LECTURE 1 (1/6): INTRODUCTION TO COURSE

1.1 COURSE OBJECTIVES

- Convey basic astronomical knowledge about stars, galaxies, and the universe.
- Describe some outstanding problems that are the focus of current research.
- Illustrate how astrophysical theories are developed and tested against observations.

A central assumption: The fundamental physical laws that apply on earth and can be tested in terrestrial laboratories also apply to astronomical objects. Physics can teach us about astronomy, and astronomy can teach us about physics.

1.2 SCIENTIFIC NOTATION

Astronomy deals with very large and very small numbers, so we will frequently use scientific notation.

10^0		1
10^1		10
10^2	10×10	100
10^3	$10 \times 10 \times 10$	1,000
10^6	$10^3 \times 10^3$	1 million
10^9	$10^3 \times 10^6$	1 billion
10^{12}	$10^6 \times 10^6$	1 trillion
10^{-1}	$1/10$	0.1
10^{-2}	$1/10^2$	0.01
10^{-3}	$1/10^3$	0.001

1.3 ELECTROMAGNETIC RADIATION

We observe the universe (and the everyday world) primarily with electromagnetic radiation.

A wave (e.g., in the ocean) is a propagating disturbance. An electromagnetic wave is a propagating disturbance in an electromagnetic field, which affects electrical charges and magnets.

Electromagnetic waves (a.k.a. electromagnetic radiation) can be characterized by their wavelength, λ, or by their frequency, $\nu = c/\lambda$.

The electromagnetic spectrum encompasses (from shortest wavelength to longest wavelength): gamma rays, X-rays, ultraviolet radiation, visible light, infrared radiation, microwaves, and radio waves.

All forms of electromagnetic radiation are carried by parcels of energy called *photons*. All photons travel at the speed of light:

$$c \;=\; 300,000 \text{ km/s} \;=\; 186,000 \text{ miles/s}.$$

Photons have properties of both waves and particles.

The energy of a photon is proportional to its frequency, $E = h\nu = hc/\lambda$. Gamma-ray photons have the highest energy, radio photons have the lowest energy.

Only visible light and radio waves can easily get through to the earth's surface. Most other electromagnetic radiation is absorbed by the atmosphere, and astronomers can observe it only from satellites.

1.4 DOPPLER SHIFTS

The wavelengths of waves emitted by a moving source are shifted by the Doppler effect.

Source moving away $\longrightarrow$ light shifted to red (longer wavelength).
Source moving towards $\longrightarrow$ light shifted to blue (shorter wavelength).
The shift is small if speed is much smaller than c.

An astronomer can use a spectrograph (very fancy prism) to measure the *spectrum* of an object, the intensity of its light as a function of wavelength.

The spectrum of a star contains many narrow dark bands, where atoms and molecules in the star's atmosphere absorb light.

By comparing the wavelength at which we observe a line to the wavelength at which it was emitted, we can determine the velocity of the star relative to us.

1.5 ASTRONOMY AND TIME

With a few exceptions, astronomical objects do not change on human timescales.

- Lifetime of a short-lived star: 10 million years
- Age of the solar system: 5 billion years
- Age of the universe: 10 to 20 billion years

We must build our understanding of the history of stars, galaxies, and the cosmos from "snapshots."

Three broad approaches:

(1) Reconstruct history via theory; test theories with observation.
(2) Infer timescale from frequency, more common $\longrightarrow$ longer lived.
(3) Look at distant objects to see back in time. Telescopes as time machines.

Unlike most sciences, astronomy is "look but don't touch." We cannot experiment with astronomical objects, we can only observe them.