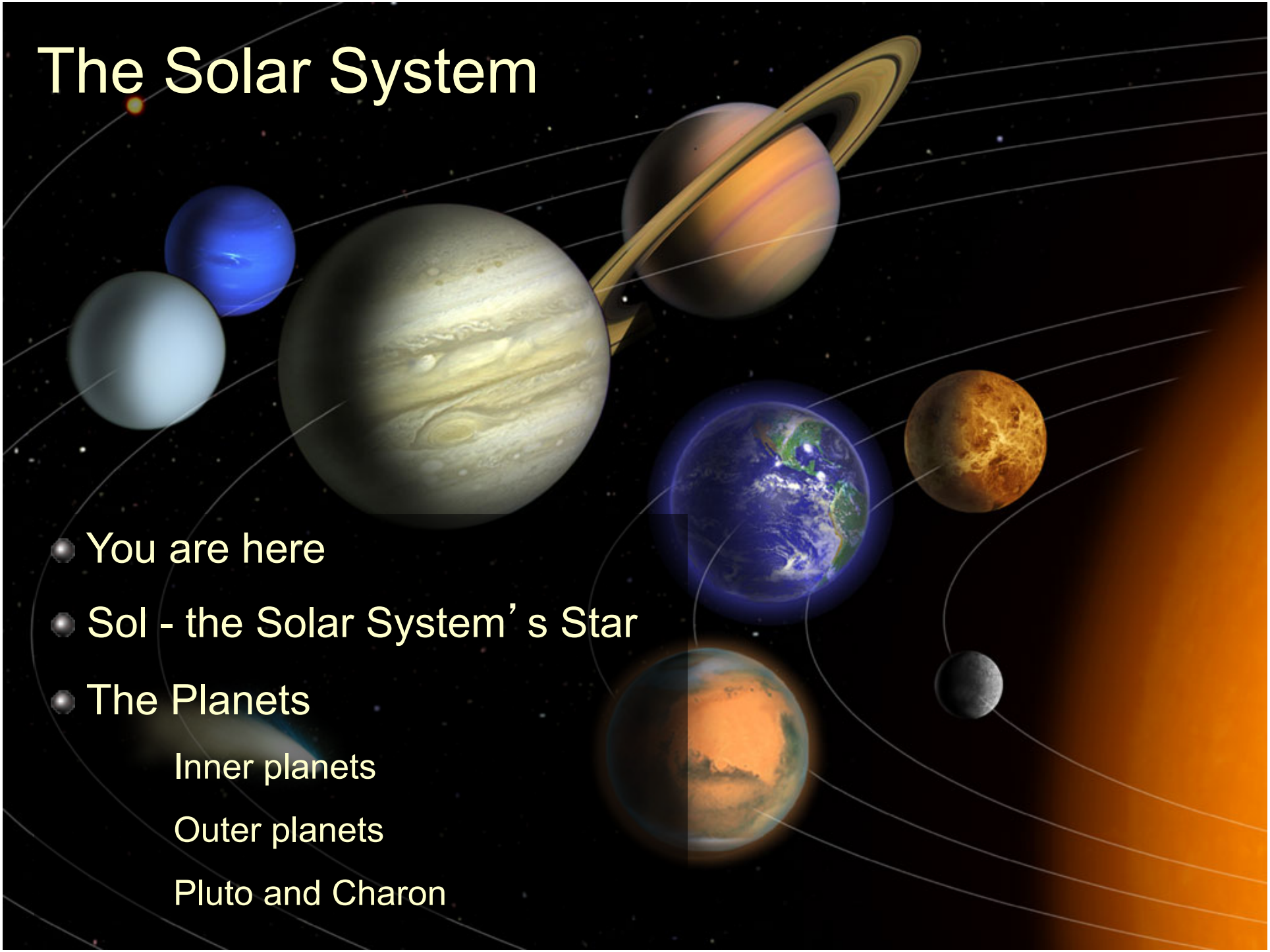
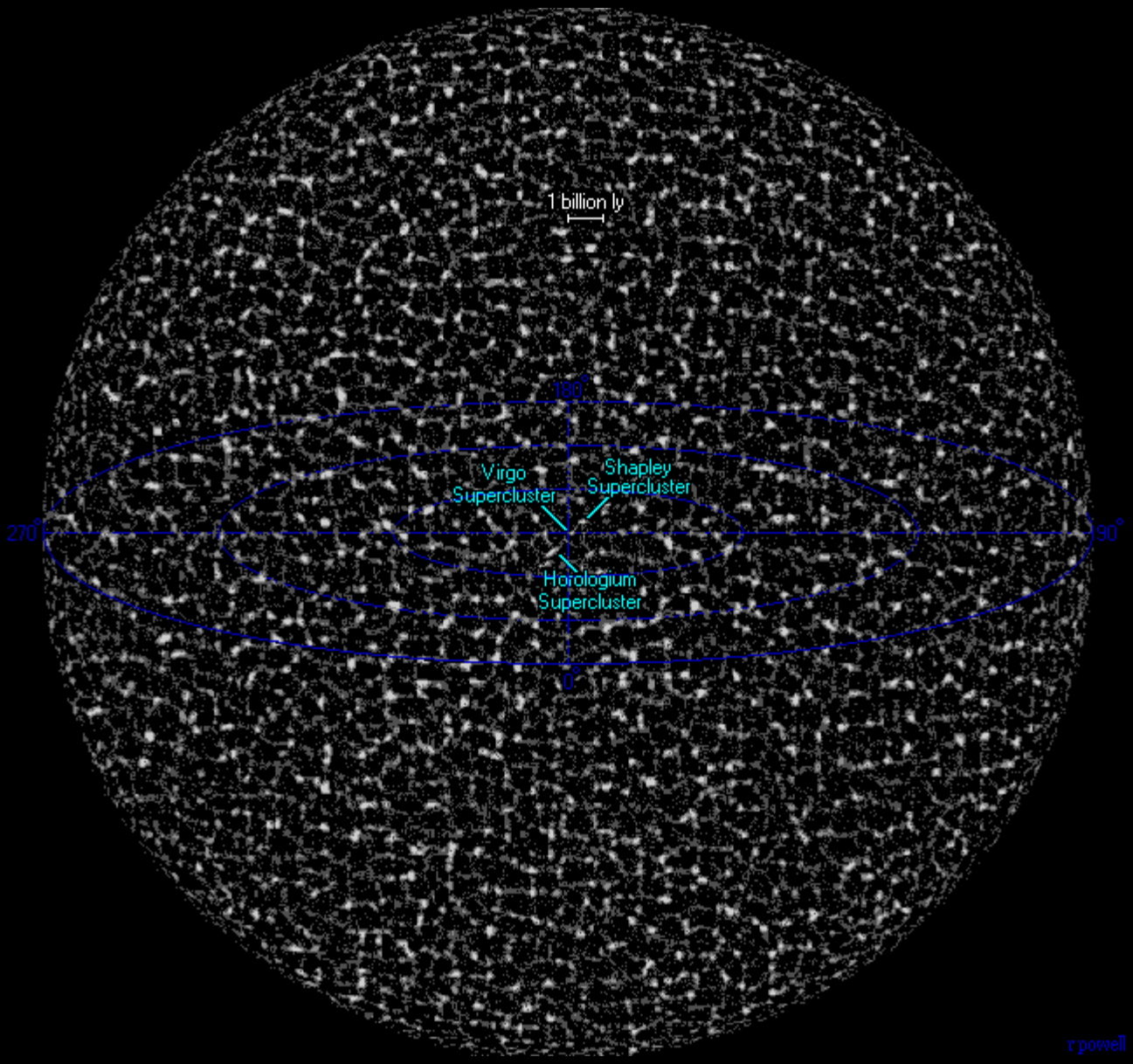
# The Solar System



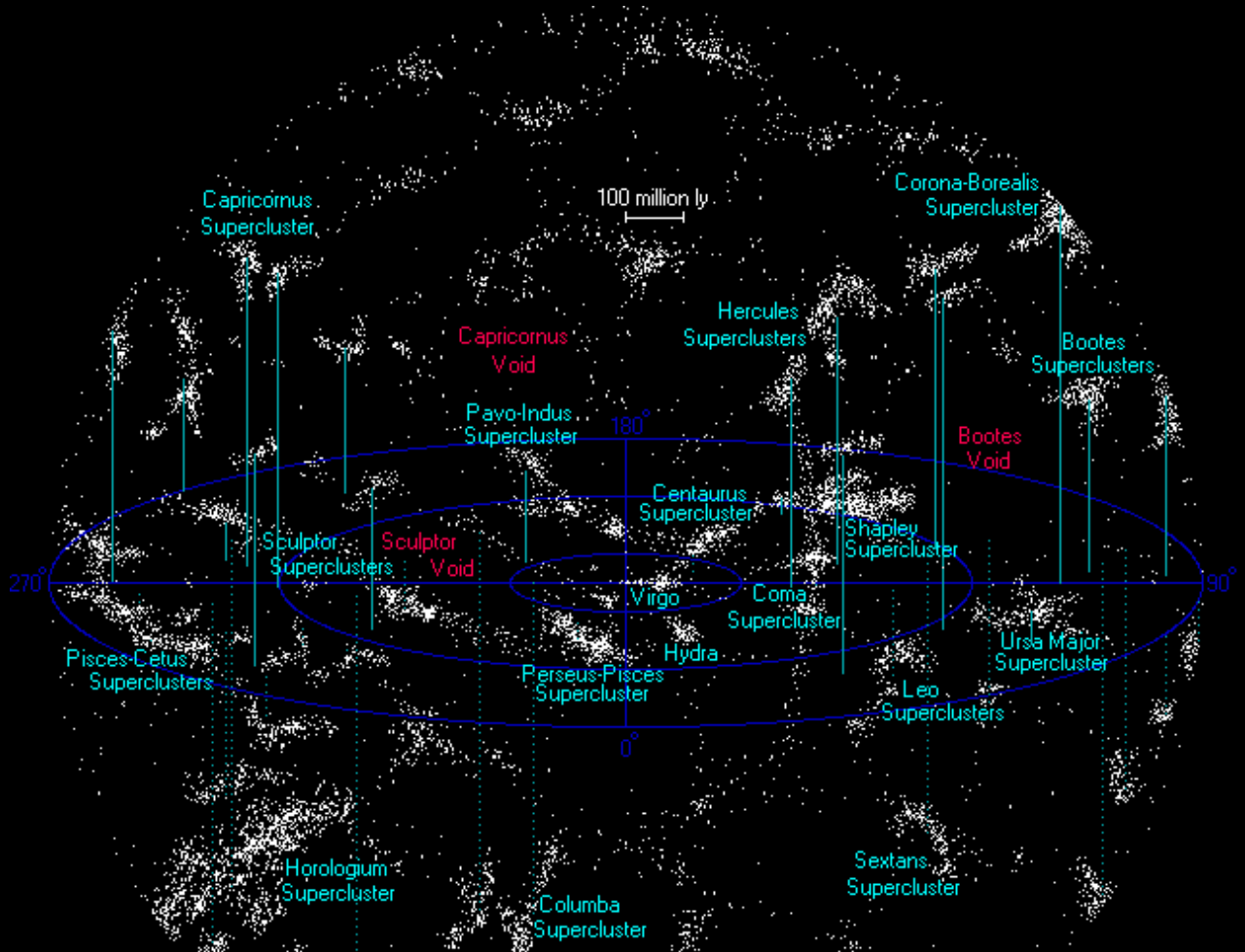
- You are here
- Sol - the Solar System's Star
- The Planets
  - Inner planets
  - Outer planets
  - Pluto and Charon

# 15,000,000,000 Light Years (hypothetical)




*http://www.anzwers.org/free/universe/*

# 1,000,000,000 Light Years (partially mapped)

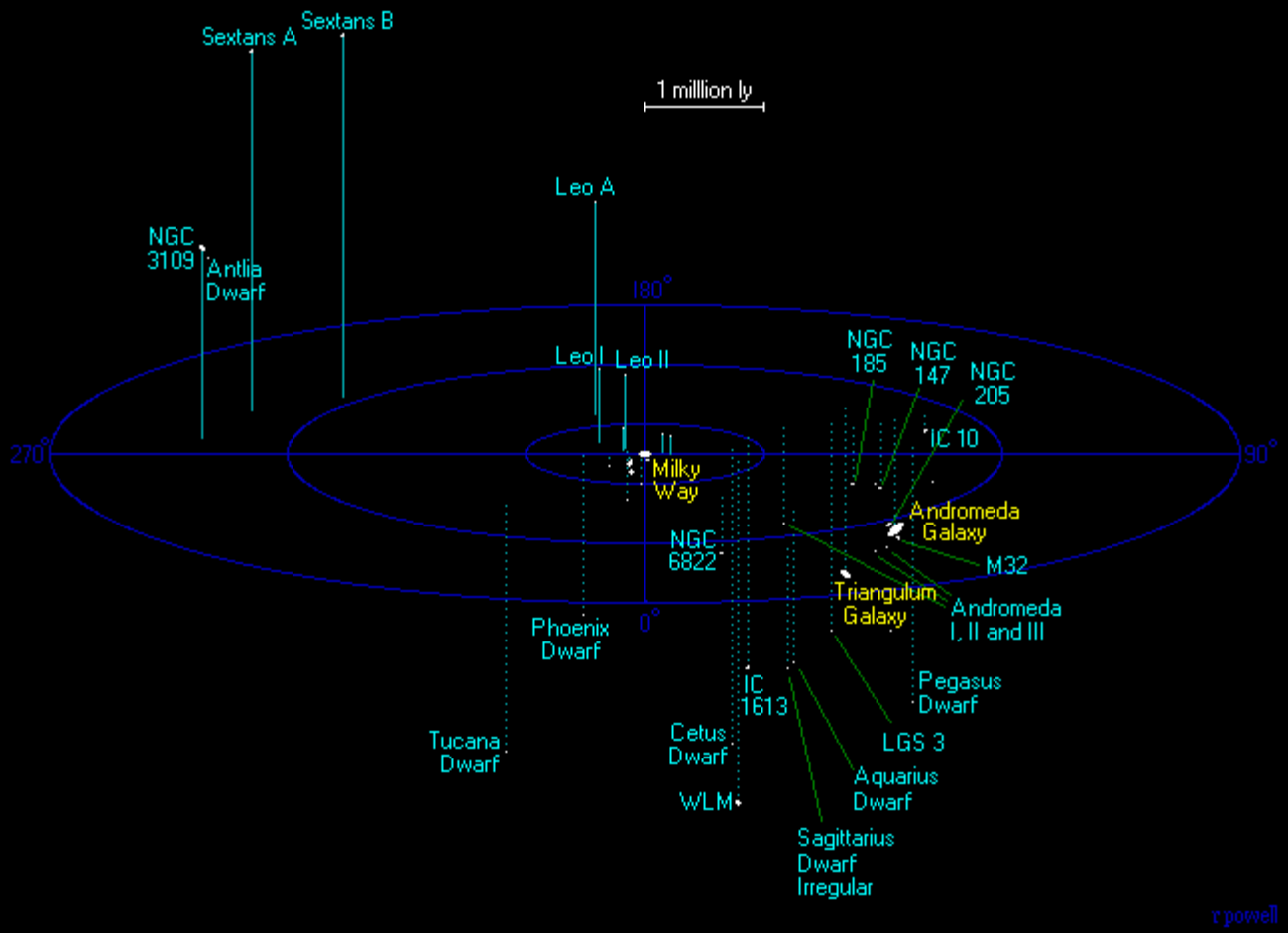



- ★ At least 80 galaxy superclusters mapped
- ★ Estimated 33,000,000 galaxies (3 million large galaxies)
- ★ Estimated 500,000,000,000,000,000 (500 million billion) stars

