Astro 301/ Fall 2005

(48310)

Introduction to Astronomy

Instructor: Professor Shardha Jogee

TAs: David Fisher, Donghui Jeong, and Miranda Nordhaus

Lecture 2 + 3: Tu Sep 6, Th Sep 8

Topics in class this/next week

-- Math review and conventions adopted

-- ‘Natural’ units: Angstrom, Astronomical Unit , parcsec and light year

-- Important astronomical objects and concepts
   Building blocks of matter: protons, electron neutrons and atoms
   Stars: Energy Generation
   Death of Stars: Planetary Nebulae, Supernovae Remnants
   Why is human life ‘star stuff’?
   Different types of Nebulae
   Planets, Brown Dwarfs, Moons and our Solar system
   Galaxies and the Milky Way
   The Local Group, Clusters of Galaxies
   Superclusters, voids and filaments

-- Distances: From the infinitesimal to the grandest scales
-- Timescales : From the earliest epochs to the present day

Lecture 2

Lecture 2: Announcements

1. The Co-op has 49 new textbooks as of Friday for this class
   "The Cosmic Perspective, 3rd edition, Media Update"

2. What is the difference between "The Cosmic Perspective, 3rd edition" and
   "The Cosmic Perspective, 3rd edition, Media Update" ?

The book contents are the same, but the media update version comes with a full e-book, Star Gazer software, and access to The Astronomy Place (a web based tutorial system). Both are at the same price.

3. QUIZ on Tuesday, Sep 13 based on lectures 2 and 3

Class website: http://www.as.utexas.edu/~sj/a301-fa05

Astronomy Picture of the Day

The Rosette Nebula:

Cluster of bright young stars in center Winds from young massive stars clearing out a hole in center; Outer layers of dust and hot glowing gas.

Astronomy

In this course we will address these issues

The present-day Universe from the infinitesimal to the grandest scales

How did the Universe begin in a Big Bang? What physical laws govern its evolution?

Over time, how did stars, planets, life, galaxies, and black holes form and evolve?

How did galaxies like our own Milky Way form?

What is the role of dark matter and dark energy?

What are predictions for the future of our Galaxy and of the Universe?

Can science solve the ultimate mystery of Nature?

<u>Math Review: Practice from Appendix C.1 to C.4</u>

Powers of 10 for very large and small numbers

Powers of 10

- 10 to the power of a positive number n means 10 multiplied by itself n times
  number between 1 and 9 inclusive is multiplied by a power of 10

10^6 = 10 x 10 x 10 x 10 x 10 x 10 = 1, 000,000

- 10 to the power of a negative number n   refers to reciprocal

10^{-4} = 1 divided by 10^4 = $1/10^4$ =   1/ 10000 = 0.0001

Scientific Notation for very large and small numbers

Scientific Notation

- Refers to notation where a number between 1 and 9 inclusive is multiplied by a power of 10 . Convenient to express very large and small numbers

Example

Radius of H atom = 0.00000000005 m = 5.0×10^{-11} m
Radius of Earth = 6,380,000 m = 6.38×10^{6} m
Radius of Sun = 696,000,000 m = 6.96×10^{8} m

Mass of H atom = 1.67×10^{-27} kg
Mass of Earth = 5.97×10^{24} kg
Mass of Sun = 2.0×10^{30} kg

Scientific Notation for very large and small numbers

How to convert a number to scientific notation

- Move decimal point till it is after FIRST non-zero digit.
- Count the no of places (n) the decimal point has moved
- If motion is to the left then the power of ten is 10^{n} else it is 10^{-n}

Example

62050 = 62050. = 6.205×10^{4} m

0.002401 = 2.401×10^{-4} m

Radius of Sun = 696,000,000 = 6.96×10^{8} m

Radius of H atom = 0.00000000005 = 5.0×10^{-11} m

à PRACTICE FROM APPENDIX

Scientific Notation for very large and small numbers

How to convert a number from scientific notation

- Power of 10 tells you how many places to move decimal point
- Positive power means move to the right, -ve to the left
- If by moving decimal places you create spaces, then fill them with zeros

Example

6.205×10^{4} m = 62050

2.401×10^{-4} m = 0.0002401

Radius of Sun = 6.96×10^{8} m = 696,000,000

Radius of H atom = 5.0×10^{-11} m = 0.00000000005

à PRACTICE FROM APPENDIX

SI Units for measuring distance, mass, time.....

Metric or SI units

m or km for length , kg for mass, s for time

Useful conversions to SI units (Appendix)

1 km =1000 m = 0.62 mile= 1094 yards

1 kg = 1000 g = 2.205 pounds

1 h = 60 min = 3600 s

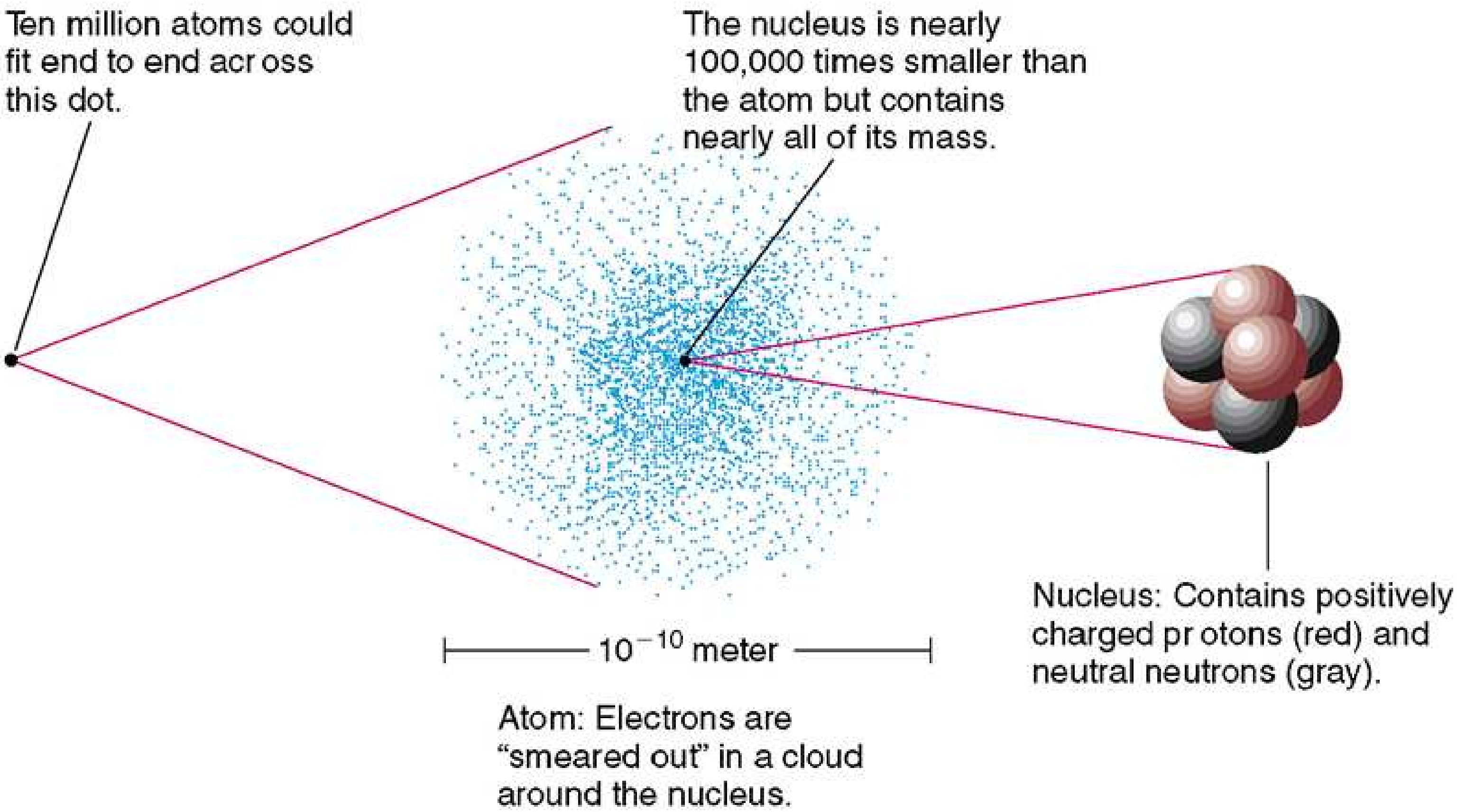
1 year = 365 days= 365 x24 h = 365x24x60 s = 31,500,000 s

