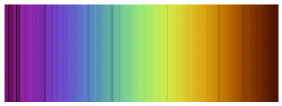
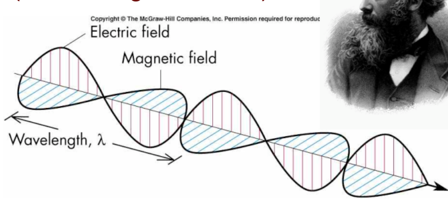
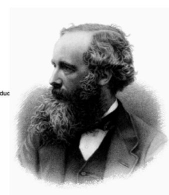
Starlight: how the physics of electromagnetism provides a key to the stars


Light is the only information we get from most astronomical objects. To understand these objects, we need to understand the physics of light and how it is produced.

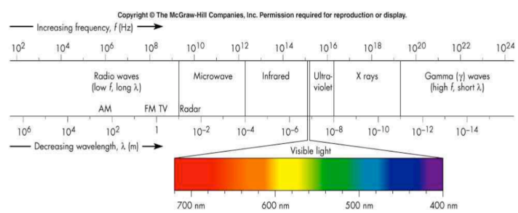
First result: light is a wave (electromagnetic wave)





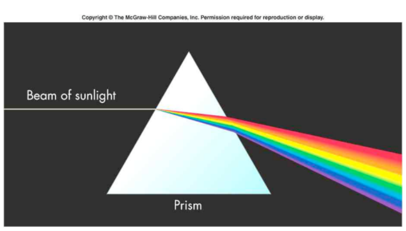
Wave characterized by wavelength, amplitude
DEMO

Amazing fact of nature: wide range of wavelengths of electromagnetic waves



EM radiation includes gamma rays, x-rays, ultraviolet, Light, infrared, microwave, radio

Concept from physics crucial for astronomy: the spectrum of light



Will do in lab this week (or soon); DEMO

Spectra (plural of spectrum)

The solar spectrum

- A fundamental measurement to extract more information from starlight
- Spread out light according to wavelength
- See Section 16.5

The Solar Spectrum as an astronomer would study it

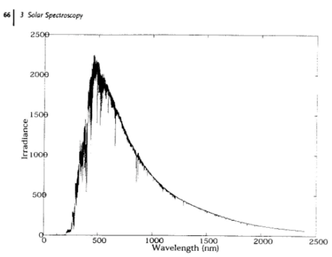


Fig. 3-1 The spectral distribution of solar irradiance measured above the Earth's atmosphere, in units of mW/sq.meter/nanometer. Kindly provided by G. Thuillier (see G. Thuillier et al., "Sun Irradiance Spectra" in "*Solar Variability and Its Effect on Climate*", J. Pap et al., Eds., AGU Monograph Series (2003).

What do the spectra of the Sun and stars tell us about those objects?

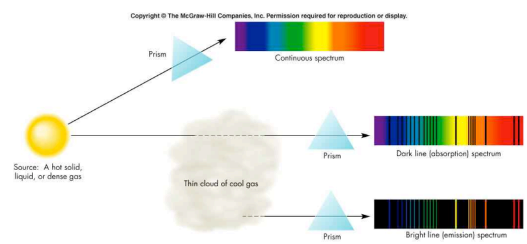
See Figure 16.11 from book

http://www.astro.umd.edu/~ssm/ASRT220/OBAFGKM.html

The Physics of Spectrum Formation, Kirchoff's Laws and Wien's Law

- Hot opaque solid or liquid produces a continuous spectrum
- Hot, tenuous gas observed against dark background produces emission line spectrum
- Cold, tenuous gas observed against bright background produces absorption spectrum
- See Figure 16.6

Kirchoff's Laws of Radiation



Kirchoff's First Law + Wien's Law

- Hot, opaque objects produce *continuous spectrum*
- The hotter the object, the bluer it is
- Wien's Law w_{max} = 2.9E-03/T
- The hotter an object, the brighter it is
- demo

Why does Wien's Law look like that?

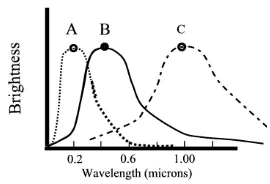
A physicist is bothered when he or she sees an equation like:

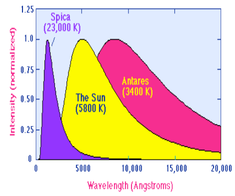
$$w_{max} = \frac{2.90 \times 10^{-3}}{T} \text{ meters}$$

The form which emerges from fundamental equations of physics is:

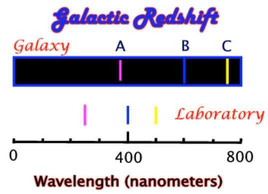
$$w_{max} = \frac{0.201hc}{k_B T}$$

Kirchoff's First Law + Wien's Law





Kirchoff's 2nd Law: Emission Line Spectra



Wavelengths of emission lines unique "fingerprint" of element

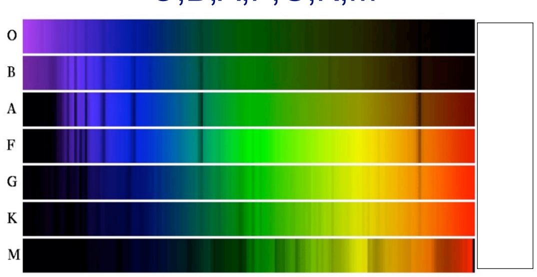
Kirchoff's Third Law: Absorption Spectra

See Figure 16.6

Starlight…application of spectroscopy to stars

- Continuous spectrum gives surface temperature (Wien's Law)
- Spectral lines give chemical composition, temperature (also), *speed of rotation* (How?) and other properties
- Examples of stellar spectra…what can we say?

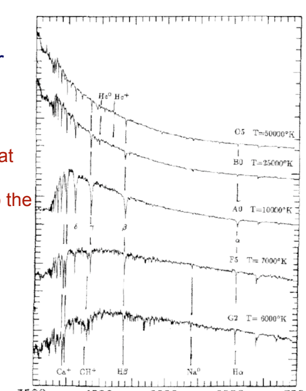
Spectral classes of stars: O,B,A,F,G,K,M



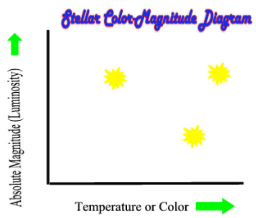
What can you say about the temperatures of these stars?

Examples of stellar spectra

Question: apply Wien's Law to the O5 star. What Can you say about its Temperature (relative to the Sun?)



With information provided by spectroscopy, we can search for *correlations* between stellar properties



What the data show: the Hertzsprung-Russell Diagram

Highest quality data from the Hipparchus spacecraft