rpowell

*http://www.anzwers.org/free/universe/*

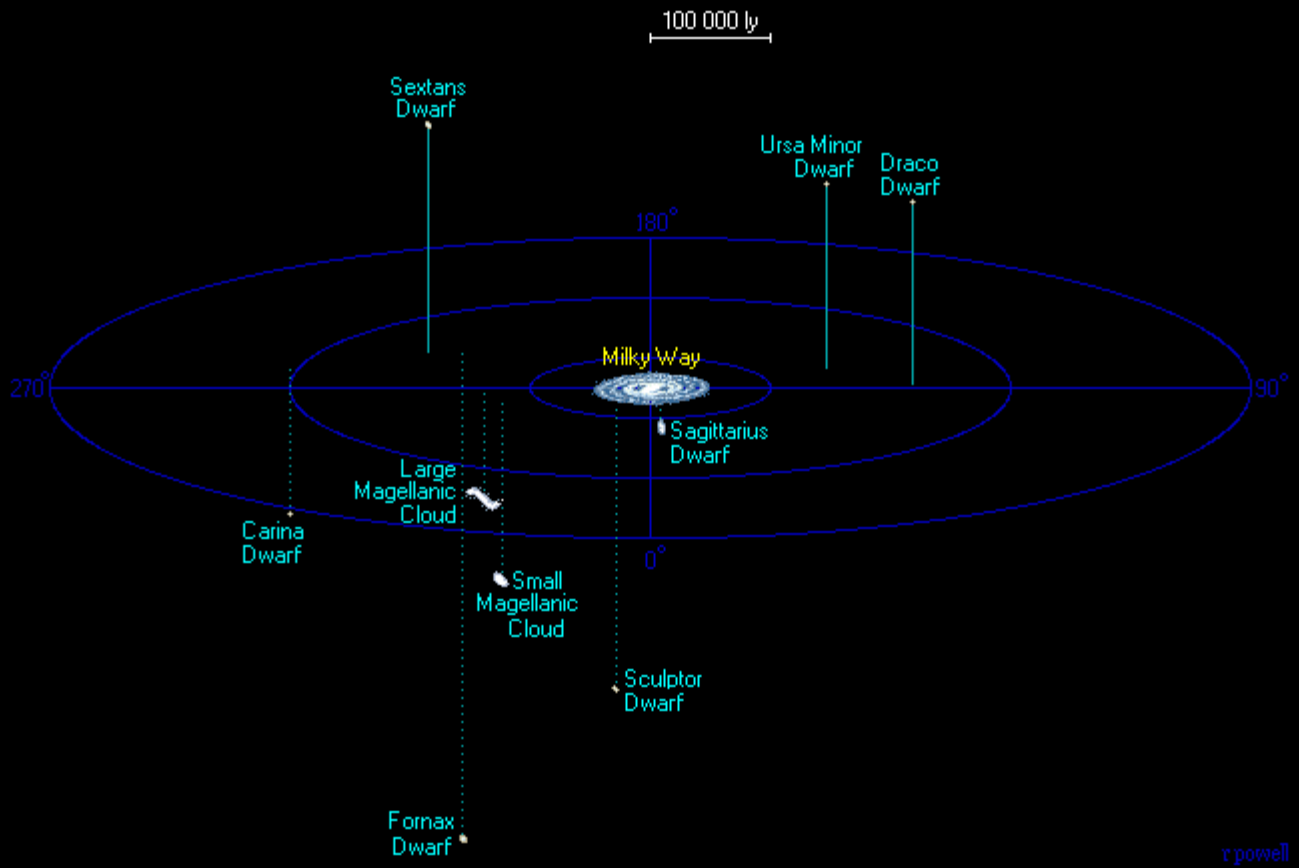
# 5,000,000 Light Years (Local Group)




- Estimated 3 large galaxies (36 small galaxies)
- Estimated 500,000,000,000 (500 billion) stars

*http://www.anzwers.org/free/universe/*

# 500,000 Light Years (Milky Way Galaxy and friends)




- 1 large galaxy (9 small galaxies)
- Estimated 200,000,000,000 (200 billion) stars

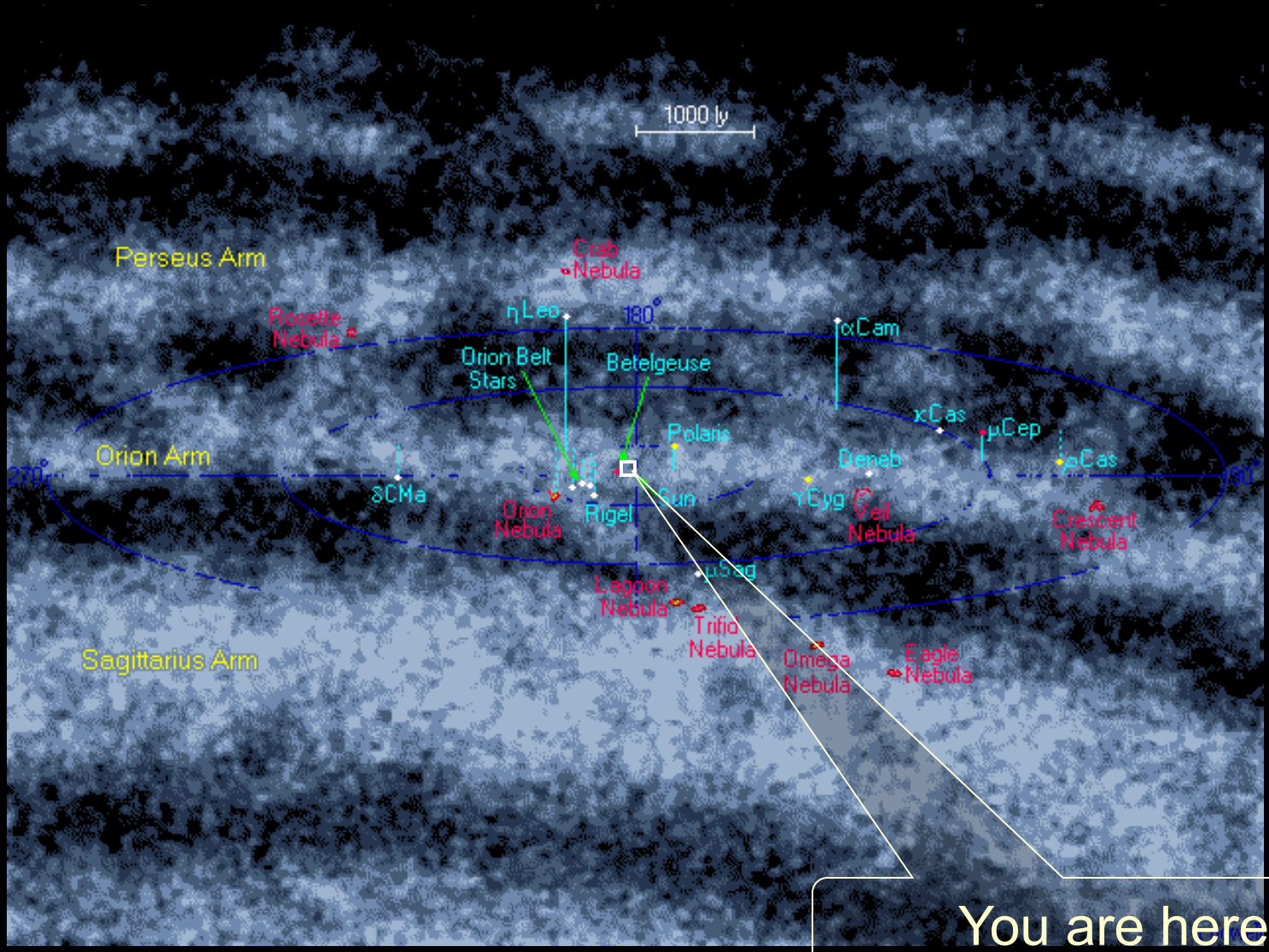
*http://www.anzwers.org/free/universe/*

# 50,000 Light Years (Milky Way Galaxy)


You are here

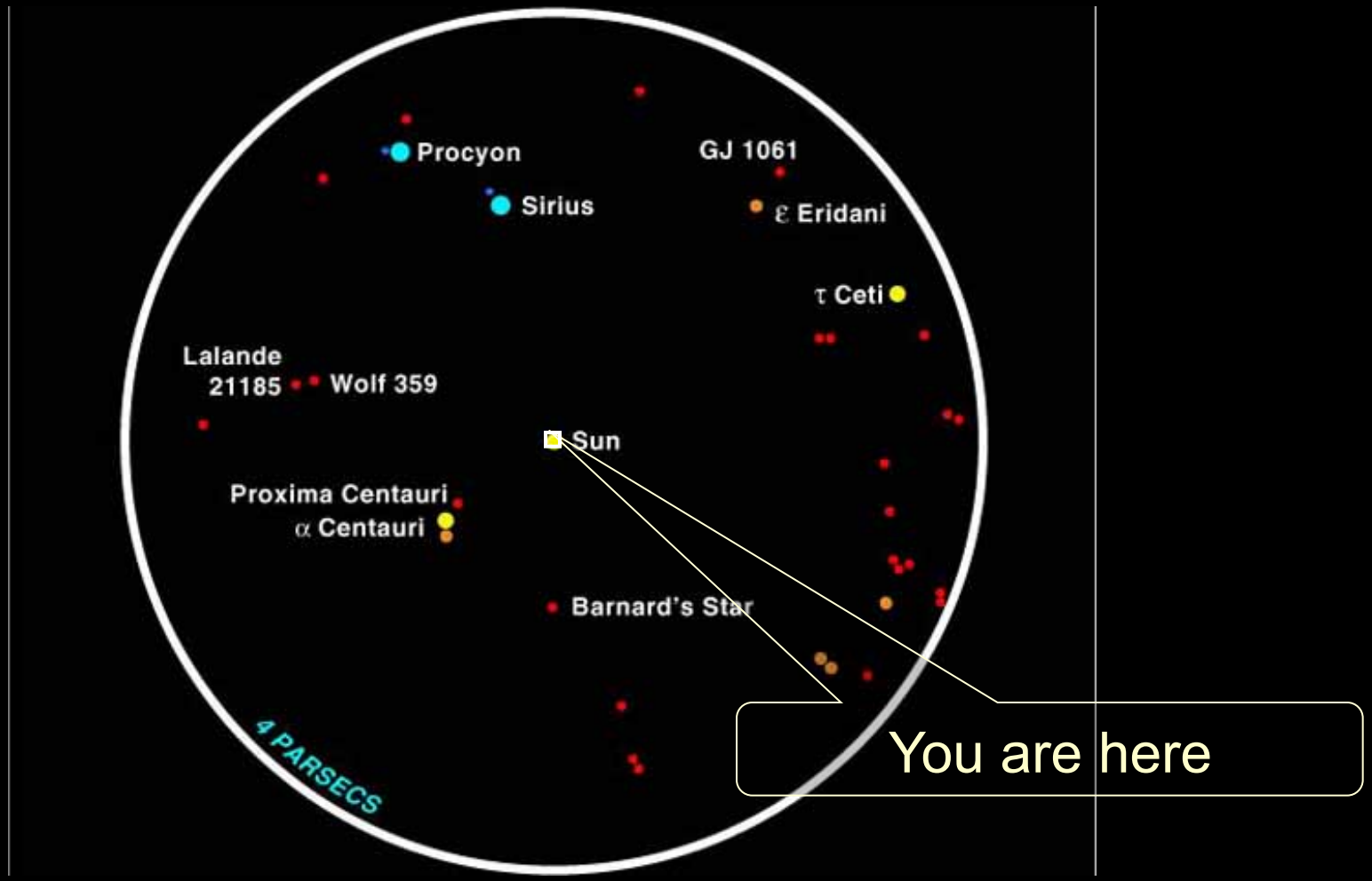
*http://www.news.wisc.edu/newsphotos/images/Milky_Way_galaxy_sun05.jpg*

# 5,000 Light Years (Milky Way Galaxy)




*http://www.anzwers.org/free/universe/*

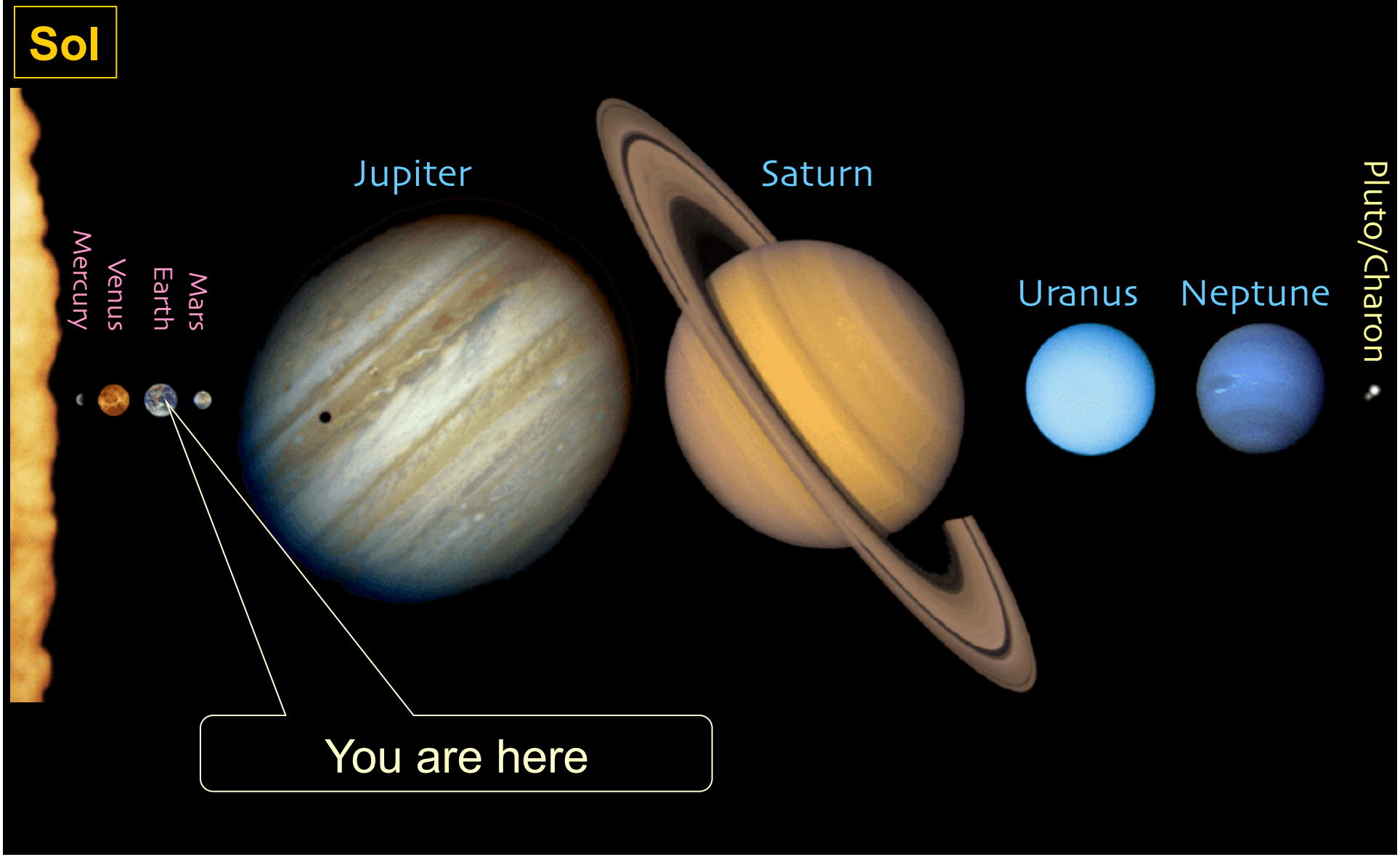
# The Local Neighborhood




All stars within 13 light years (4 parsecs) of the Earth's Sun. There are only 25 other stars, many of which are dim red dwarfs that can not be seen from Earth with the naked eye.