‘Natural’ units: Angstrom, Astronomical Unit , parcsec and light year

See in-class notes

Building blocks of matter: protons, electron neutrons and atoms

Structure of an Atom



See in-class notes

Structure of an Atom

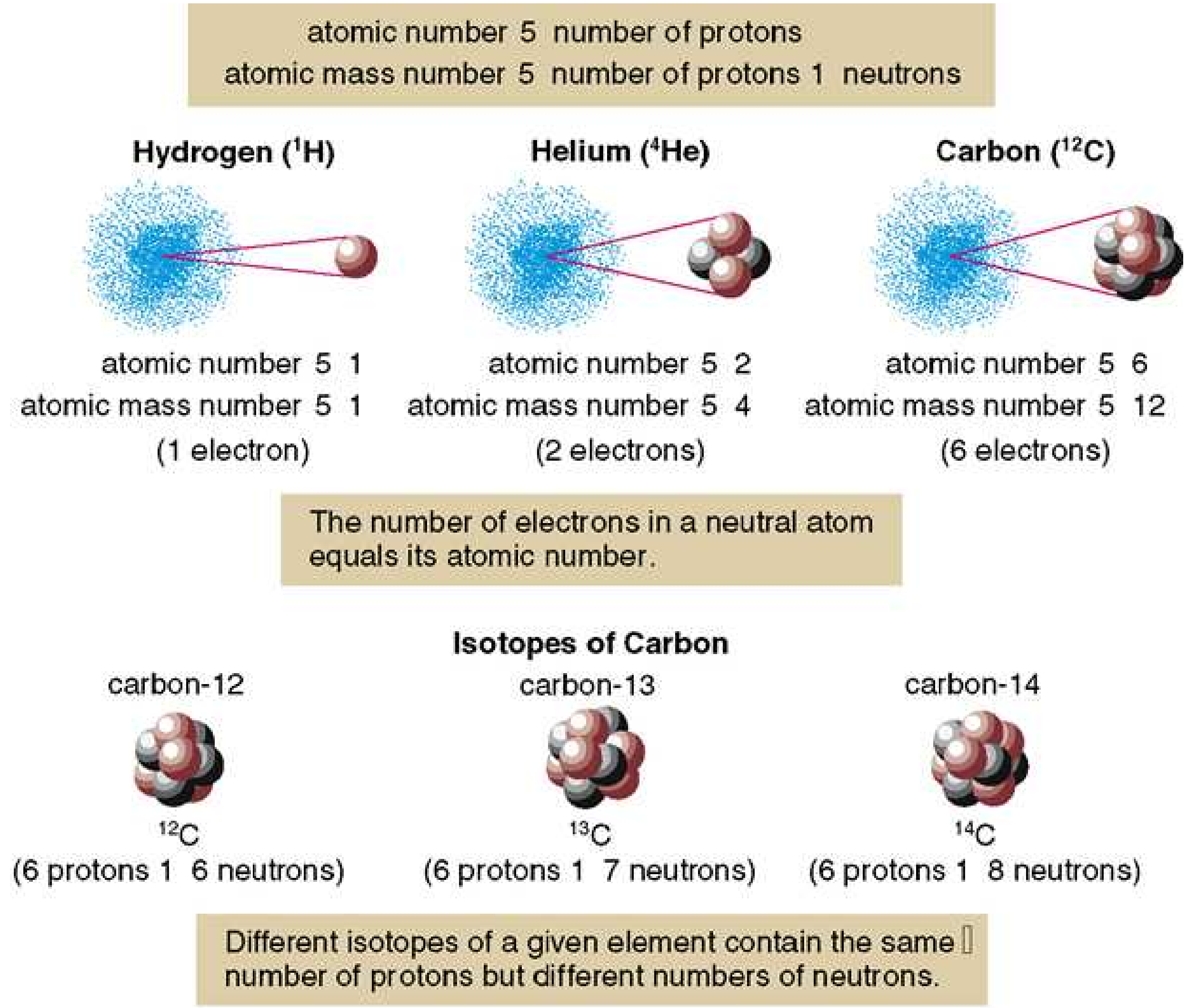
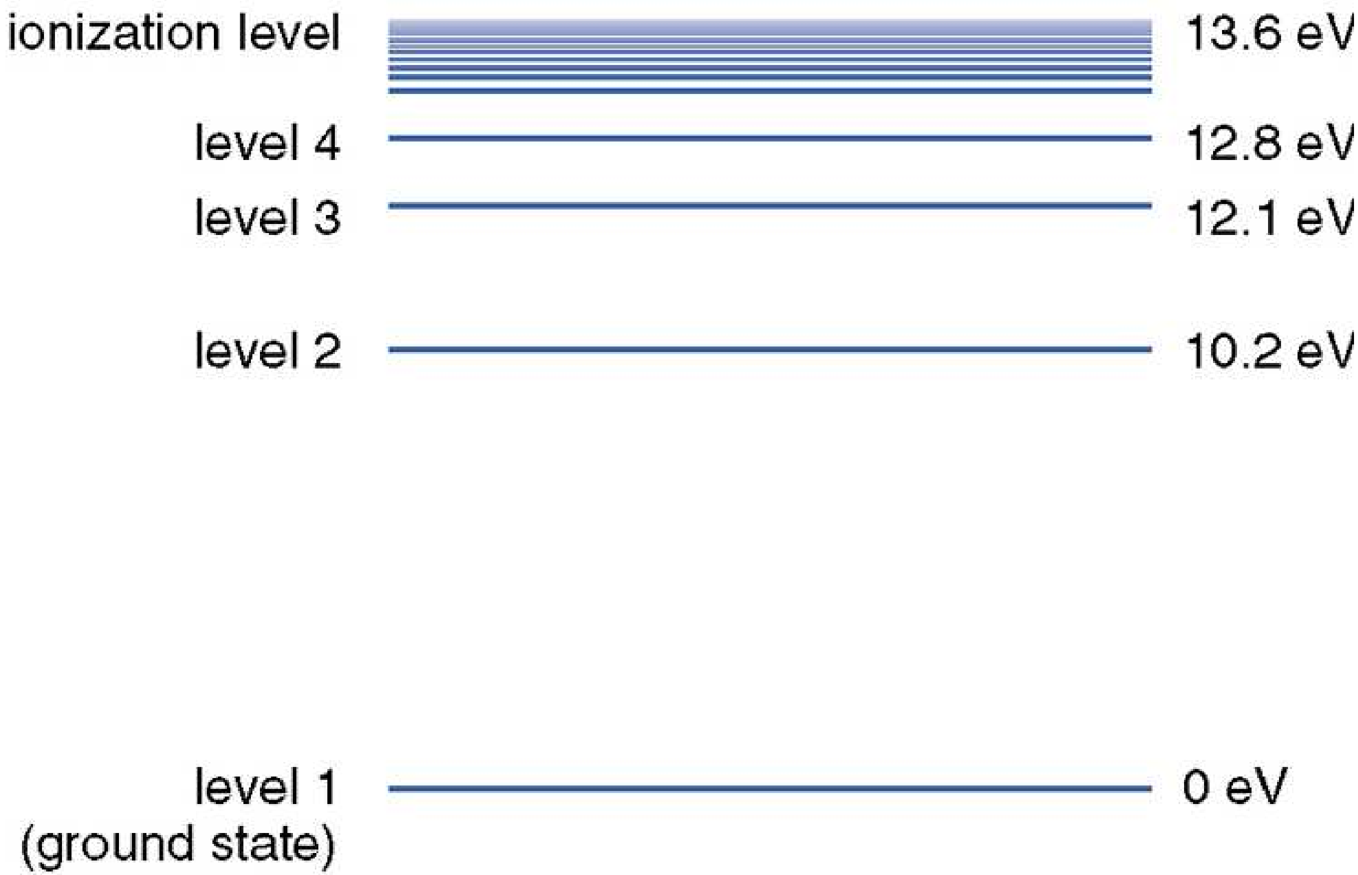


Figure captions are misprinted in book : “5” should be “=“, “1” should be “+“

E.g., 2nd caption should read : atomic mass number = number of protons + neutrons

