Observing the Sky

- Almost everything we know about the universe comes from light.
- By understanding the nature of light we can get information about stars, planets and distant galaxies
  - distance
  - size
  - mass
  - motions (direct and rotational)
  - composition

Nature of Light

- Light = radiant energy = “radiation”
  - some light we can see (visible light)
  - mostly we cannot (UV, X-rays, radio, etc.)

- Newton was interested in the nature of light
  - Passed light though a prism
  - Light separated into separate colors
White light
Prism
Red
Orange
Yellow
Green
Blue
Indigo
Violet

People thought colors came from the glass, but Newton showed that the light itself is made up of colors.

The Speed of Light

- 1675 -- Ole Roemer
  - Time when Jupiter eclipsed one of its moons did not always agree with that predicted by Kepler’s laws.
  - It depended on the Earth’s distance to Jupiter.

Orbit of the Earth
Distance shorter
Distance longer so it takes longer for light to travel

The Speed of Light

- Speed of light, \( c = 300,000 \text{ km/sec} \) (186,000 mi/sec) \{precisely known to be 299,792.458 km/s\}
  - It takes 8 minutes for light to travel from the Sun to the Earth.

- Light-year = distance light travels in a year
  \[ = 9.4605 \times 10^{12} \text{ km} \]

\[ \rightarrow \] All information from outer space is delayed…we see everything in the past!
Light as a Wave

• Wavelength (\(\lambda\)) = distance from peak to peak (measured in meters)
• Frequency (\(f\)) = number of peaks to pass a certain point (measured in Hertz = #/sec)

Animation applet

\[ c = f\lambda \]

• The greater the frequency, the shorter the wavelength.
• The speed in vacuum always remains the same!

Color is determined by the wavelength of light (\(\lambda\))

- 1 nanometer (nm) = 1 billionth of a meter
  \[ = 1 \times 10^{-9} \text{ m} \]
Light as a Particle

- Photon = particle of light
- Energy of photon depends on its wavelength

\[
\text{Energy} = \frac{h \times \text{frequency}}{\text{wavelength}} = \frac{hc}{\lambda}
\]

- The longer the wavelength, the lower the energy.
- The lower the frequency, the lower the energy
- eV is a unit of energy \(1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}\)

The Electromagnetic Spectrum

- Spectrum divided up by wavelength
- All light, regardless of wavelength, travels at the same speed of light.
Atmospheric Opacity

- The atmosphere (and sometimes material in outer space) blocks some wavelengths of light
- Opacity = percentage of light blocked by atmosphere
- Wavelengths where light can get through the atmosphere are called “windows”
  - Low opacity: Visible and Radio:
  - Medium opacity: Infrared and UV
  - High opacity: Gamma Rays, X-rays & some UV