Astro 301/ Fall 2006
(50405)

Introduction to Astronomy
http://www.as.utexas.edu/~sj/a301-fa06

Instructor: Professor Shardha Jogee
TAs: Biqing For, Candace Gray, Irina Marinova

Lecture 2: Tu Sep 5
Some topics we will address

Constituents of the Universe: stars, galaxies, planets, dark matter, dark energy.

What physical laws govern the evolution of the Universe from the Big Bang to now?

How do stars form, shine and die? Why are we ‘stardust’?

When and how did stars, planets, galaxies, and black holes form?

How did galaxies like our own Milky Way form? How will they evolve?

What is the role of dark matter and dark energy?
Recent and Upcoming Topics in class

-- Recap: Course Overview and Basic Math Skills

-- Natural units in Astronomy

-- Overview of Astronomical Objects
   Building blocks of matter: protons, electron, neutrons, and atoms
   Stars
   Brown Dwarfs, Planets, and Moons
   Death of Stars: Planetary Nebulae, White Dwarfs, Supernovae remnants
   Why is human life `star stuff’?'
   Different Type of Nebulae: Star-forming nebulae vs Planetary nebulae
   Galaxies and the Milky Way

-- Scales and Distances: From the infinitesimal to the grandest
-- Angular scales and sizes

-- Timescales : From the earliest epochs to the present day
**Basic Math Skills For This Course**

- For this class, you need to master **all the basic math skills in Appendix C** of the textbook (also posted on the class website) by the next lecture. e.g.,
  - Powers of 10 and Scientific Notation
  - Metric or SI units (e.g., m for length, kg for mass, s for time)
  - Unit conversions: e.g., from Angstrom, pc, ly to m, from years to seconds, etc

**Examples**

- Radius of H atom = 0.00000000005 m = \(5.0 \times 10^{-11}\) m
- Radius of Earth = 6,380,000 m = \(6.38 \times 10^6\) m
- Radius of Sun = 696,000,000 m = \(6.96 \times 10^8\) m
- \(10^{-4} = \frac{1}{10^4} = 1/10000 = 0.0001\)
- 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 x 24 h = 365 x 24 x 60 s = 31,500,000 s

- Symbols and conventions for the course: see in-class notes
Lecture 2

Announcements

1. See class website for latest announcements

2. Quiz on Tu Sep 12 based on
   - lectures in week 02 (Sep 5 and 7),
   - assigned reading for weeks 02 and 03.
Overview of Astronomical Objects
Building blocks of matter: protons, electrons, neutrons and atoms

Ten million atoms could fit end to end across this dot.

The nucleus is nearly 100,000 times smaller than the atom but contains nearly all of its mass.

Atom: Electrons are “smeared out” in a cloud around the nucleus.

Nucleus: Contains positively charged protons (red) and neutral neutrons (gray).

See in-class notes
The electrons in the “electron cloud” around the nucleus can only have certain specific amount of energies. They are said to occupy discrete allowed energy levels. The allowed levels for the e in a Hydrogen atom is shown above.
Atomic Number $X$ and Atomic Mass Number $A$

See in CLASS NOTES

Hydrogen ($^1\text{H}$)

Helium ($^4\text{He}$)

Carbon ($^{12}\text{C}$)

Isotopes of Carbon

- Carbon-12 ($^{12}\text{C}$)
- Carbon-13 ($^{13}\text{C}$)
- Carbon-14 ($^{14}\text{C}$)
Stars
Nuclear fusion occurs in core where temp and pressure are very high. T drops from $1.5 \times 10^7$ K in the core down to 5800 K at the surface or photosphere. The energy released is transported from core to the photosphere where it is released as light and heat.
Corona of the Sun

T drops from core ($1.5 \times 10^7$ K) to photosphere (5800 K), but rises again in the solar corona ($10^6$ K). The hot gas in the corona emits most of the 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
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Lecture 3: Th Sep 6
Lecture 3

Announcements

1. See class website for latest announcements

2. Quiz on Tu Sep 12 based on
   - lectures in week 02 (Sep 5 and 7),
   - assigned reading for weeks 02 and 03.

For those with textbook edition 3    follow reading list in online calendar
   1.1, 4.3, 1.2, 2.1 (Milky Way), 2.2 (Angular measures of size and distance)

For those with textbook edition 4    we will post an alternate calendar tonight
   1.1, 5.3, 1.2, 2.1 (Milky Way), 2.1 (Angular size, physical size, and distance)
Brown Dwarfs, Planets, and Moons
Planet: see in-class notes

Mercury is heavily cratered, but also has long, steep cliffs—one is visible here as the long curve that passes through the center of the image.

The central structure is a tall, twin-peaked volcano on Venus.

Earth has a variety of geological features visible in this photo from orbit.

The Moon's surface is heavily cratered in most places.

Mars has impact craters like the one near the upper right, but it also has features that look much like dried up channels.

Mercury, Venus, Earth, E’s Moon, Mars

Jupiter, Saturn, Uranus, Neptune
Our Solar System

Sun (star) + 9 planets M, V, E, Mars, J S N U (P=dwarf planet)
Distance between Earth and Sun = $1.5 \times 10^{11}$ m = 1AU;  Pluto-Sun= 39.5 AU
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
Cassini-Huygens mission to Saturnian system and Titan.

* Cassini-Huygens mission: Launch Oct 1997; reached Saturnian system in 2004;
* Will study Saturnian system: rings, moons, atmosphere of Titan (Saturn’s largest moon) till 2008
* Scientific probe Huygens: released in Nov 2004, parachutes through atmosphere and lands on Titan
  - first spacecraft to land in the outer Solar System.
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
Death of Stars: Planetary Nebulae, Supernovae remnants
Supernovae Remnants and Neutron Stars or Black Holes
- See in class notes

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

Supernova remnant called Crab Nebula; VLT/Optical
To boldly go where no one has before....

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

“A small step for man, one giant leap for mankind”
Planetary Nebulae and White Dwarfs

- See in class notes
- Planetary nebulae have nothing to do with planets!

Ring Nebula  Eskimo Nebula  Hourglass Nebula
Why is human life `star stuff'?'
- See in class discussion
A metal-rich gas cloud collapses to form a star + its planetary system

Simulation starts with a gas cloud having
mass ~ 50 x Mass of Sun
diameter = 1.2 ly (10^16 m)
temperature ~10 K

Cloud collapses under the force of gravity and fragments into dense gas clumps. These clumps form stars

Around some of these stars are swirling discs of gas which may go on later to form planetary systems like our own Solar System.