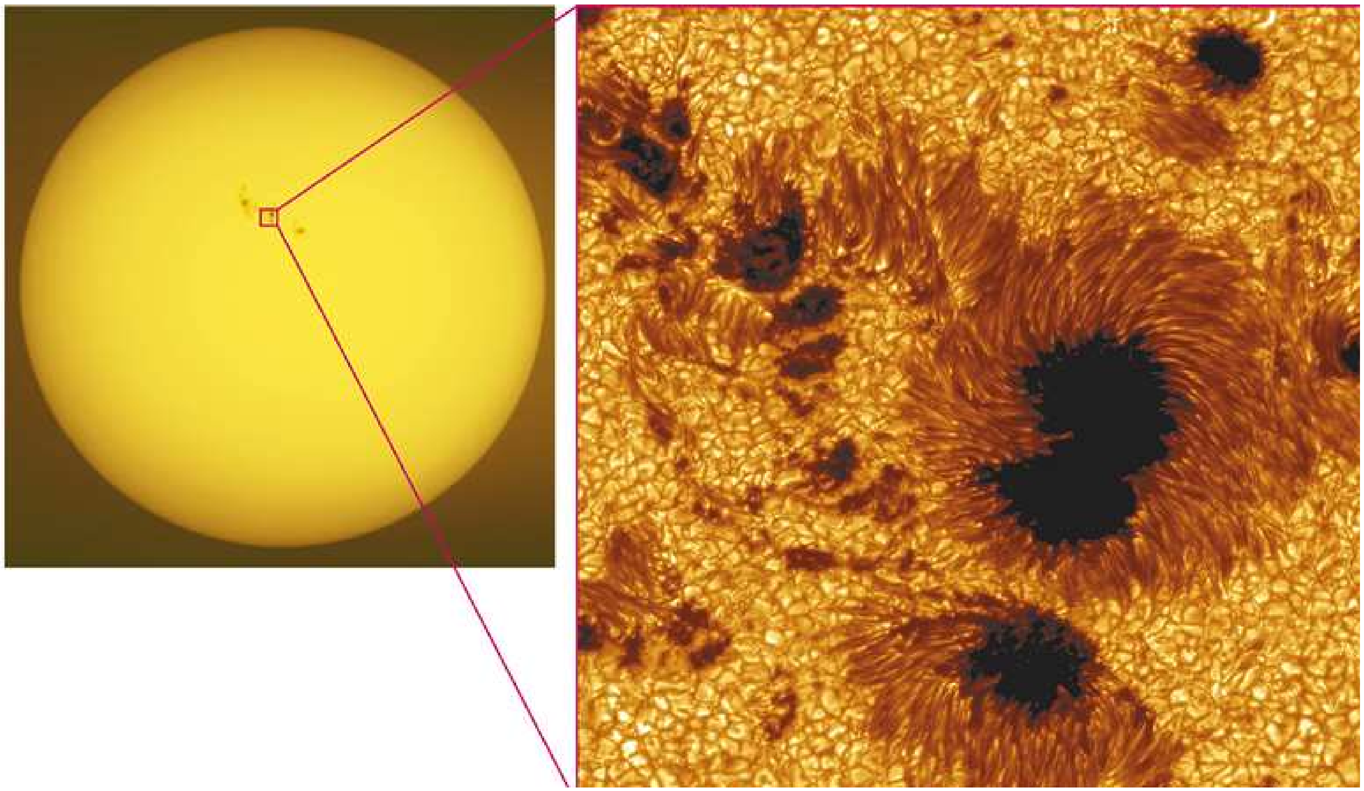
Structure of an Atom



Electrons in an atom can only populate certain discrete quantized energy levels
e, g., discrete levels for Hydrogen atom above

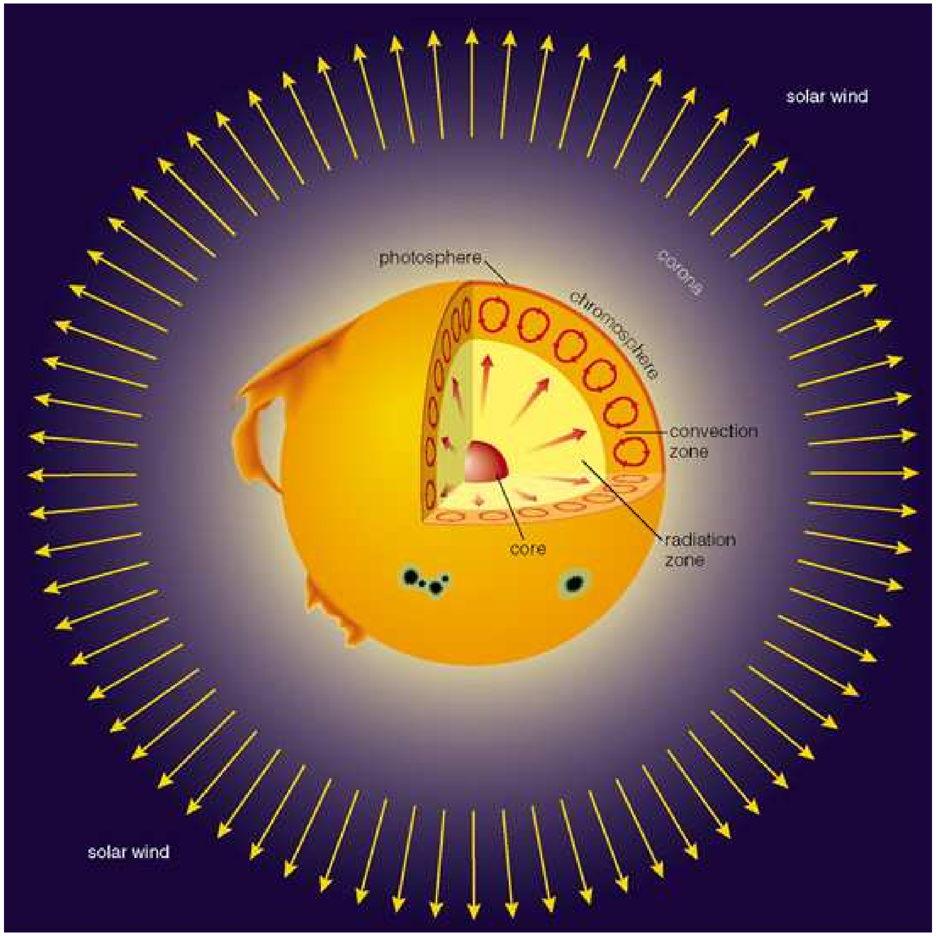
Stars: Energy Generation

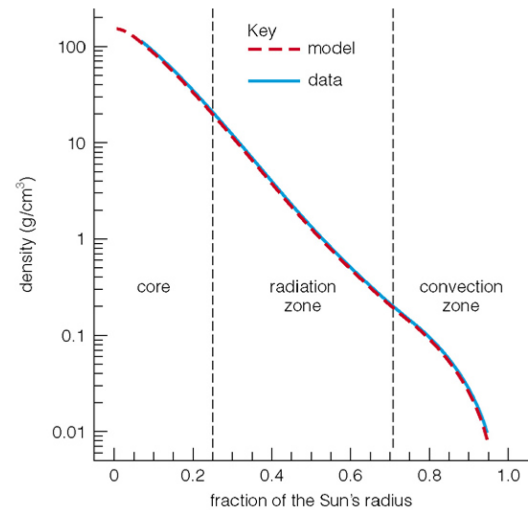
Stars: see in-class notes

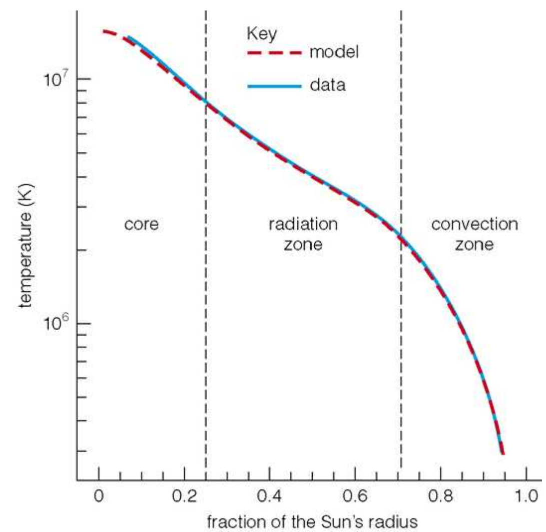


Our Sun

Structure of a star like the Sun



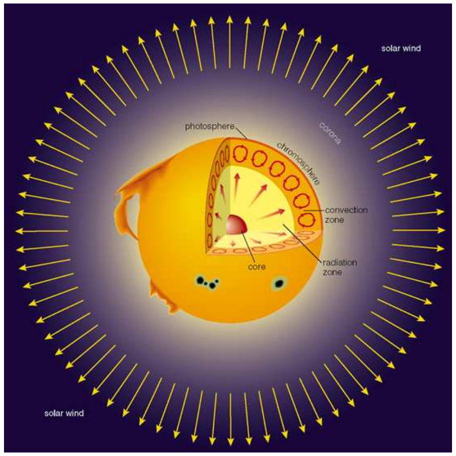


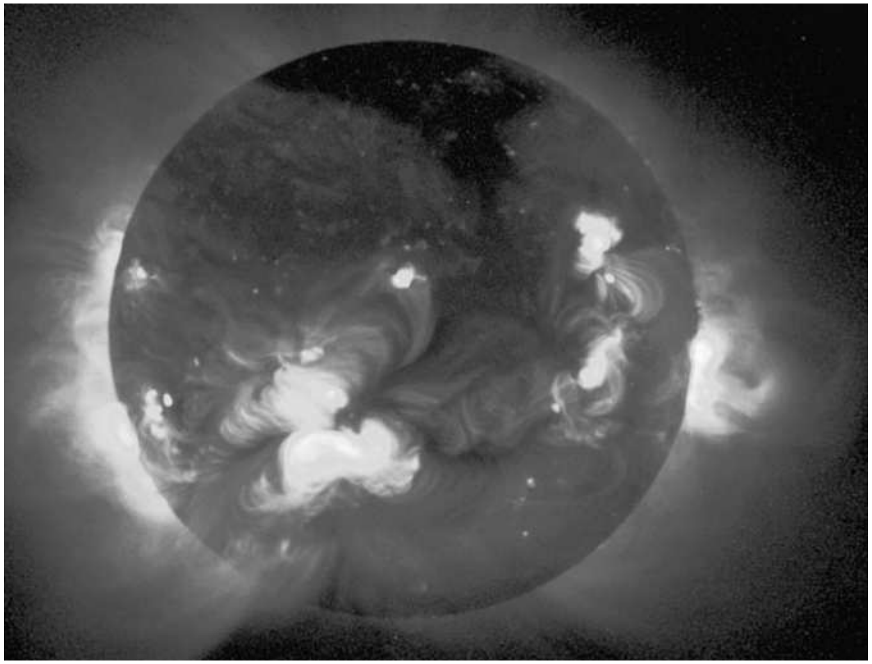


- Nuclear fusion occurs in core where temp and pressure are very high.
- The energy released is transported from core to the cooler surface (called photosphere) where it is released as light and heat. This is the ‘surface’ where visible yellow light from the Sun comes from.