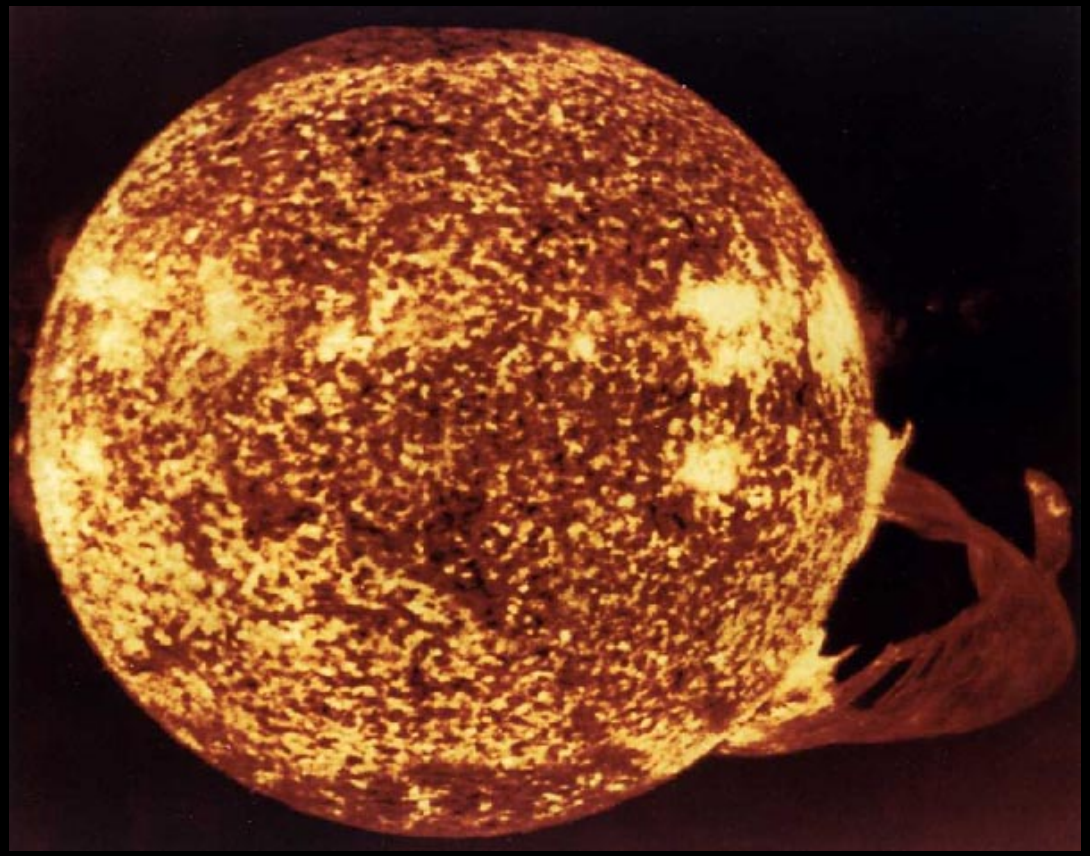
*http://stardate.org/*

# Earth's Solar System



# Sol - The Solar System's Star

## 98% of the Solar System's Mass

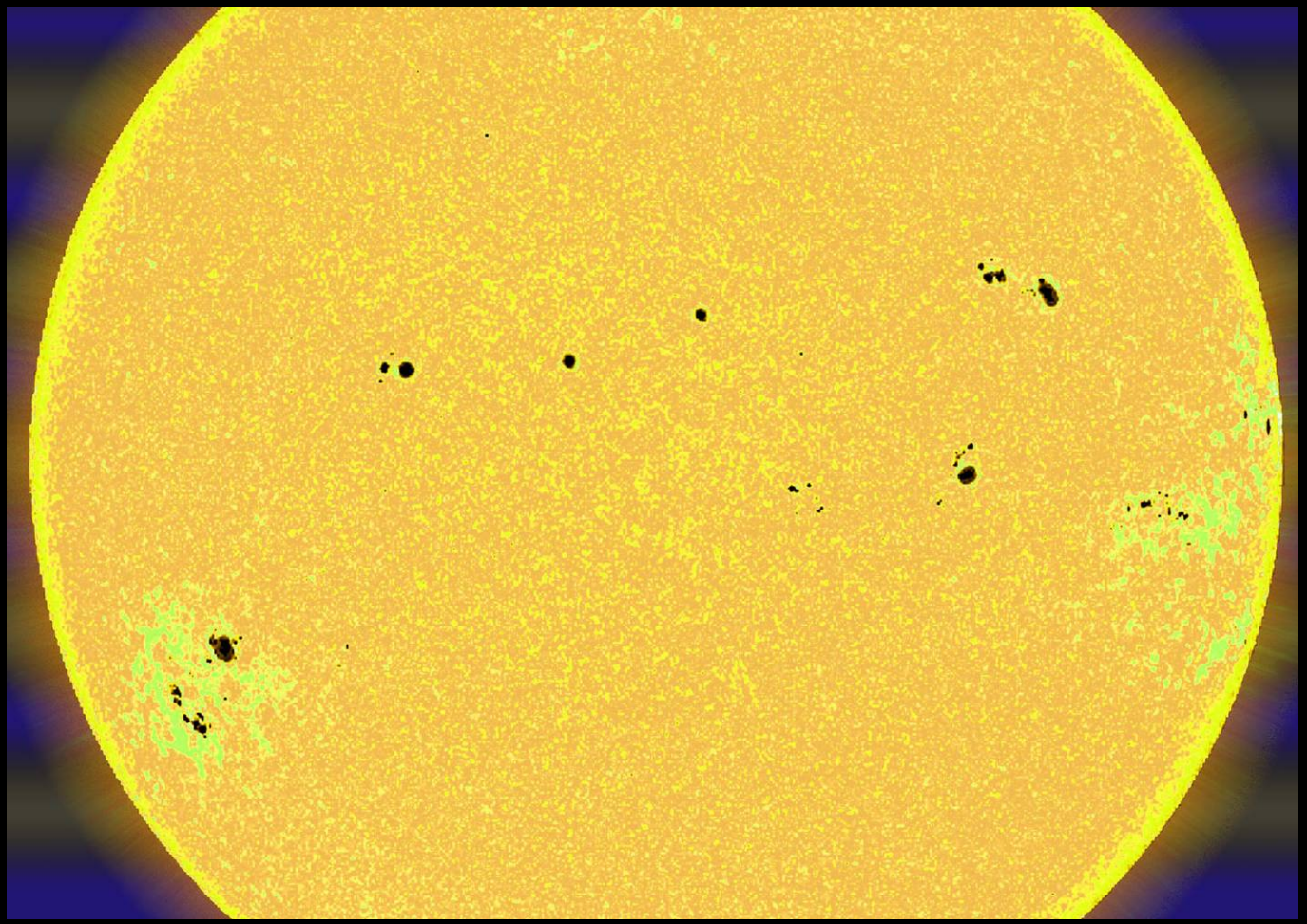


Hydrogen - 92.1%
Helium - 7.8%

also contains oxygen, carbon, nitrogen, neon, iron, silicon, magnesium, sulfur and trace amounts of elements

Sol is a main sequence star. The energy it releases is produced by hydrogen fusion in the star's core.

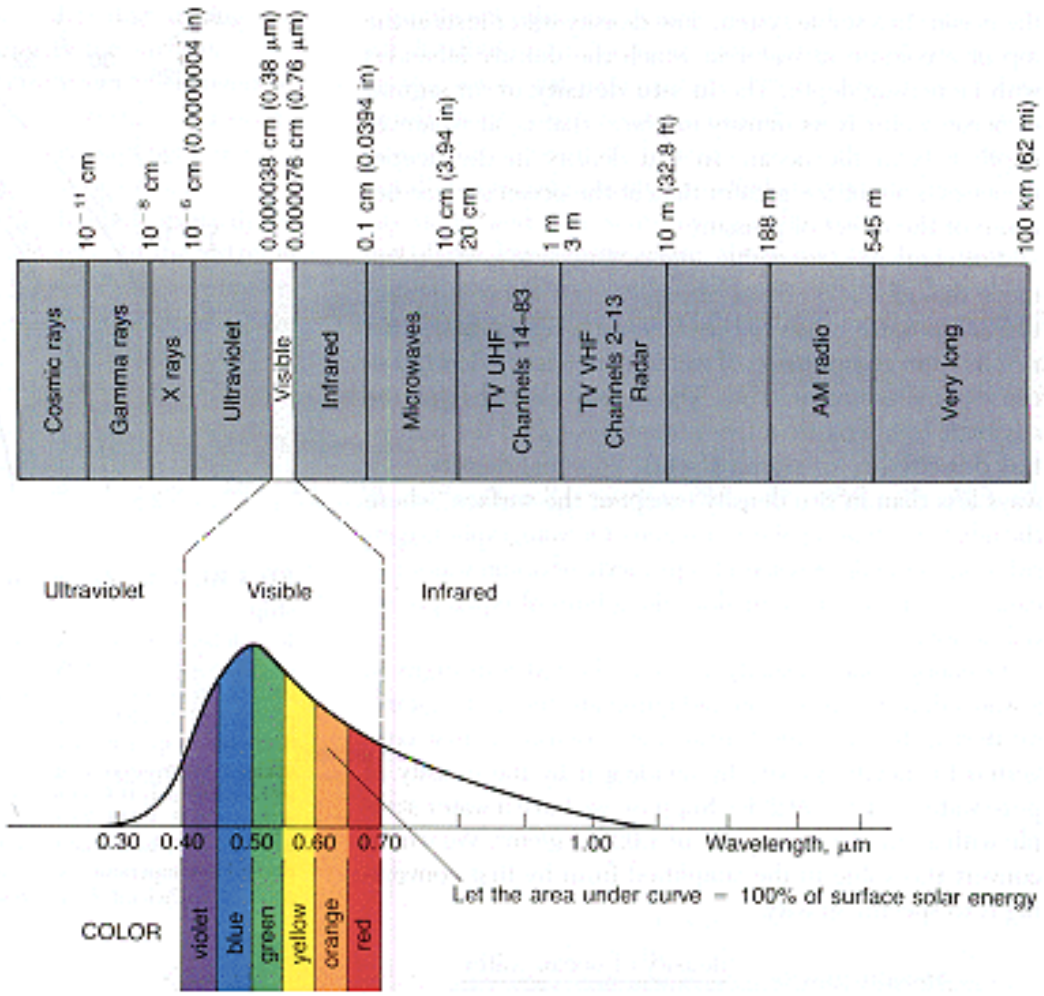
# Sol - The Solar System's Star



Sol in visible light. The Earth's Sun is a yellow star that is subject to dark splotches called sunspots. The spots are cooler (~2,000$^{o}$C cooler!) than the surrounding bright areas and are areas of active, intense magnetism.

*Hill, Steele. 2003. SOHO: The Sun as Art. Goddard Space Flight Center.*

# Sol - The Solar System's Star



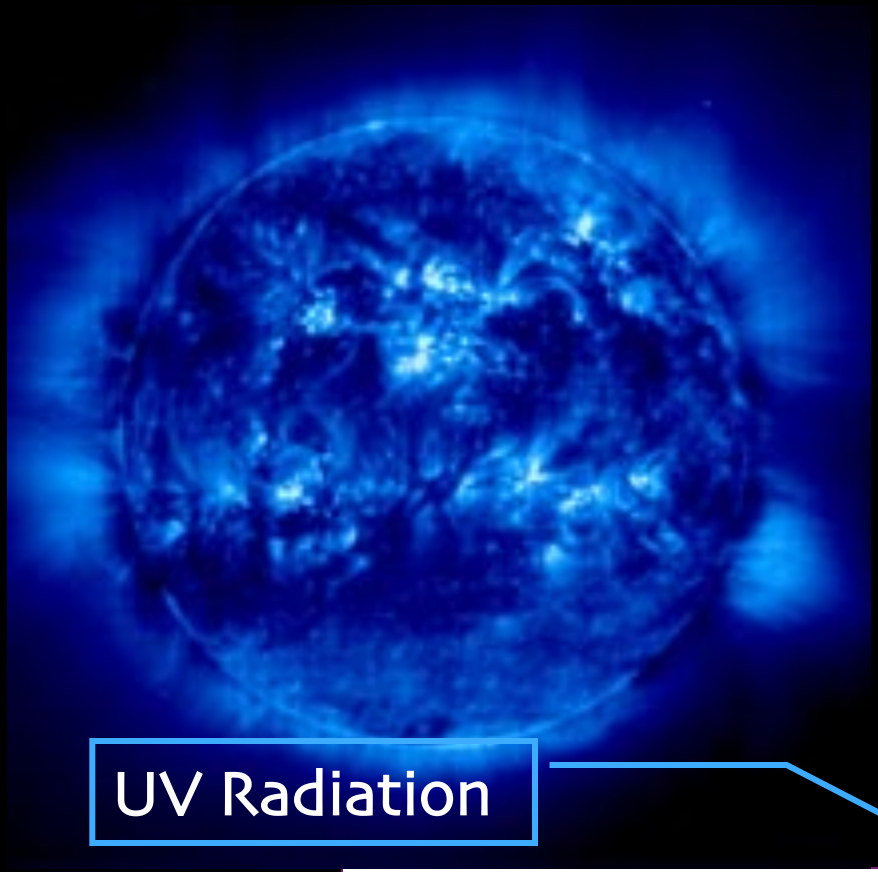

## Electromagnetic Radiation

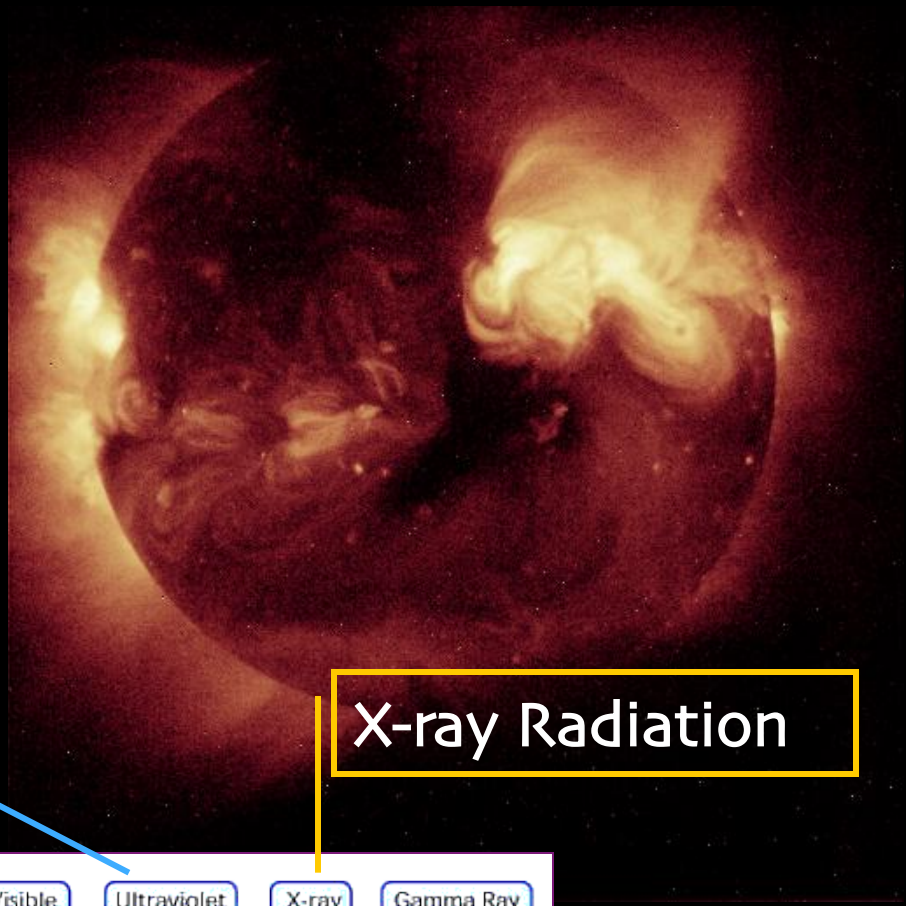
Sol radiates light energy over much of the electromagnetic spectrum

Most of Sol's radiation is in the "visible" part of the spectrum, but it can release much higher and lower energy radiation.

