Announcements

- Exam 1: Well done!   A=40%  B=30%  C=18%  D=7%  F=5%

- Homework 2 given back today. Solution set posted outside lecture hall
  Q1: Candace   Q2: Irina   Q3: Bi-Qing

- Quiz 3 next Tuesday: Everything since quiz 2.
Recent and upcoming topics in class

- Light as electromagnetic waves (continued)
  - Processing light as electromagnetic waves
  - Optical light and optical color

- Unveiling the properties of stars from their light (continuum emission)
  - Luminosity versus Flux
  - Spectrum of an object: continuum emission, absorption lines, emission lines
  - Kirchhoff’s first law
  - Wien’s law: relating surface temperature and wavelength of maximum emission
  - The temperatures of stars
  - Stefan Boltzmann’s law: relating surface temperature and surface flux of a star
  - The luminosity function of stars
  - The Hertzsprung-Russell diagram.
  - Types of stars
  - The norms and extremes of stellar radii and densities.
Dispersing while light into its constituent optical EM waves
Violet, Blue, Green, Yellow, Orange Red
Processing light as electromagnetic waves

Emission, Transmission, Absorption, Reflection
**Optical light and optical color**

A body emits light across a large range of the EM spectrum: infrared, optical, UV, etc. But human eye is sensitive to the optical (visible) part of the EM spectrum.

<table>
<thead>
<tr>
<th>Type of EM wave</th>
<th>Typical wavelength</th>
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<tbody>
<tr>
<td>Gamma rays</td>
<td>$10^{-16}$ m</td>
</tr>
<tr>
<td>X rays</td>
<td>$10^{-12}$ m</td>
</tr>
<tr>
<td>Ultraviolet</td>
<td>$3 \times 10^{-7}$ m</td>
</tr>
<tr>
<td>Optical</td>
<td>$4$ to $9 \times 10^{-7}$ m = Violet, blue, green, yellow, orange, red</td>
</tr>
<tr>
<td>Infrared</td>
<td>$10^{-6}$ m to $10^{-4}$ m</td>
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<tr>
<td>Radio</td>
<td>$10^{-3}$ m to $10$ m</td>
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</table>
Concept of ‘color’ of an object

Light bulb emits white light.
Mirror reflects light.
Cones and rods in human eye absorb light.
Glass transmits light.
Sun emits light.

Opaque Red Chair
Absorbs all colors except red.
Reflects (scatters) red.

Opaque Blue Shirt
Absorbs all colors except blue.
Reflects (scatters) blue.

Snow
Absorbs some light, which aids melting.
Scatters most light, so it looks bright.

Ground
Absorbs some light (heats it up).
Scatters some light (which is how we see it).

Tree
Absorbs all colors except green.
Reflects (scatters) green.
How to Hold the Prism to See a Spectrum

Hold the prism point down, below eye level.
Why does the same galaxy (M81) look so different when we look at the light it emits at different wavelengths (from X-ray to visible to radio)?
Luminosity versus Flux of an object

1. See in –class notes: difference between flux and luminosity
   flux depends inversely on the square of the distance.

2. Demo : Which object has a higher luminosity?
What information does light from distant stars/galaxies carry?

Pleiades stellar cluster

M80 globular cluster (HST image)

What does the light from a star tell us about the properties of the star? (temperature, radius, luminosity of the star)
1) A spectrum is a plot of the intensity of light at each wavelength. When the total flux from an object is separated into the flux at different wavelengths and the intensity of the flux is plotted against wavelength, we get a spectrum for that object.

2) In general a spectrum can have 3 types of features:
   - continuum emission: emission over a continuous range of wavelengths
   - emission lines: emission above the continuum at specific wavelengths
   - absorption lines: lack of emission (dip below the continuum) at specific wavelengths
Amazingly, the continuum emission, emission lines, absorption lines, in the spectrum of an object can reveal to us its temperature, the total flux at its surface, its chemical composition, (like a DNA genetic code), its recession speed, its distance.