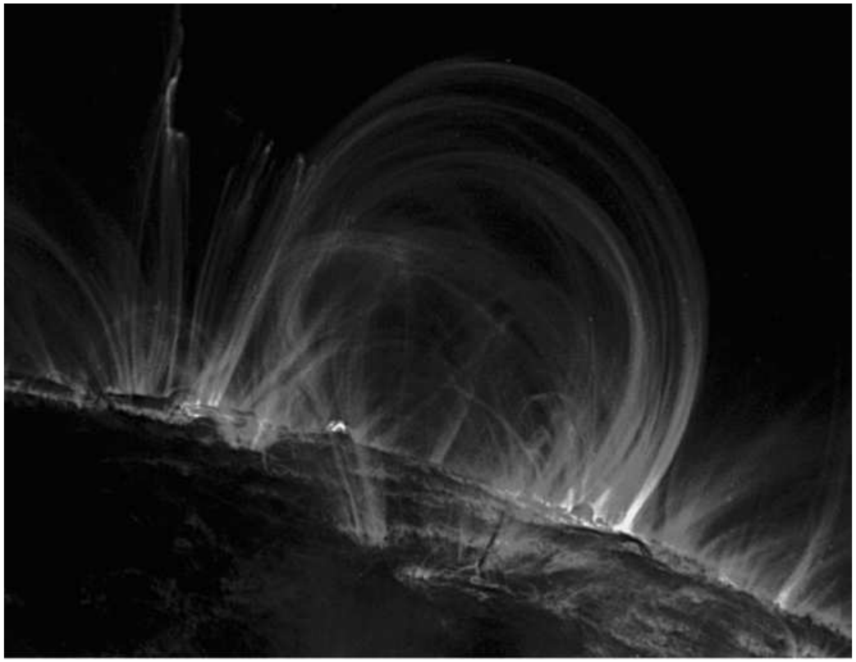
Corona of the Sun

As we move away from the photosphere (solar surface) temperature suddenly start to go up again….
Corona at T=10^6 K emits most of Sun's X-rays





X-ray image (Yonkoh Space Observatory)
Hot million-degree gas in Solar corona



X-ray image (NASA's TRACE mission): hot million degree gas trapped in magnetic field

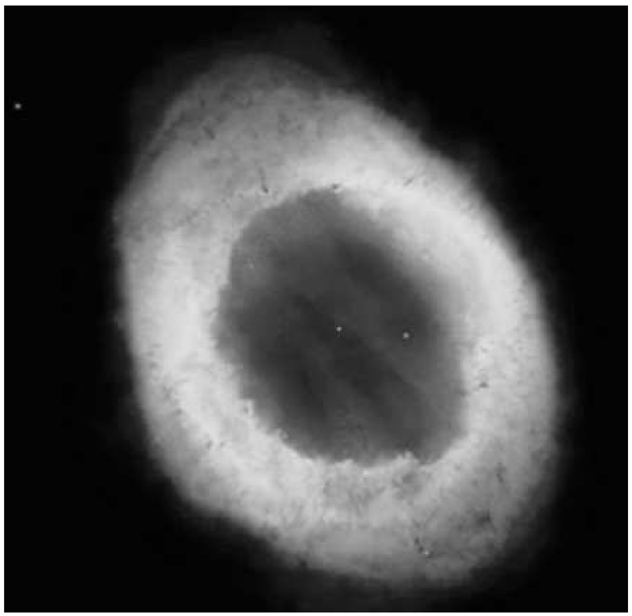
Death of Stars: Planetary Nebulae, Supernovae Remnants

When a_low-mass (M=0.08 to 1.5 solar ,mass) star dies

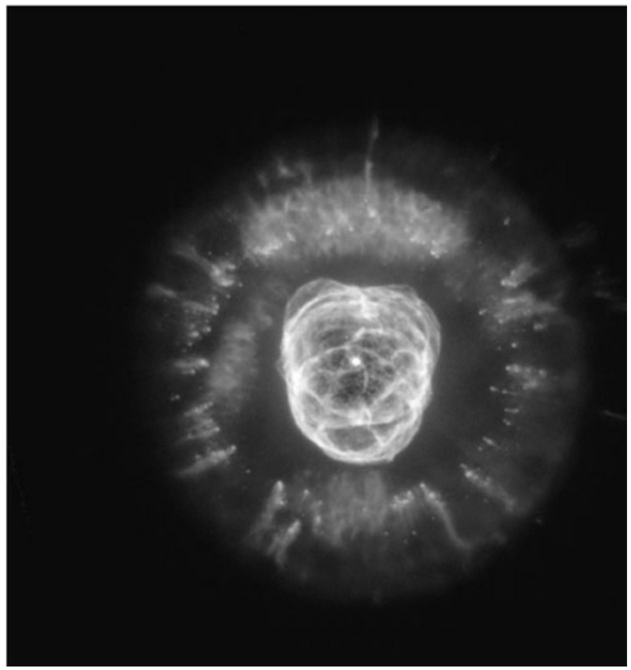
à its inert core becomes a white dwarf

à its outer layers of gas are ejecte as a glowing hot ball of gas called a planetary nebula which contains mostly H, He, C, but no significant amounts of O, N, Sulfur, Silicon, Iron.

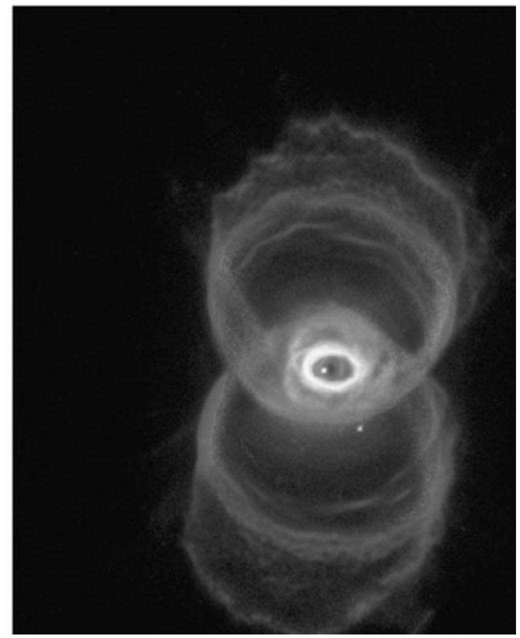
à Glow fades within a million years as core cools and gas cools and disperses.



Ring Nebula



Eskimo Nebula



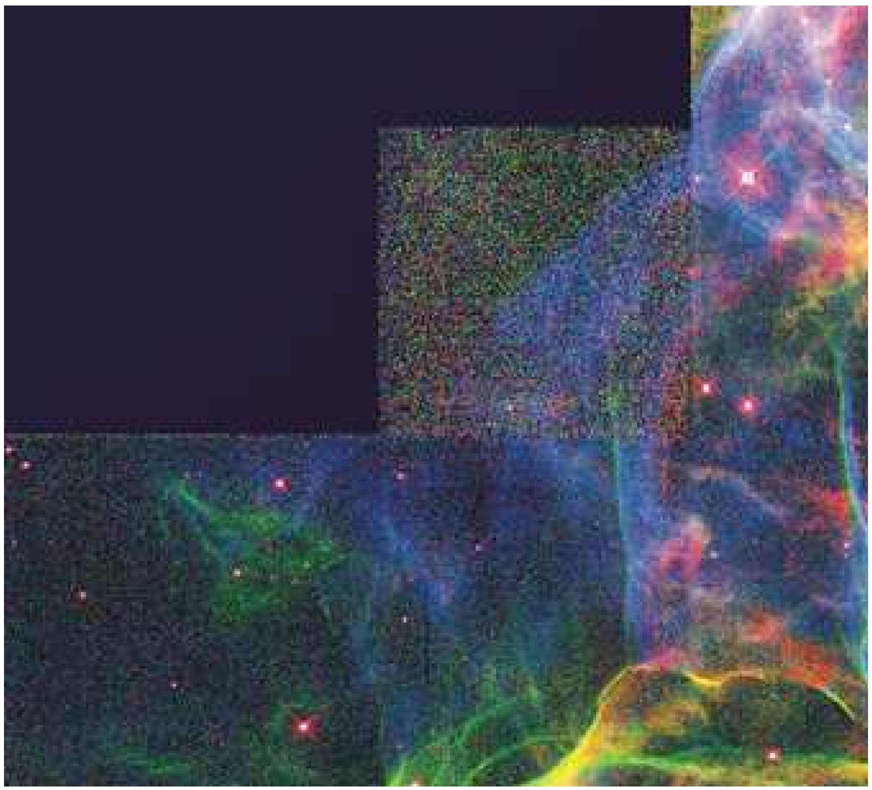
Hourglass Nebula

Planetary nebulae have nothing to do with planets!