*http://www.carleton.ca/~tpatters/teaching/climatechange/solar/solar1a.html*

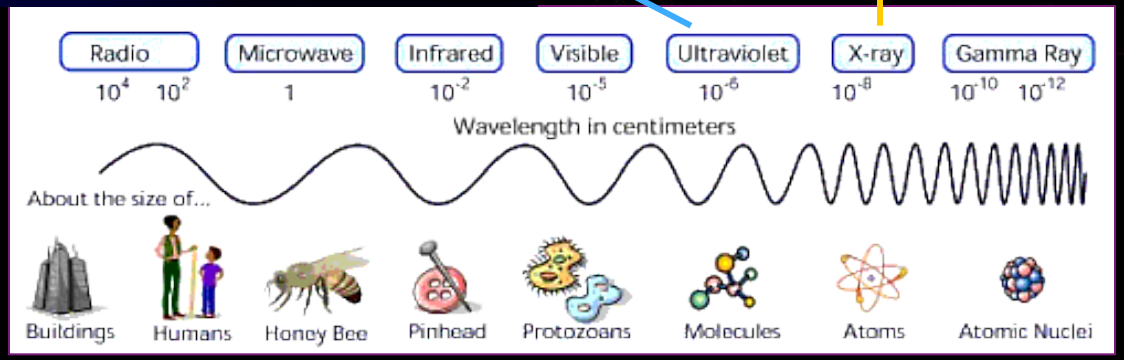
# Sol - The Solar System's Star





UV Radiation

X-ray Radiation

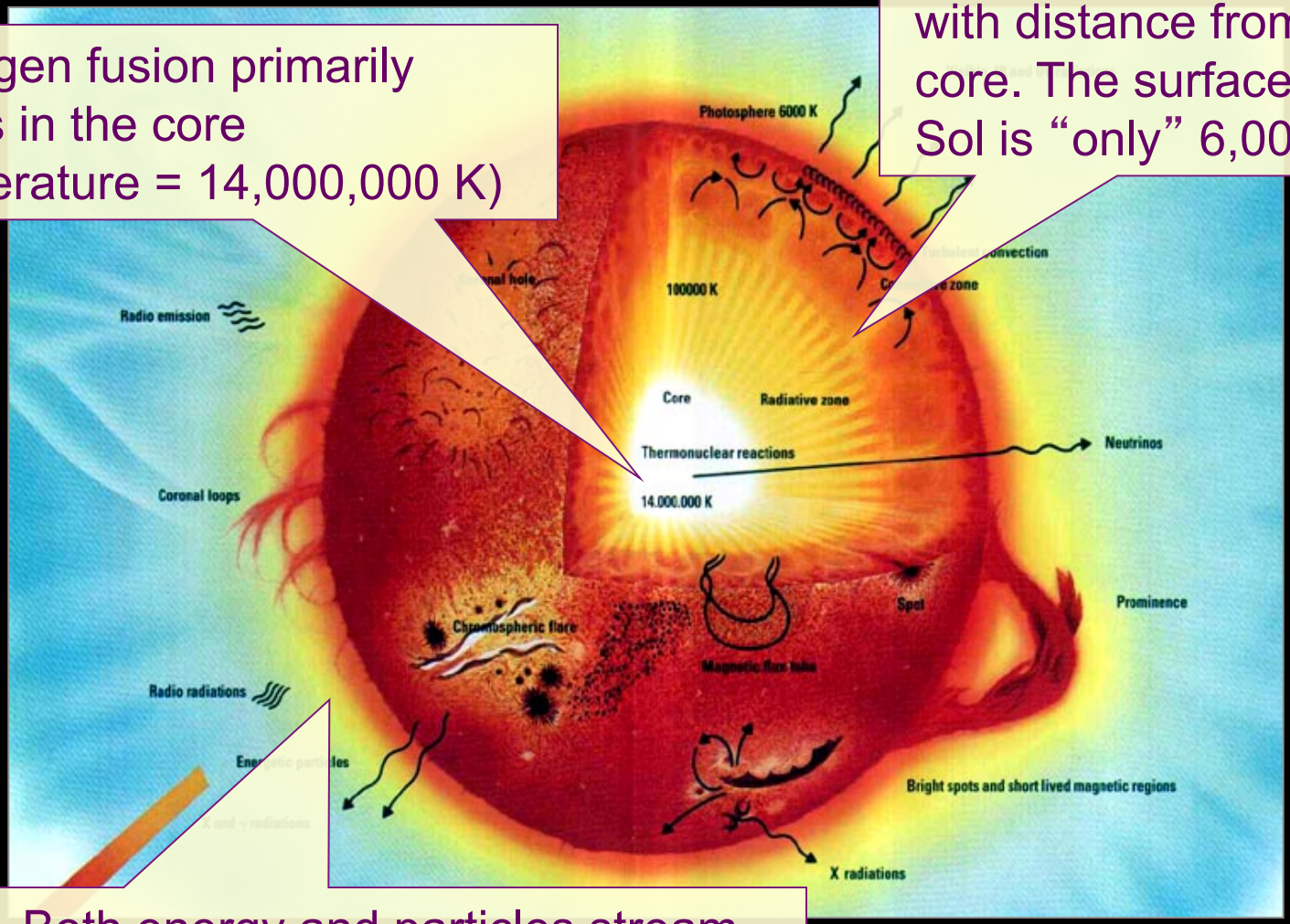



*http://imagers.gsfc.nasa.gov/ems/uv.html*

# Sol - The Solar System's Star

Hydrogen fusion primarily occurs in the core (temperature = 14,000,000 K)

Temperature drops with distance from the core. The surface of Sol is "only" 6,000 K.

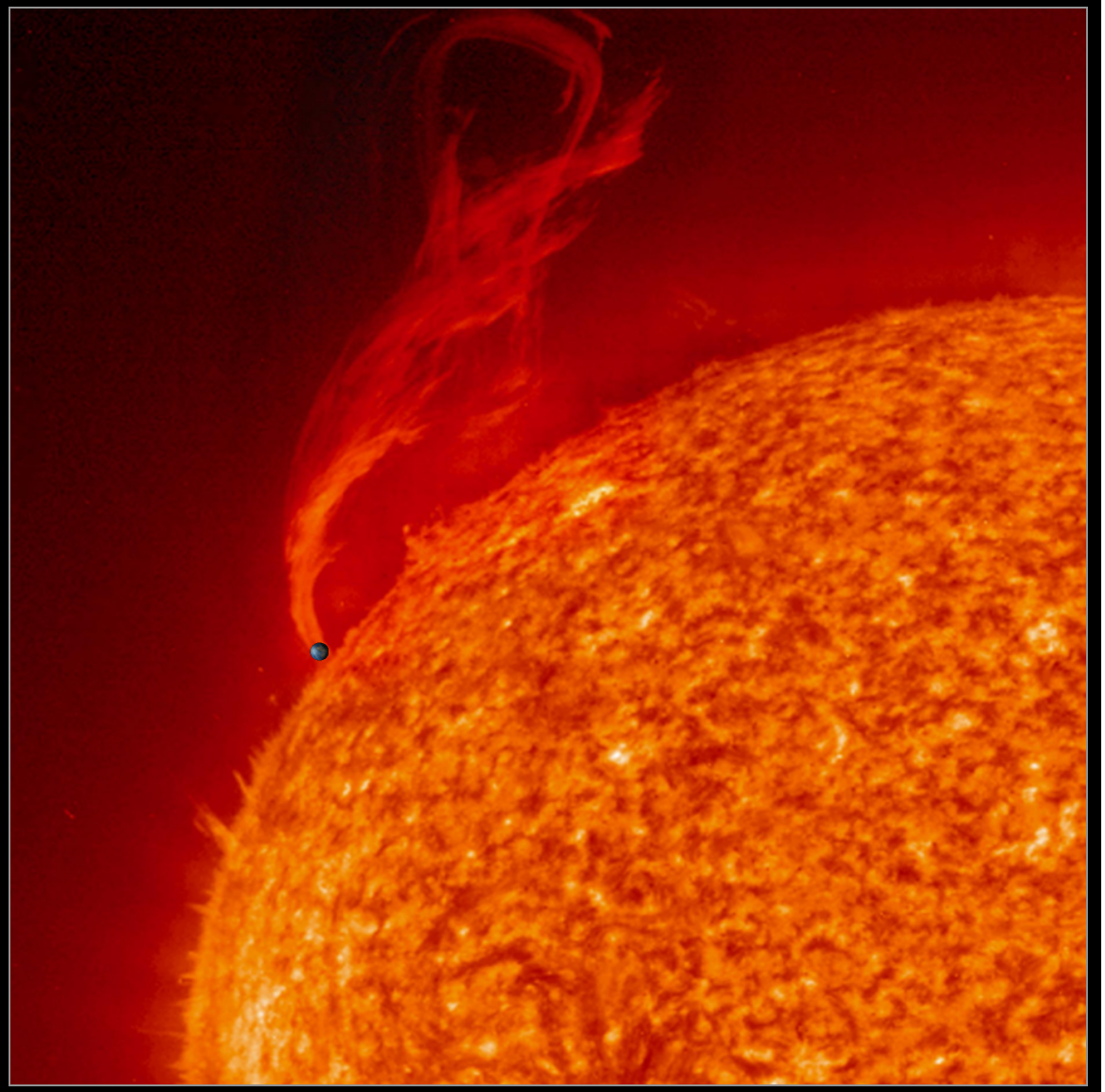



Both energy and particles stream out from the surface of the Sun.

# Sol - The Solar System's Star

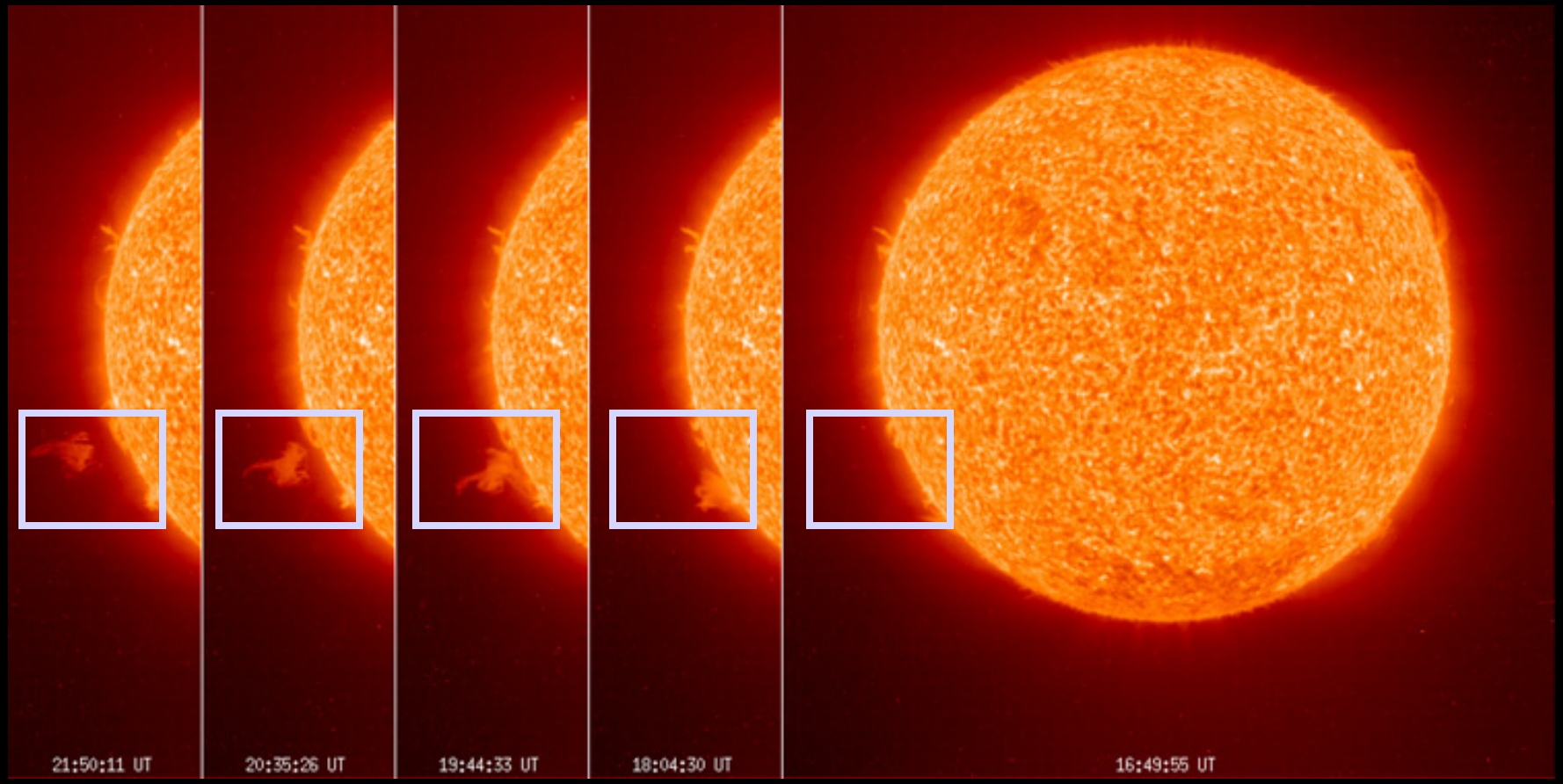
A solar prominence imaged by the SOHO satellite. A prominence is an eruption of plasma that escapes the atmosphere of the Sun (at least temporarily).

Prominences are frequently huge (this one is as long as 35 Earths).