When a_high-mass (M> 8 solar mass) star dies

à its core becomes a neutron star or black hole,

à its outer layers of gas are blown by a supernova (SN) explosion into a glowing hot ball of gas called a SN remnant . The remnant contains H, He, C, and also heavy elements O, N, Sulfur, Silicon, Iron that were made via advanced fusion.



SN remnant called Cygnus loop;
HST/optical image: Blue, green =O, Red= S

Supernova remnant called Crab Nebula; VLT/Optical

Why is human life ‘star stuff’?

Elements produced a few minutes after the Big Bang, and before the first stars

= H (~77%0, He (~23%), Li (trace amounts)

à no C, N O in the primorodial gas

But today, humans are made up of water (H_2 0) , carbon (O), N (protein, DNA)

Earth's atmosphere : mostly N, O

C, N and O are produced by advanced fusion in core and layers of high-mass (M> 8 solar mass) star. (Low mass stars may produce some C, but no significant N O).

When the high mass star dies

- its core becomes a neutron star or black hole,
- its central and outer layers of gas containing H, He, C, and N, O, Sulfur, Silicon, Iron are blown out by a supernova (SN) explosion, and form a SN remnant, made of hot glowing gas.

The remnant enriches surrounding gas with these elements and the gas later collapses to form a new generation of stars and planets, where life based on C, N 0, Iron may develop

Supernova remnant called Crab Nebula; VLT/Optical

Lecture 3

Lecture 3: Announcements

QUIZ on Tuesday, Sep 13 based on lectures 2 and 3

Book is on reserve at the Physics, Math and Astronomy (PMA) library

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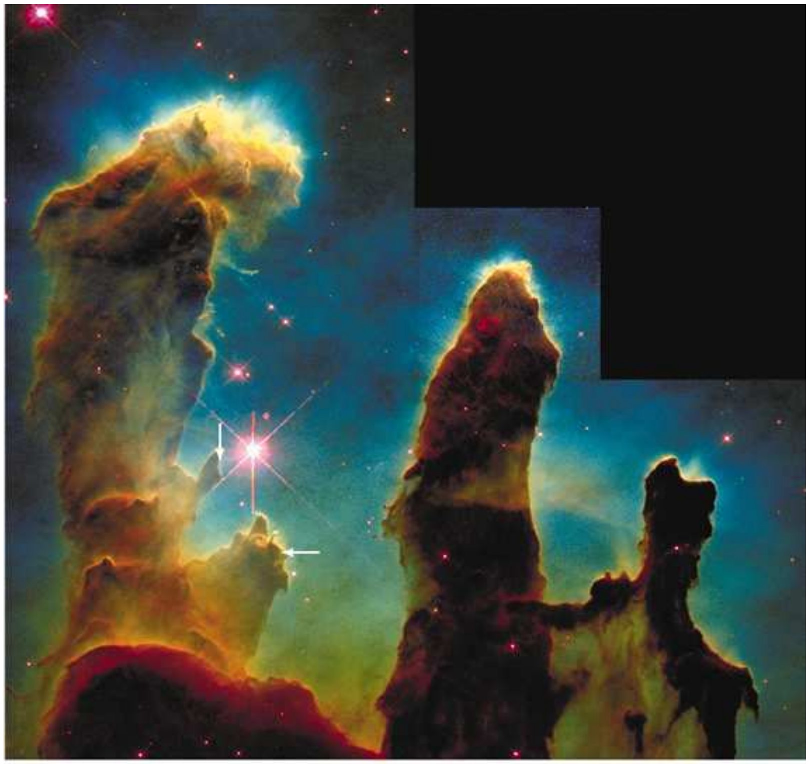
***Different types of Nebulae ***

What is the difference between nebulae like Orion and a planetary nebula?

See in-class note

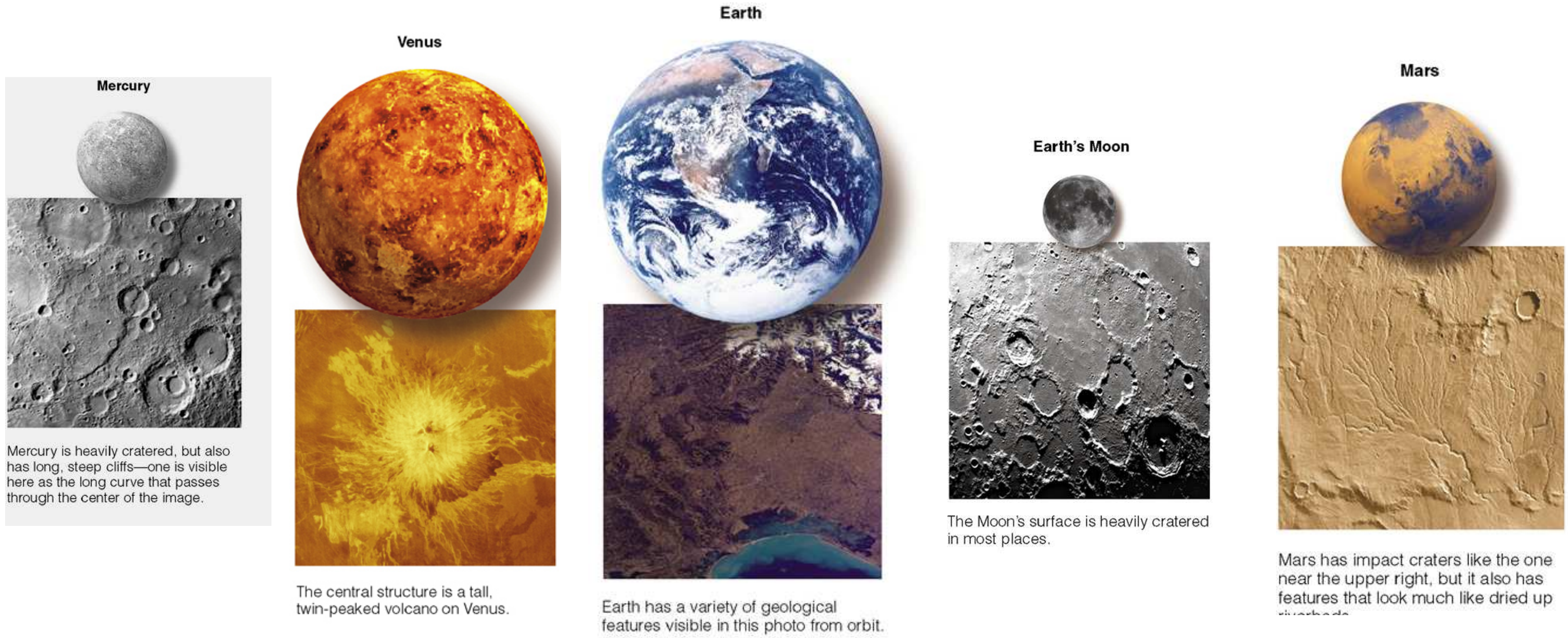


Part of Eagle Nebula
(5 ly across)

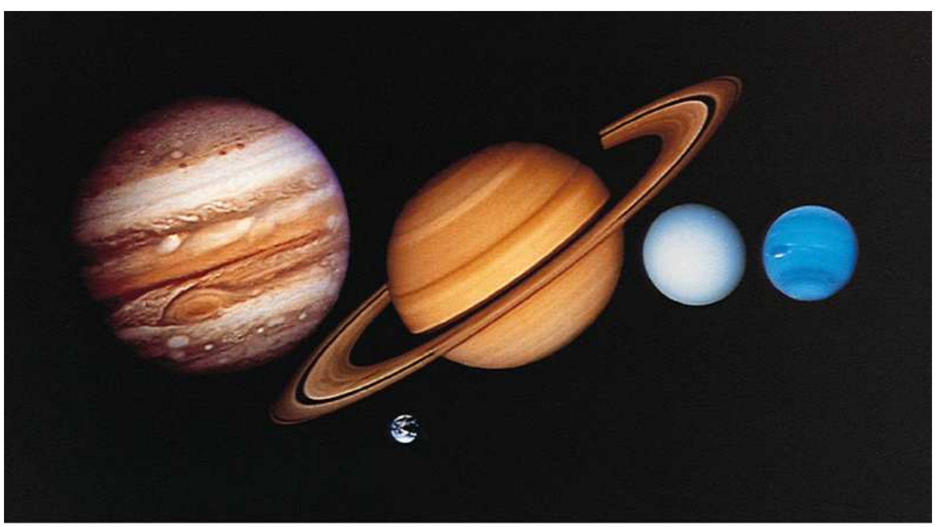
Orion Nebula

Planets, Brown Dwarfs, Moons and our Solar system

Planet : see in-class notes



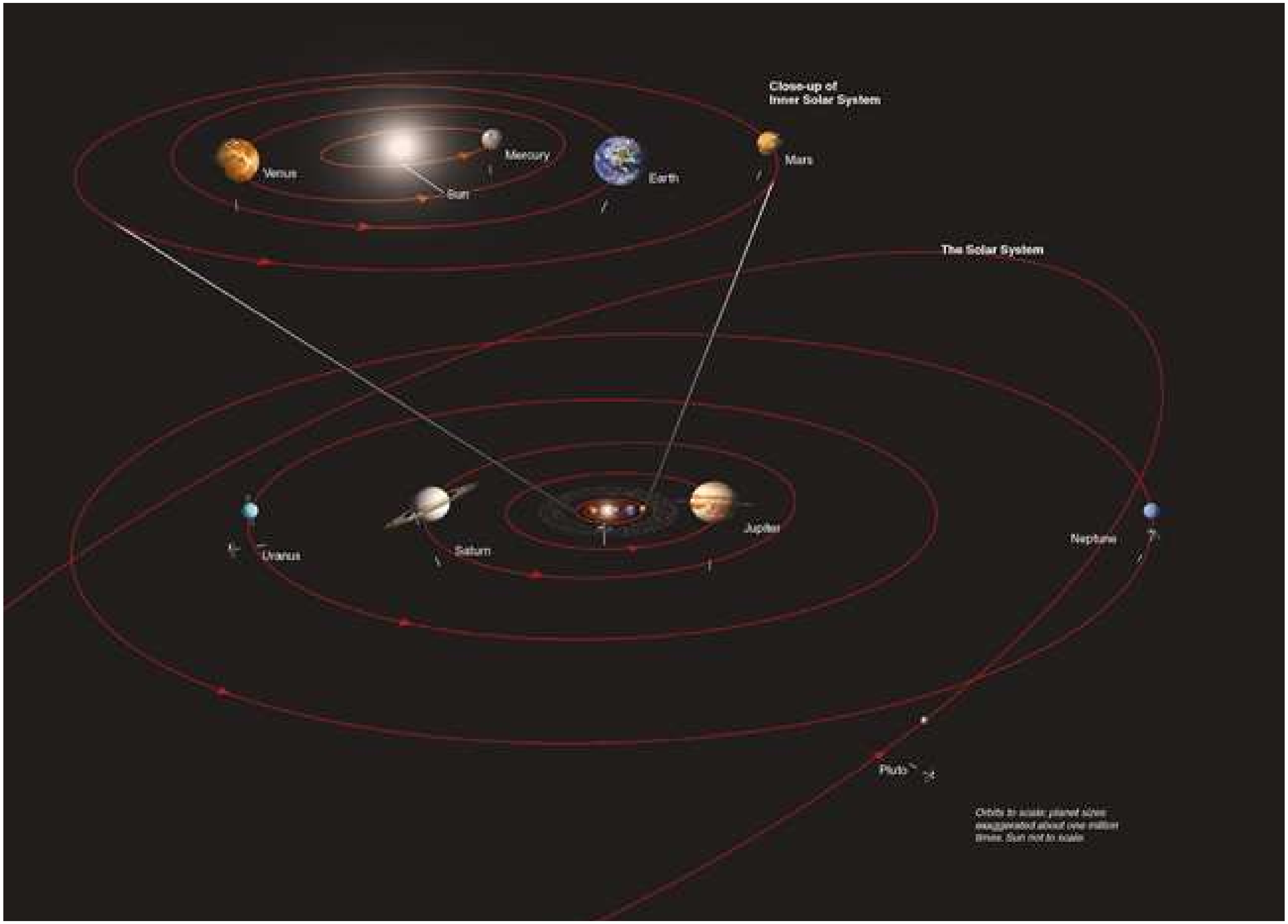
Mercury,Venus,Earth,E's Moon, Mars



Jupiter, Saturn, Uranus, Neptune

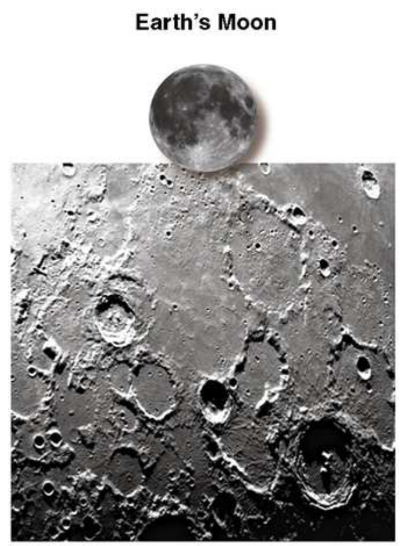
Our Solar System

Distance between Earth and Sun = 1.5×10^{11} m = 1AU ; Pluto-Sun ~ 39.5 AU

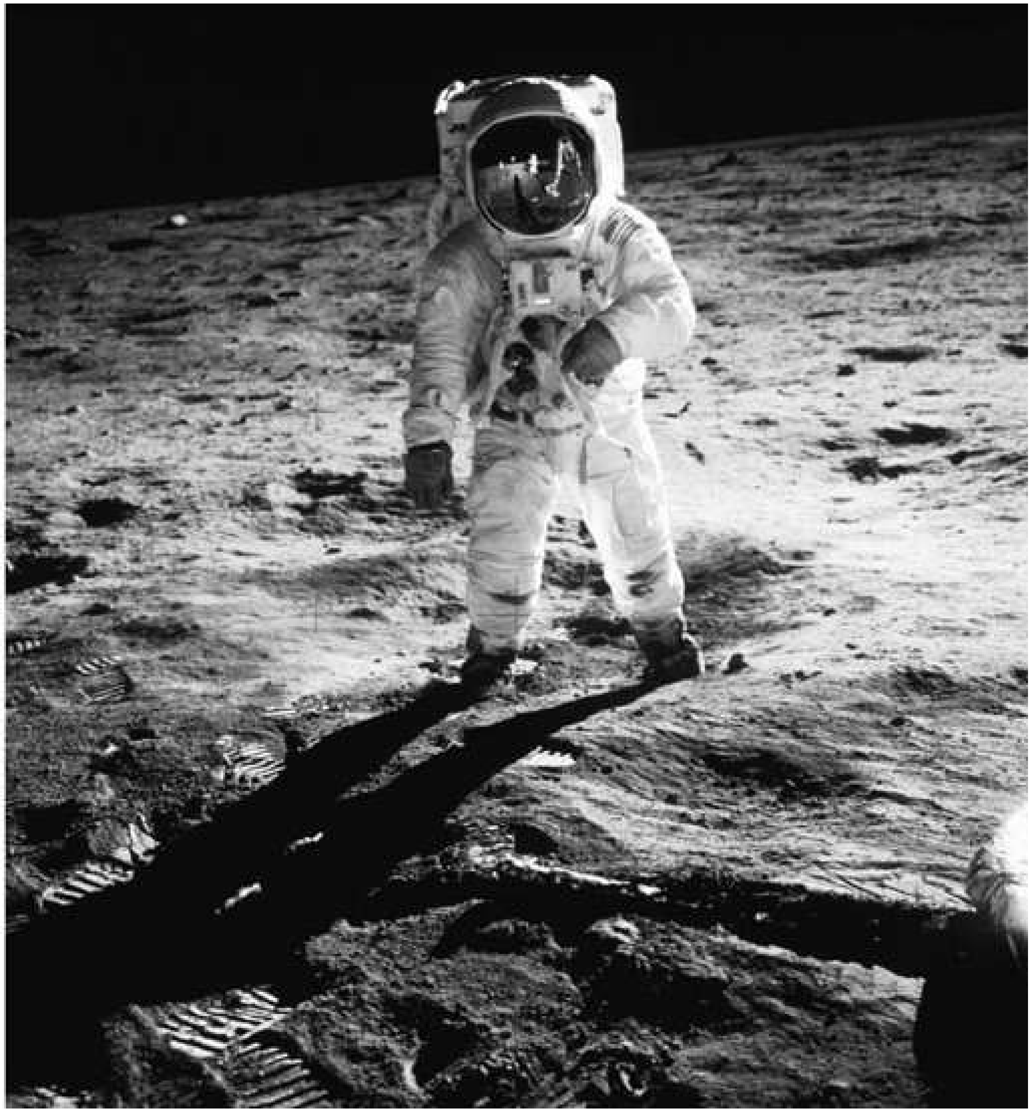


Moon: see in-class notes

Titan, moon of Saturn is one of the largest moons in solar system. It is comparable in size to the planet Mars!