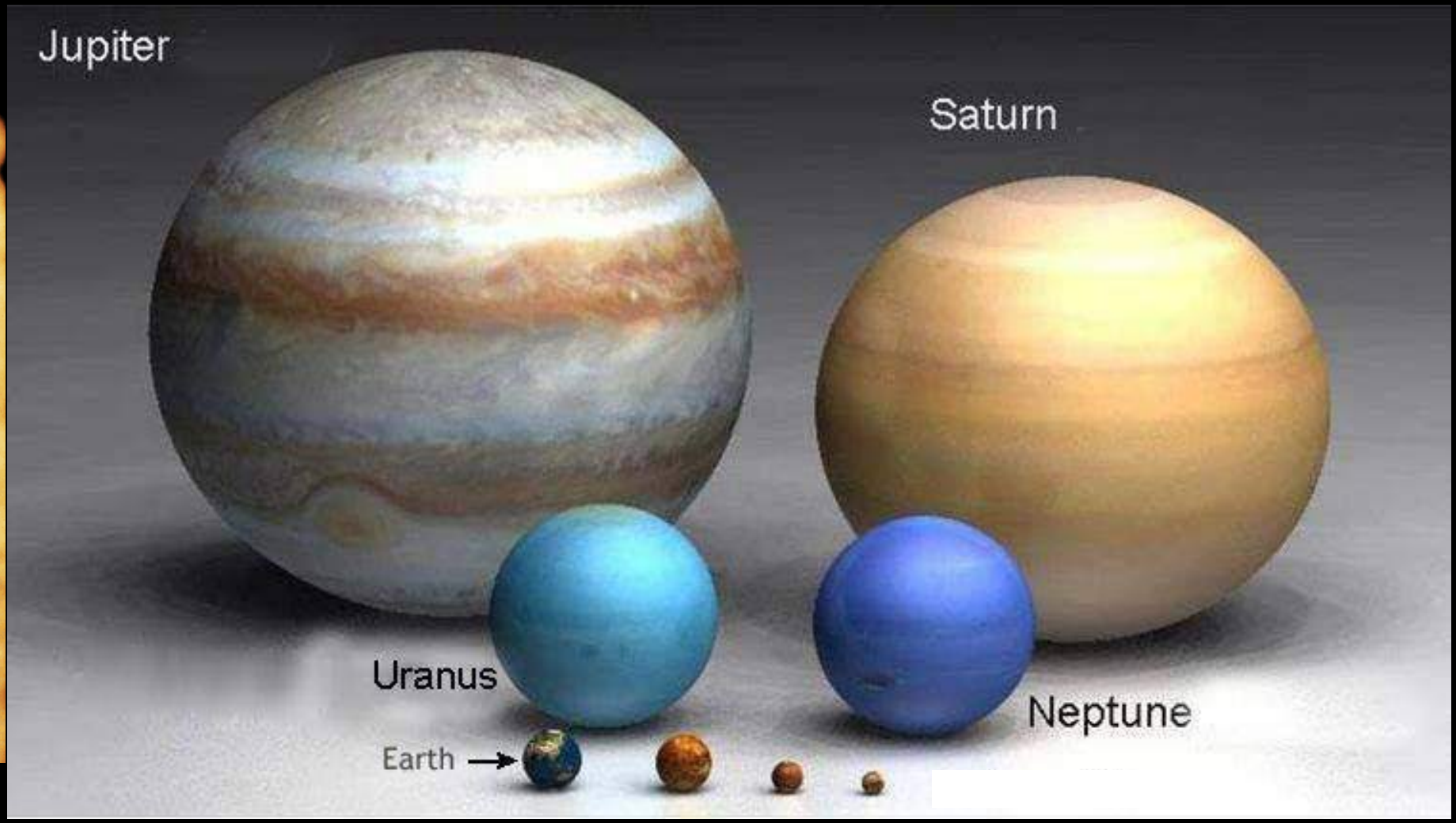


*Hill, Steele. 2003. SOHO: The Sun as Art. Goddard Space Flight Center.*

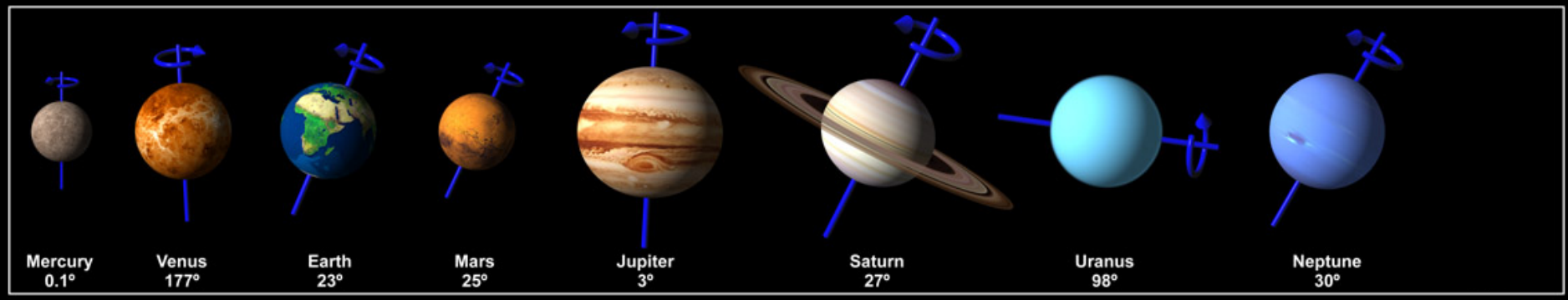
# Sol - Eruption



# Our Solar System



# Planetary Axial Tilts

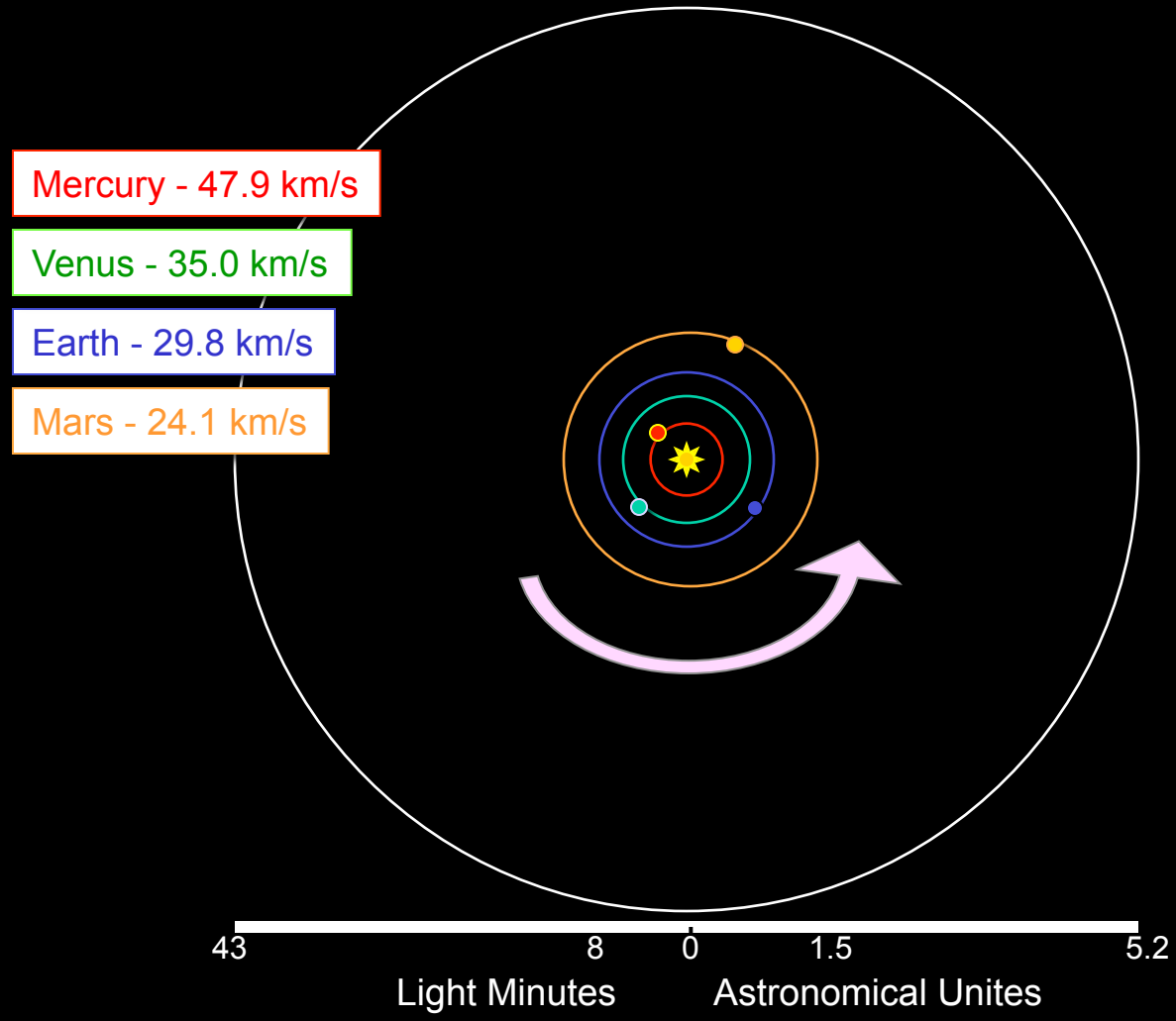



Obliquity of the Nine Planets



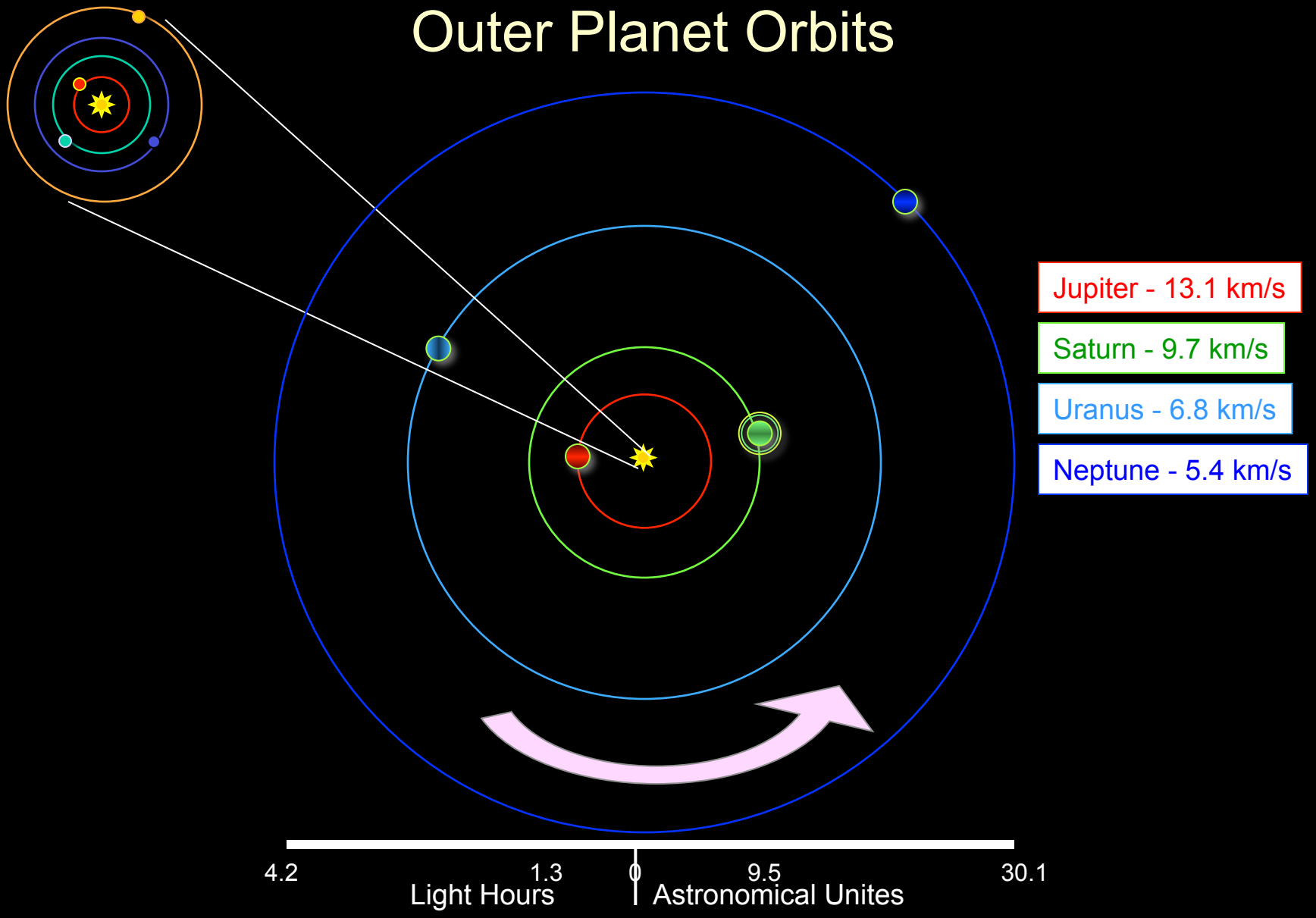
All planets are tilted somewhat with respect to their orbital plane. The greater the tilt, the greater the seasonality (difference between winter and summer) on the planet.

# Inner Planet Orbits




Orbital speed decreases with distance from Sun

# Outer Planet Orbits




Orbital speed decreases with distance from Sun

# Inner Planets versus Outer Planets

*Neptune*
*Uranus*
*Saturn*
*Jupiter*

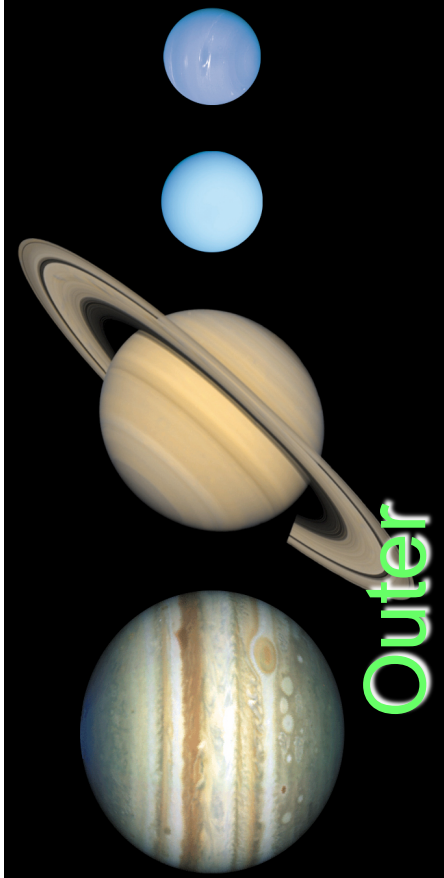
*Mars*
*Earth*
*Venus*
*Mercury*

low density
high mass

high density
low mass

Large and gassy

Small and Rocky



Outer

## *Density ($g/cm^3$)*

**0.7 - 1.6**

low density

**3.9 - 5.5**

high density

Inner

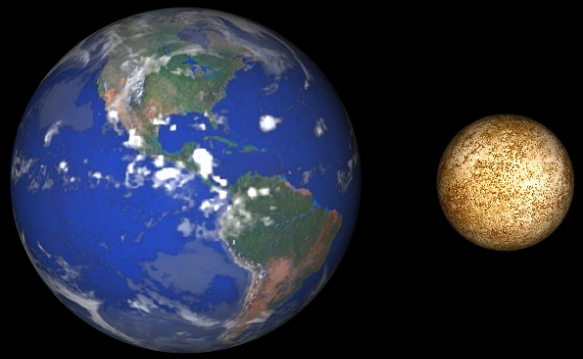
## *Escape Velocity (km/sec)*

**21.1 - 59.6**
high mass

**4.3 - 11.2**
low mass

# The Inner Planets

## Mercury



http://www.arcadiastreet.com/cgvistas/mercury_002a.htm

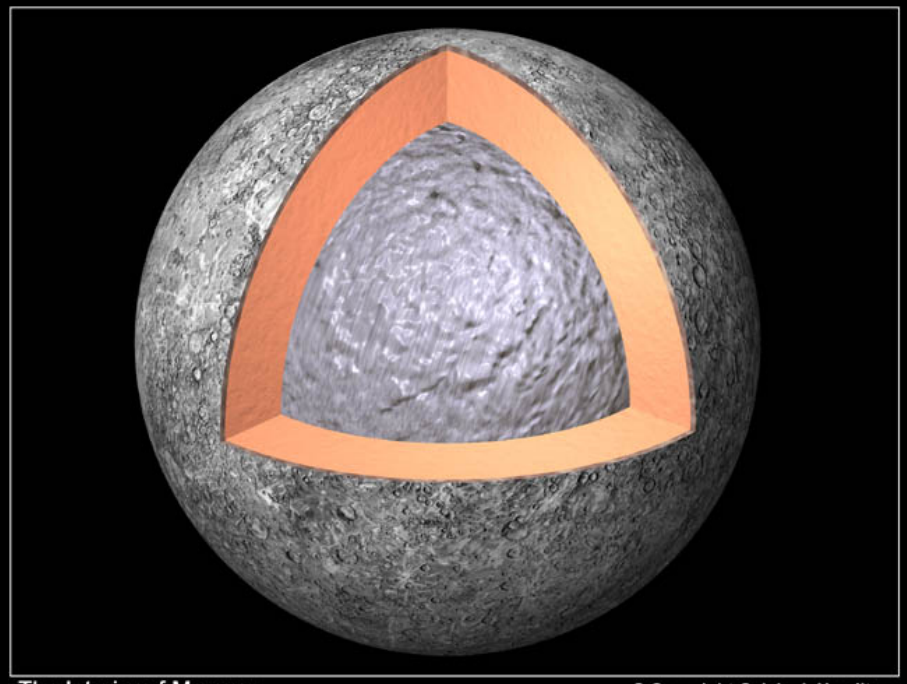


- *Radius:* 2,439 km
- *Surface Temperature:* -183 to 427° C
- *Atmosphere* - He(42%), Na(42%), O(15%)

*Core:* 60-70% Iron

*Mantle:* rocky

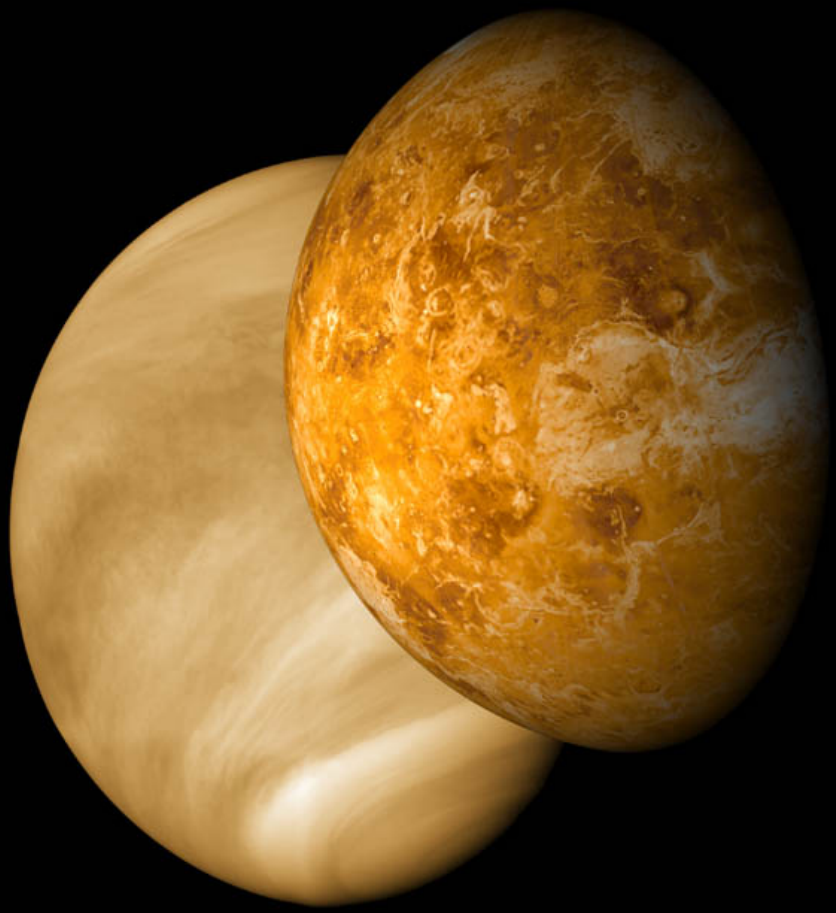
*Crust:* thin (<100 km)



The Interior of Mercury

# The Inner Planets

## Venus



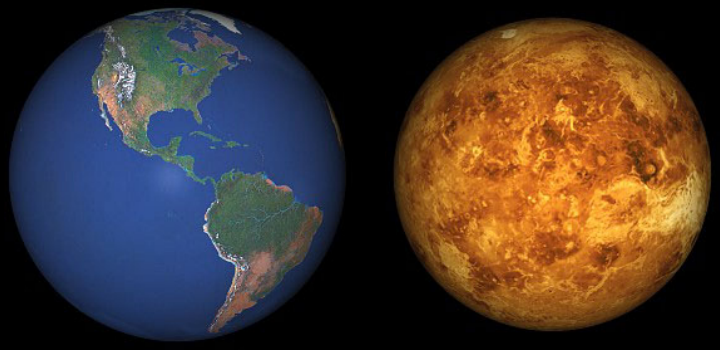
Venus with Visible and Radar Illumination



- Venus is covered in thick clouds, that give it a serene look from space.
- The surface, however, is a tortured landscape with unbearable pressures, high temperatures, and a vile atmosphere.

# The Inner Planets

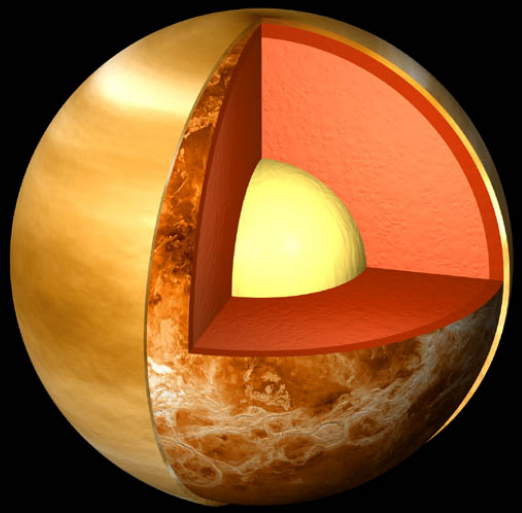
## Venus



http://www.arcadiastreet.com/cgvistas/mercury_002a.htm



- *Radius:* 6,052 km
- *Surface Temperature:* 455° C
- *Atmosphere*: $CO_2$ (96%), $N_2$(3%); also $H_2O$, Ar, CO, Ne, $SO_2$ , HCl, HF



The Interior of Venus



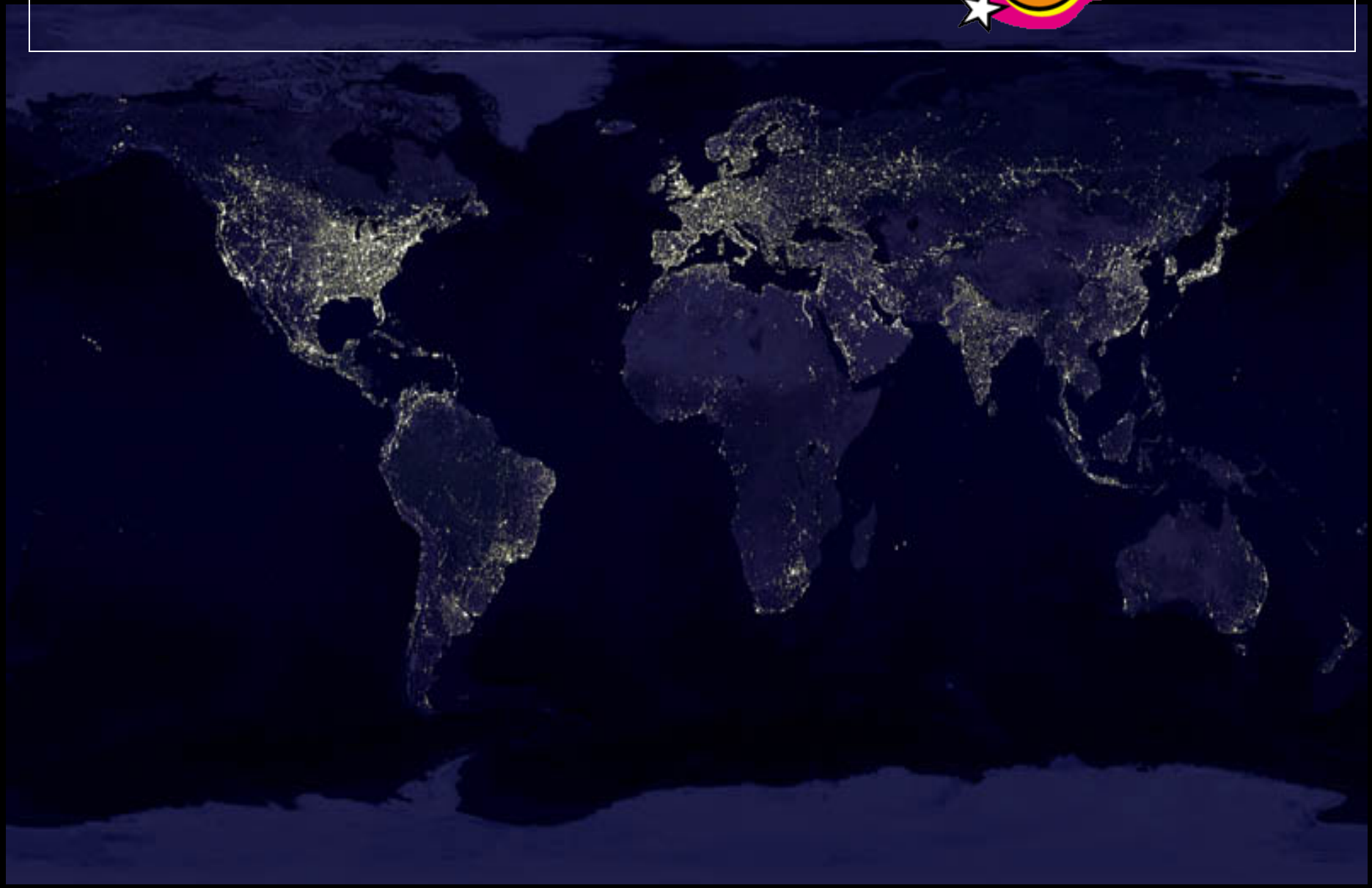
*Core:* under debate

*Mantle:* under debate

*Crust:* basalt, thin (25-60 km)

# The Inner Planets

Earth



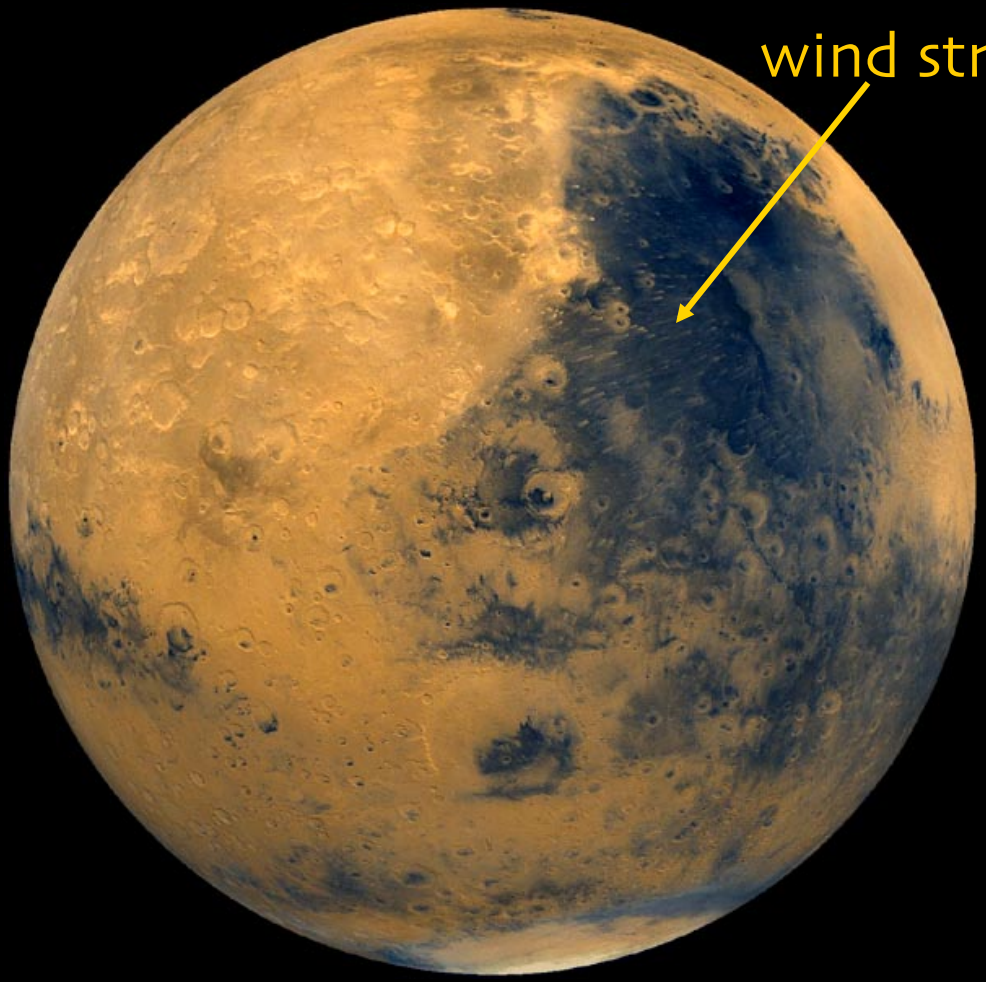
# The Inner Planets

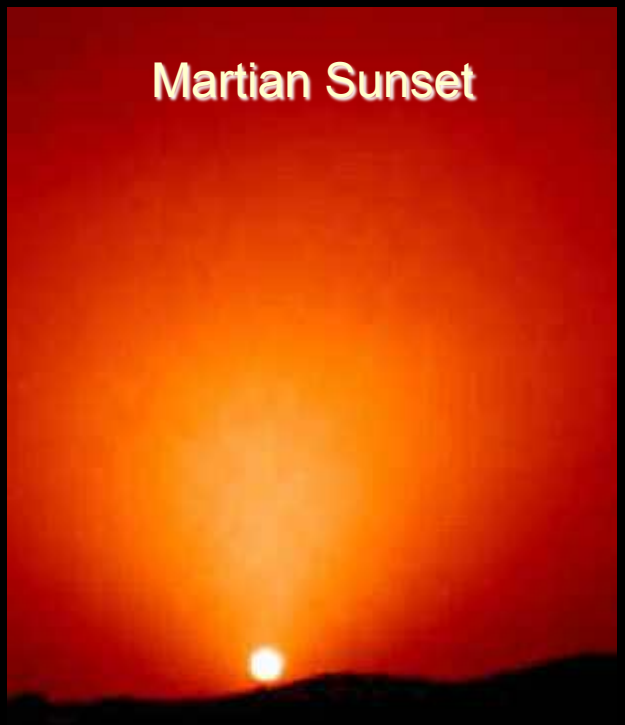

- The Earth has an unusually large satellite – the Moon. The Moon is similar in size to the larger satellites of the gas giants like Jupiter.
- Earth's Moon is in revolution-rotation synch with the Earth. It rotates on its axis once for every revolution around the Earth – i.e., the same side of the Moon always faces the Earth.

*http://www.freemars.org/jeff/planets/Luna/Luna.htm*

# The Inner Planets

## Mars



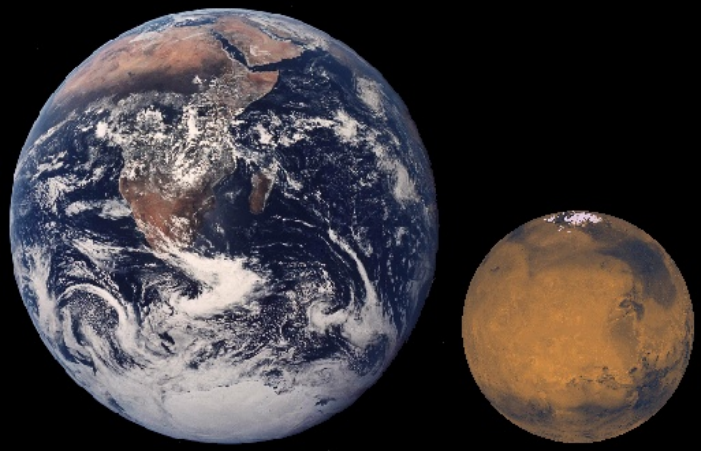




**An enhanced image of a Martian sunset as seen by the Sojourner rover in 1997**

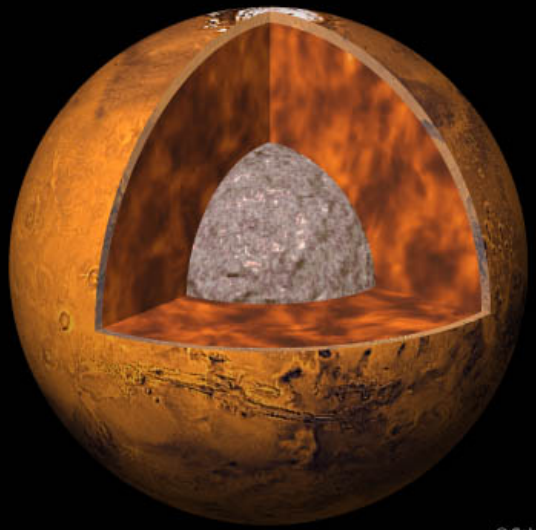
*http://stardate.org/*

# The Inner Planets

## Mars



- *Radius:* 3,397 km
- *Surface Temperature:* -140 to 20 $^{o}$C
- *Atmosphere*: $CO_2$ (95%), $N_2$ (2.1%), Ar (1%), $O_2$ , CO, $H_2O$, Ne, Kr, Xe, $O_3$