Earth's moon has a heavily cratered surface



To boldly go where no one has before….

Apollo II i(1969). First landing on Earth's moon!

"A small step for man, one giant leap for mankind"

Cassini-Huygens mission to Titan, the moon of Saturn

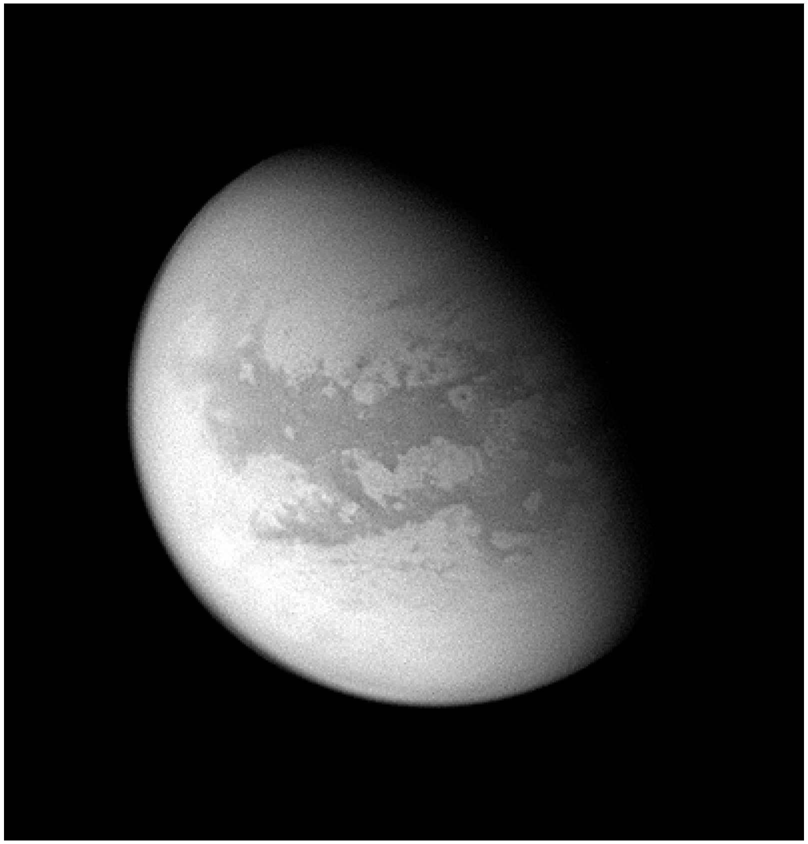
Huygens probe descending through Titan's Atmosphere (ESA)

- Cassini-Huygens mission to Saturn : robotic spacecraft sent on to orbit Saturn and study the Saturnian system. Launch Oct 1997; 7 years to reach Saturn; study Saturn system for 4 years till 2008)

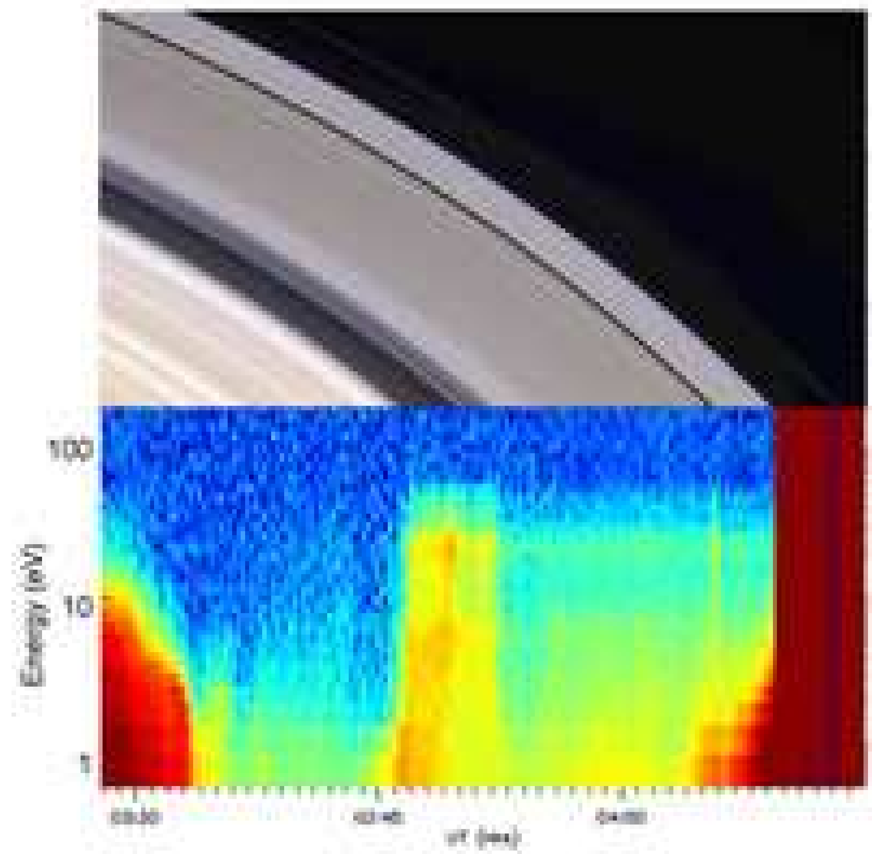
- Scientific probe Huygens : released in Nov 2004 from the main spacecraft; parachutes through the atmosphere and lands on the surface of Titan, Saturn’s largest moon.