*Core:* under debate

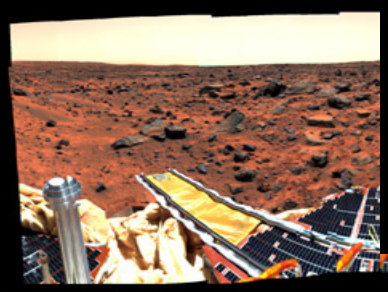
*Mantle:* under debate

*Crust:* varied

# The Inner Planets

## Mars

NASA/JPL/Malin Space Science Systems





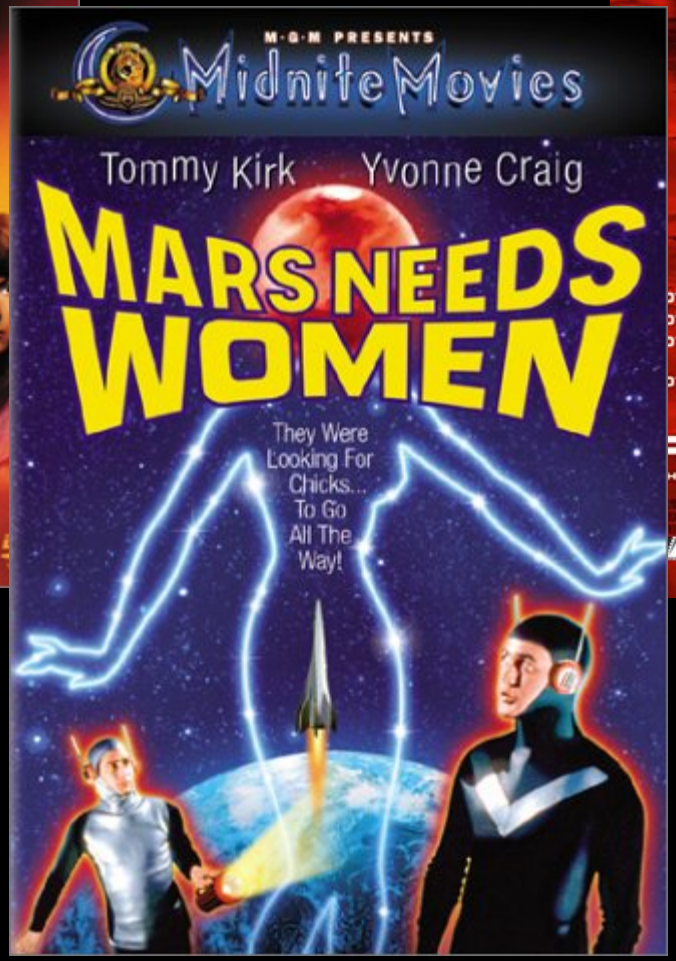
Earth and Moon as seen from the Mars Global Surveyer in orbit around Mars

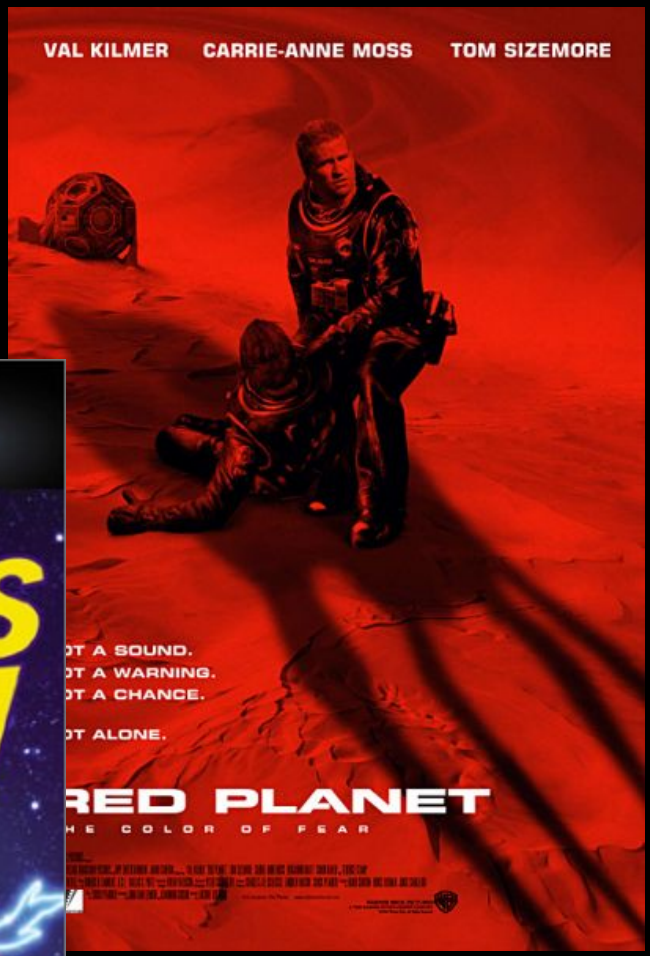
Systems/NASA

USGS

http://astrogeology.usgs.gov

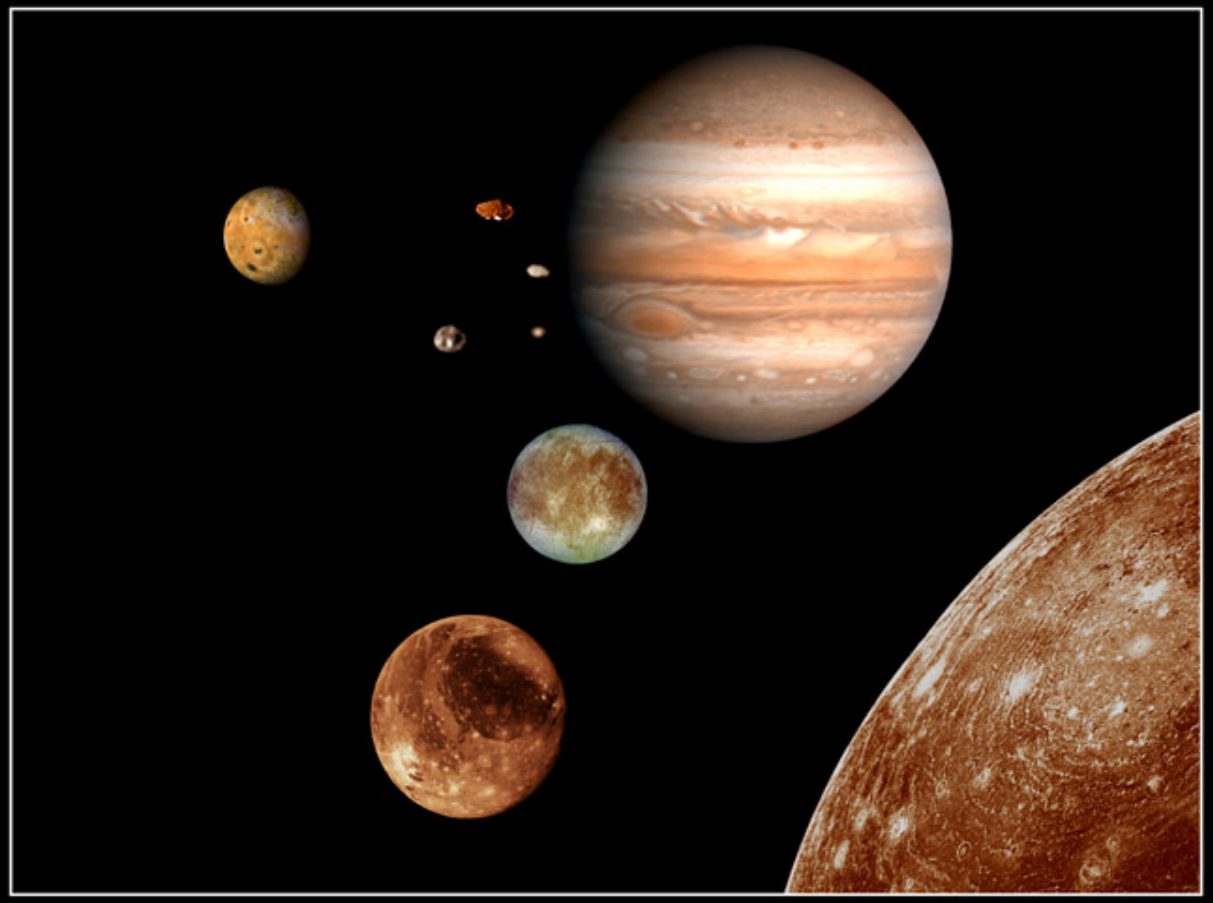

SPECIAL EDITION
ICE CUBE · MEAGAN GOOD
JOHN CARPENTER'S
GHOSTS OF MARS
Terror is the same on any planet.


M-G-M PRESENTS
MidniteMovies
Tommy Kirk
Yvonne Craig
MARS NEEDS WOMEN
They Were Looking For Chicks... To Go All The Way!


VAL KILMER
CARRIE-ANNE MOSS
TOM SIZEMORE
OT A SOUND.
OT A WARNING.
OT A CHANCE.
OT ALONE.
RED PLANET
HE COLOR OF FEAR

# The Outer Planets

## Jupiter



The Jupiter System

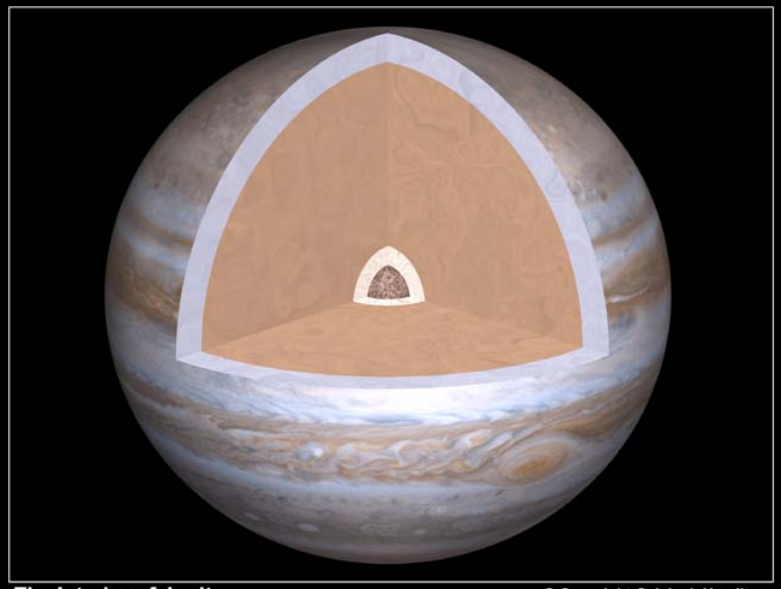


- Jupiter is the largest of the Solar System's planets, and the second largest object in the Solar System.
- Like other gas giants, dozens of moons (some as large as Mercury) orbit this huge planet.

# The Outer Planets

## Jupiter

- *Radius:* 71,492 km
- *Cloud Temperature:* -121$^{o}$ C
- *Atmosphere*: $H_2$ (90%), He (10%), $CH_4$ , CO, $NH_3$ , $C_2H_6$



The Interior of Jupiter



*Outer:* gaseous H

*Middle:* increasing pressure, H acts as liquid, and then liquid metal

*Inner*: "icy" layer of heavier molecules ($H_2O$, $NH_4$, $NH_3$)

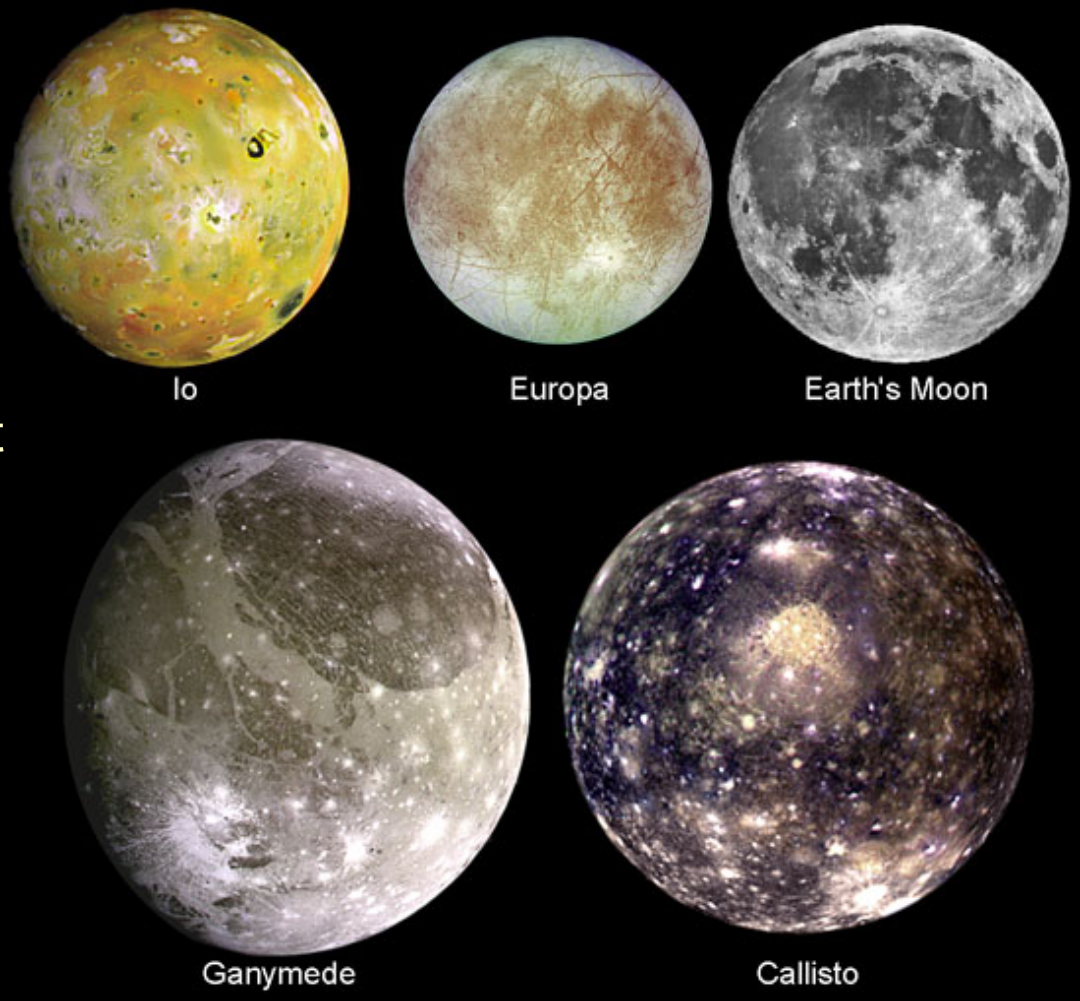
*Core*: rock or rocky "ice" up to 10x mass of Earth

# The Outer Planets

Jupiter

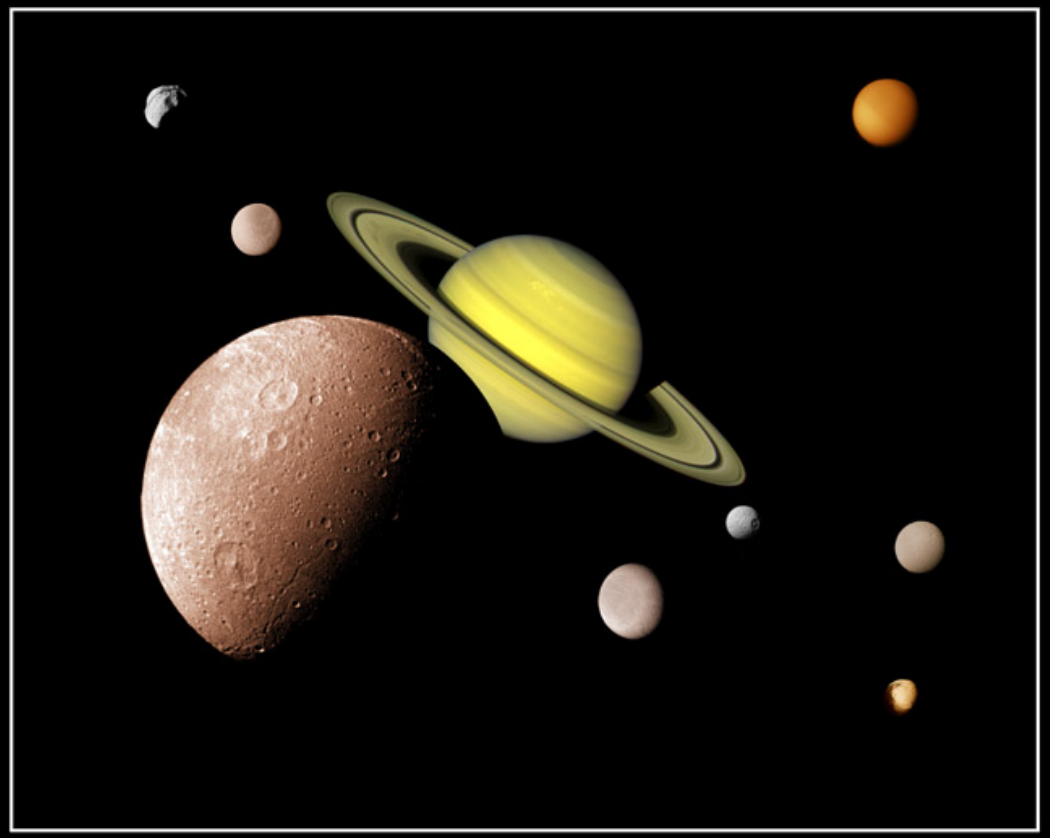
## Jupiter's Moons

- The composition of Jupiter's moons is highly variable. Some are icy, some are rocky, and least one (Io) is volcanic!
- One moon (Europa) is covered in what appears to be water ice, perhaps covering a vast, global ocean.