Huygens= first spacecraft to land on a world in the outer Solar System. I

Cassini-Huygens mission to Titan, the moon of Saturn

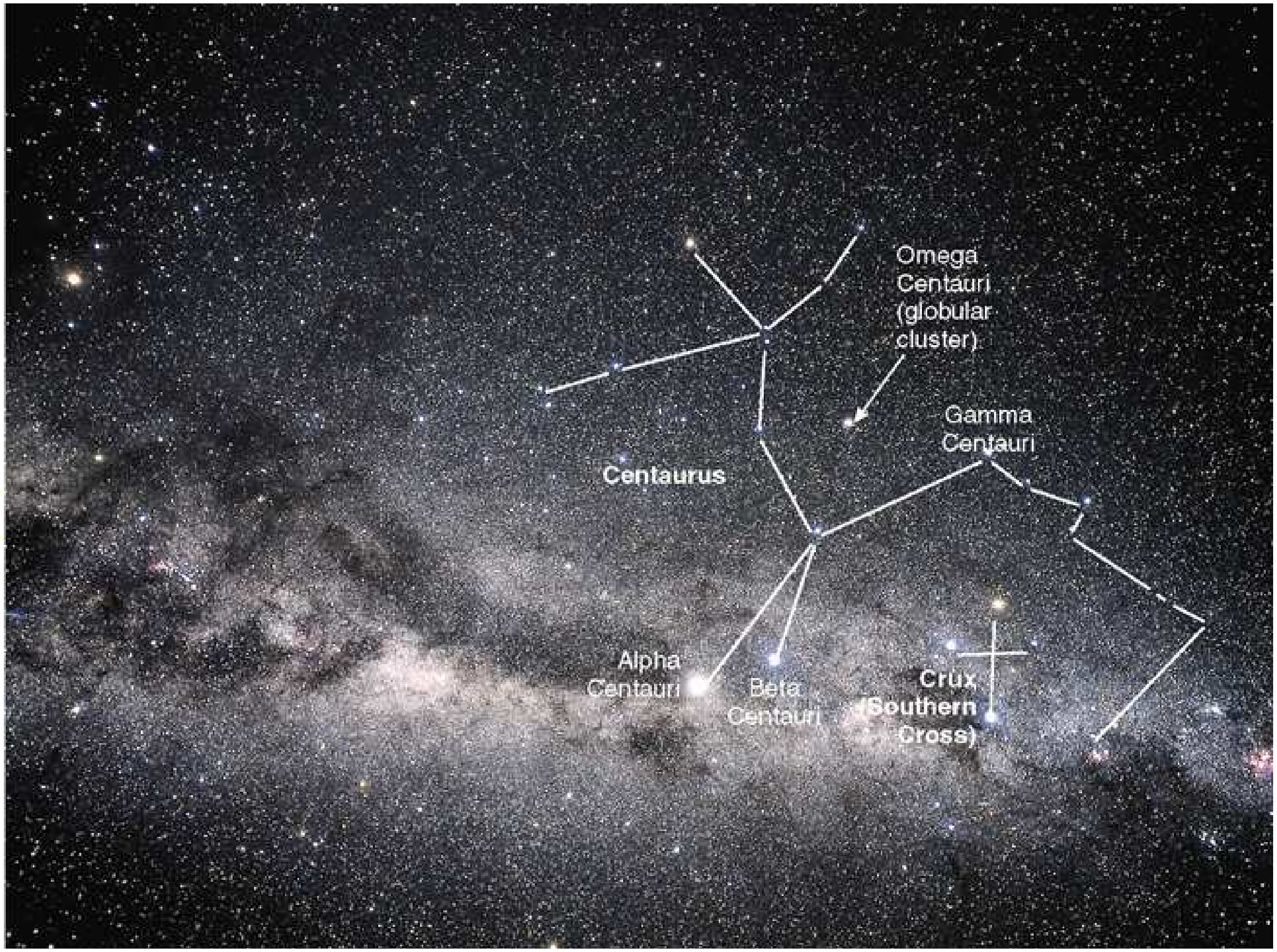


Titan as seen from Cassini's fly-by on August 22, 2005



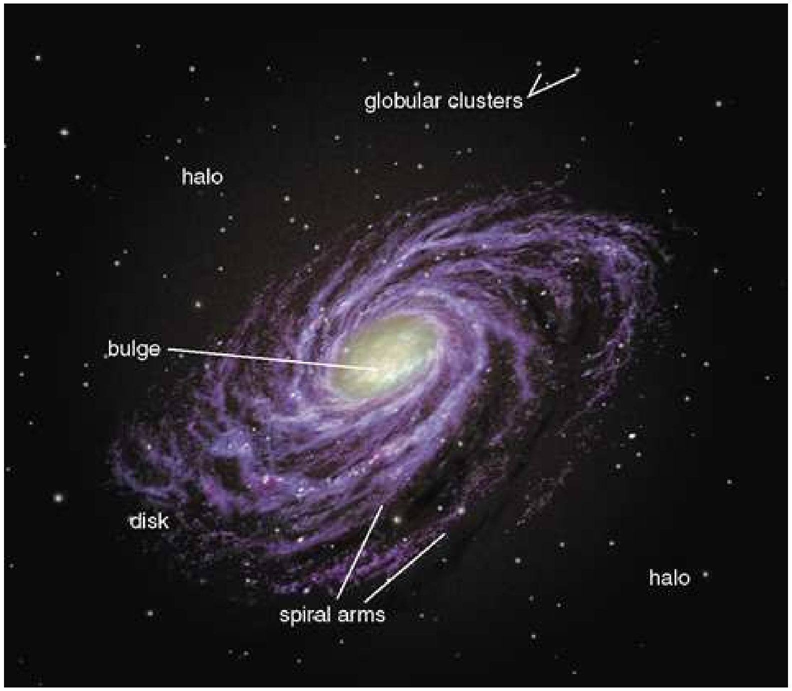
Saturn’s rings have own atmosphere, composed principally of molecular oxygen

The nearest star from the Sun


Omega Centauri (globular cluster)
Gamma Centauri
Centaurus
Alpha Centauri
Beta Centauri
Crux (Southern Cross)

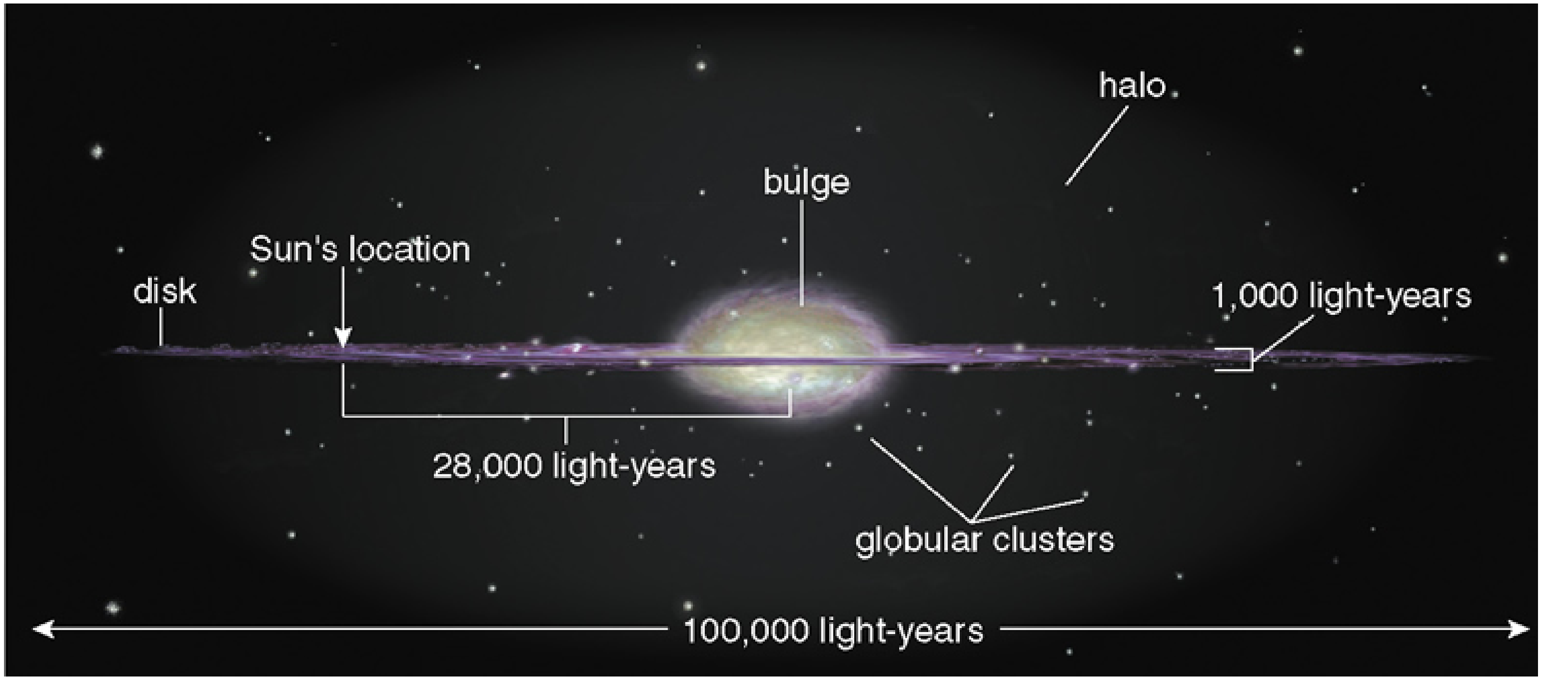
Galaxies and our Milky Way

Galaxies: See in-class notes



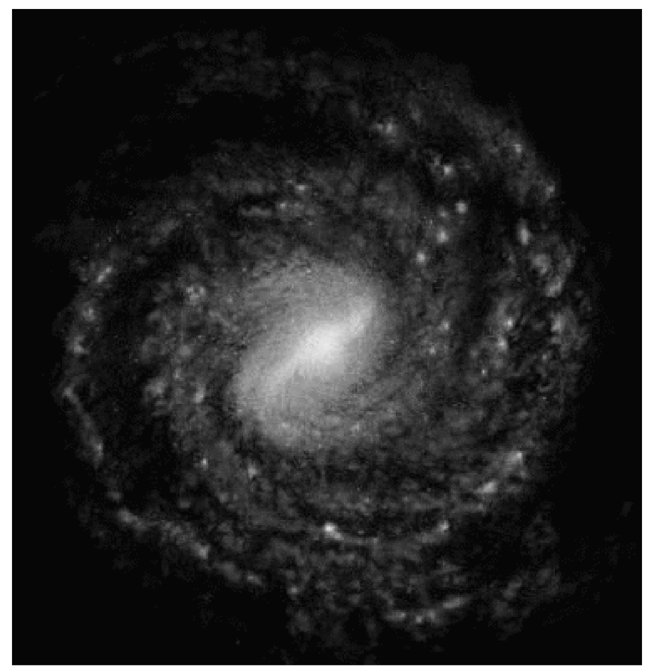
Ubarred spiral

NGC1300; Barred spiral
150,000 ly across



Edge on view

Face on view



Or Galaxy, the Milky Way is a barred spiral galaxy, 100,000 light years across, hosting our Sun and Solar system

In-class demo: Zooming 26 orders of magnitude (part 1)

Human - Earth - Solar System - Alpha Centauri - Milky Way Galaxy

Groups and Clusters of Galaxies

The Local Group

See In-class notes

Brightest members of Local Group?

Closest galaxy neighbors of Milky Way? Interactions of Milky Way?

LMC; Irr;

Size = 30,000 ly Dist = 0.16×10^{6} ly