# The Outer Planets

## Saturn



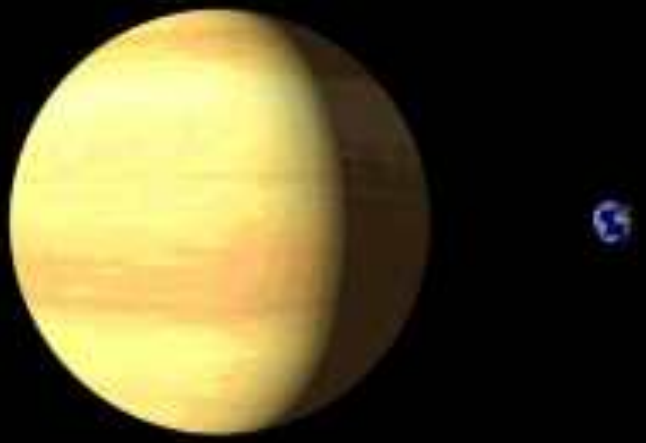
The Saturn System



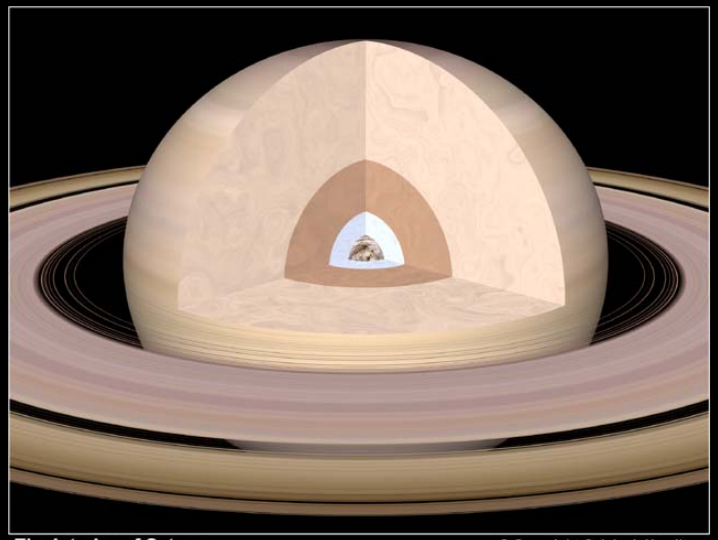
- Saturn is twice as far from the Sun as Jupiter.
- Saturn has a large number of moons, but the most spectacular feature is the beautiful ring system orbiting the planet.

# The Outer Planets

## Saturn



- *Radius:* 60,268 km
- *Surface Temperature:* -176$^{o}$ C
- *Atmosphere*: $H_2$ (97%), He (3%), $CH_4$ , $NH_3$ , $C_2H_6$



The Interior of Saturn



*Outer:* gaseous H, He

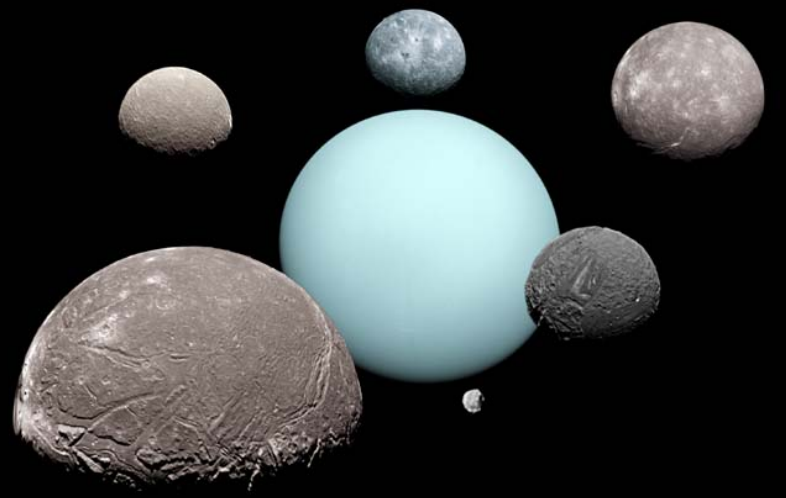
*Middle:* increasing pressure, H acts as liquid, and then solid

*Inner*: "icy" layer of heavier molecules ($H_2O$, $NH_4$, $NH_3$)

*Core*: rock or rocky "ice"

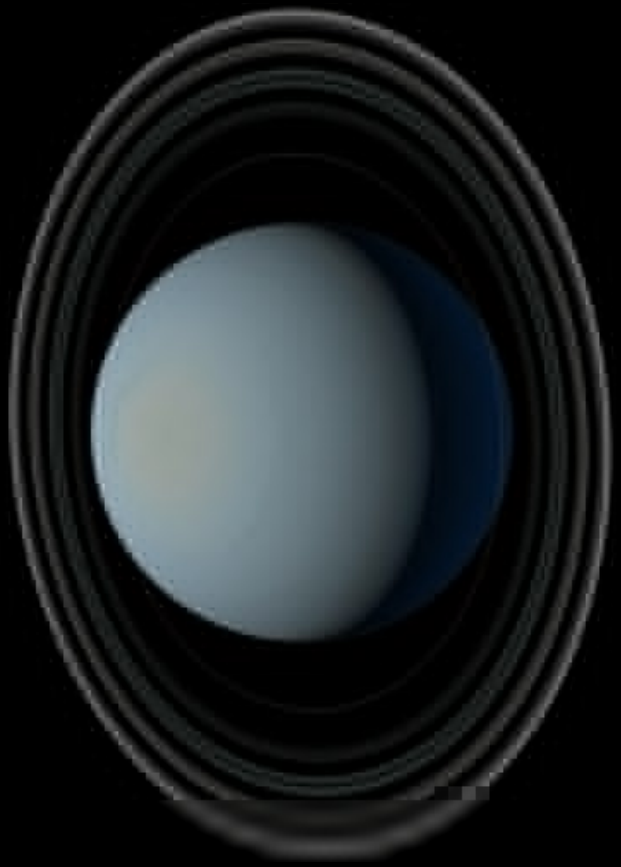
# The Outer Planets

## Uranus



Uranian System

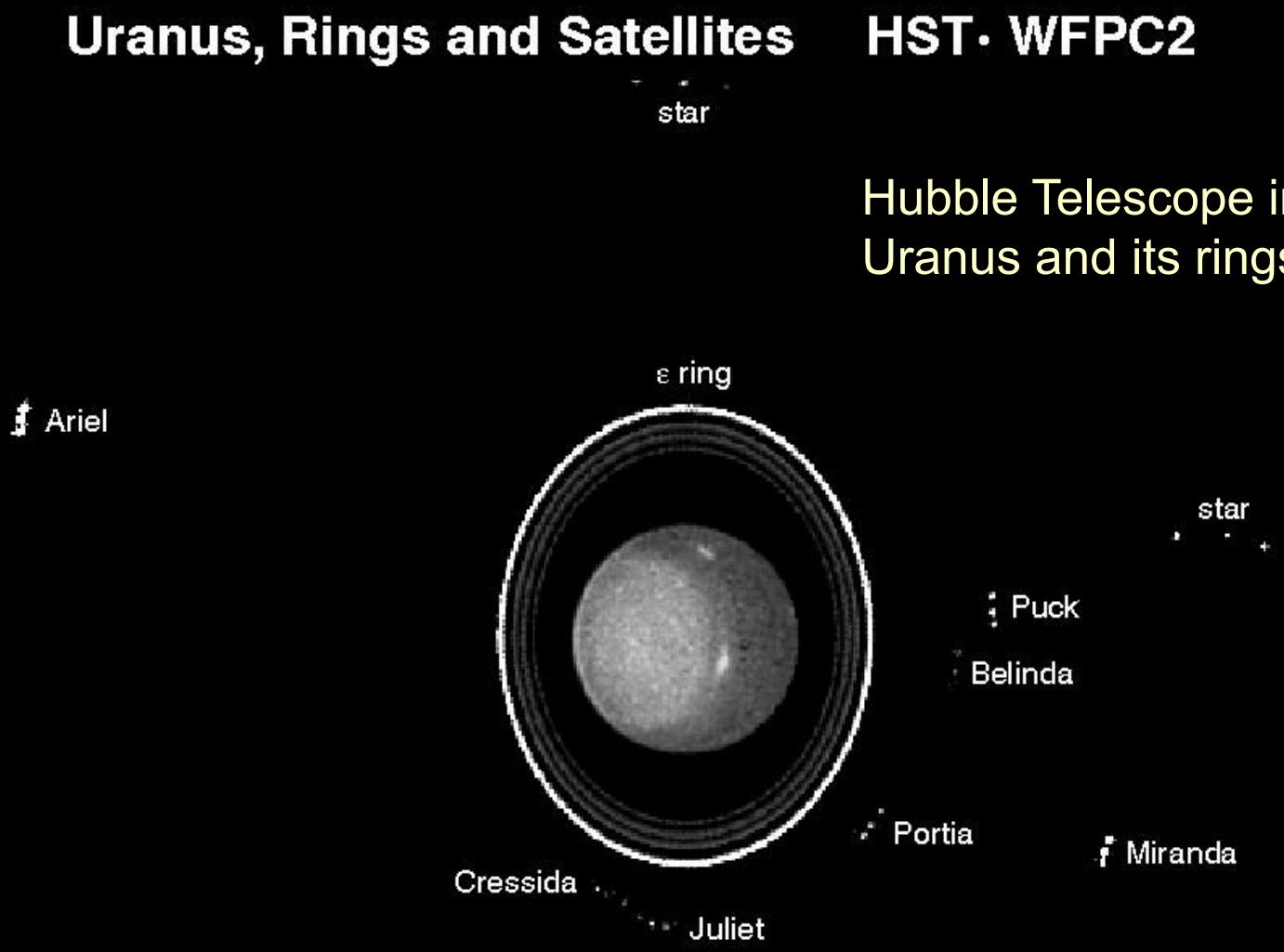




- Uranus is a typical gas giant in a lot of ways (rings, lots of moons, etc.).
- However, its axis of rotation is “tipped over” on its side, presumably resulting in extreme seasonality.

# The Outer Planets

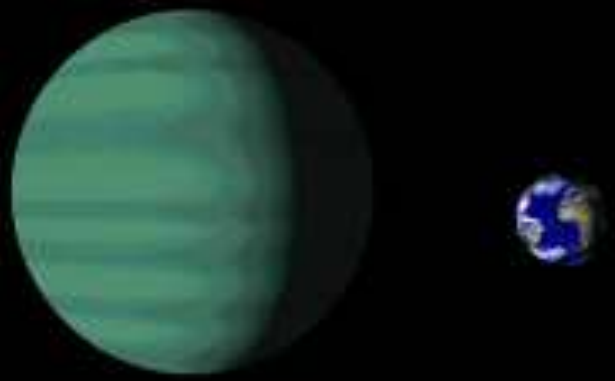
Uranus



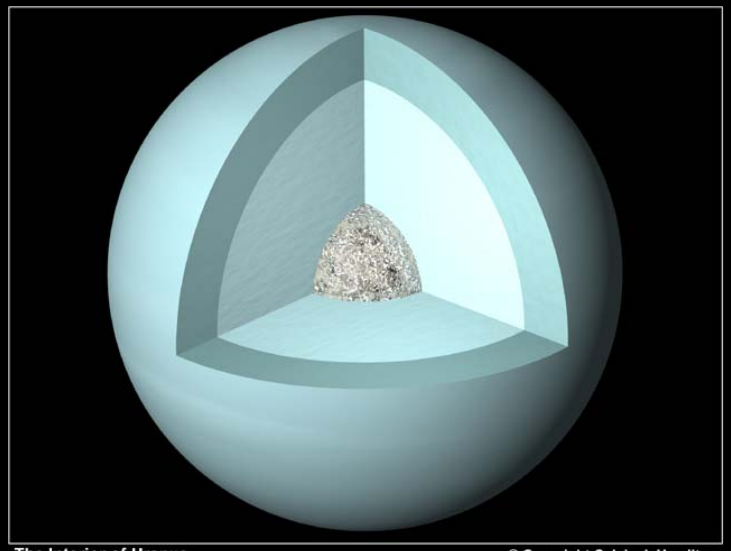

Hubble Telescope image of
Uranus and its rings and moons

# The Outer Planets

## Uranus



- *Radius:* 25,559 km
- *Surface Temperature:* -216$^{o}$ C
- *Atmosphere*: $H_2$ (82%), He (15%), $CH_4$ (2%)



The Interior of **Uranus** © Copyright Calvin J. Hamilton

*Outer:* $H_2$, He, $CH_4$

*Mantle:* $H_2O$, $CH_4$, $NH_3$ under high temperature and pressure

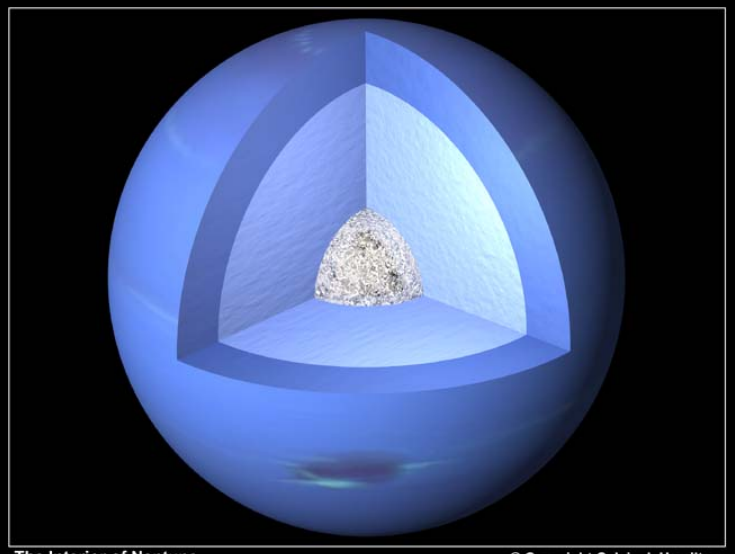
*Inner*: "icy" layer of heavier molecules ($H_2O$, $NH_4$, $NH_3$)

*Core*: rock or rocky "ice" of 1 Earth mass or so

# The Outer Planets

## Neptune

- *Radius:* 24,746 km
- *Surface Temperature:* -193$^{o}$ C
- *Atmosphere*: $H_2$ (85%), He (13%), $CH_4$ (2%)



The Interior of Neptune



*Outer:* $H_2$, He, $CH_4$

*Mantle:* $H_2O$, $CH_4$ under high temperature and pressure

*Inner*: "icy" layer of heavier molecules ($H_2O$, $NH_4$, $NH_3$)

*Core*: rock or rocky "ice" of 1 Earth mass or so