ASTR368
Review of ASTR367

Review topics today:

Units
Spectra
Magnitudes
Stars
Virial Theorem
Readings: C+O, 2.4, 3.2, 3.5, 5.3, 8.2, 9.2

Units! (Everyone's favorite; C+O, 3.2, page 60, 3.5 page 70)

a) Flux: The amount of energy passing through a unit area, per unit time: W m^{-2}

- This is essentially what a telescope observes. Called "Radiant flux" in your book. Increase flux by increasing energy output or increase collecting area

- Sometimes flux is only given per wavelength interval, in which case the units are W m^{-2} m^{-1} and the wavelength may be subscripted.

b) Luminosity: The amount of energy emitted per second, W.

- Can also be per wavelength interval in which case the units are W m^{-1} and the wavelength may be subscripted

- Star luminosity (Stephan-Boltzmann)

$$L = 4\pi R^2 \sigma T^4 \tag{1}$$

To get more luminosity, increase temperature or increase size

- Of course, these are related:

$$F = \frac{L}{4\pi d^2} \tag{2}$$

c) Blackbody (Planck Functions)

$$B_\lambda = \frac{2hc^2}{\lambda^5} \frac{1}{e^{hc/\lambda kT} - 1} \tag{3}$$

$$B_\nu = \frac{2h\nu^3}{c^2} \frac{1}{e^{h\nu/kT} - 1} \tag{4}$$

These units are the same as for flux, except for the addition of the steradian.

Remember, two things about blackbodies:
1) Hotter objects emit more energy than cooler objects of the same size AT ALL WAVELENGTHS!
2) Blackbody curves of hotter objects peak at shorter wavelengths. This is Wien's Law:

$$\lambda_{\text{peak}} = \frac{0.2898\,\text{cm}}{T} \tag{5}$$

Also, we only get blackbody radiation from dense objects! More on this later.

d) Angles: 60 arcseconds per arcminute, 60 arcminutes per degree

e) distances: parsec (pc), Mpc

Formation of Spectra (C+O, 5.3, page 126)

Three types of spectra: continuous, line, and absorption, and reasons for each

- Continuous spectrum is BB (dense objects), maximum energy from you can get out for a given temperature

- Emission lines are from diffuse sources. We get emission lines from discrete transitions in atomic and molecular gas (and even dust)

- Absorption lines are from cooler gas in front of a dense object excite atomic or molecular gas transitions. These photons are therefore removed from the path.

What we see depends on the line of sight. A different line of sight would see a different type of spectrum.

Optical depth (C+O, 9.2, page 242)

=0 for optically thin (glass)

=1 for optically thick This is the "surface" that we can see down to, on average True for all surfaces!

$= \infty$ maximum

If optically thin, we can see entire material. If optically thick, we only see the surface

$$\tau = \int \kappa \rho ds \tag{6}$$

$$\text{mfp} = \frac{1}{n\sigma}\,, \tag{7}$$

where n = number density and σ = cross section.

As photons pass through a material, they are attenuated (absorbed and scattered) by that material. The observed intensity is related to the initial intensity by:

$$I_\lambda = I_{\lambda,0} e^{-\tau_\lambda} \tag{8}$$

Magnitudes (C+O, 3.2, page 60)

- Hipparchos originally cataloged all visible stars from 6 (faintest) to 1 (brightest)

- So it's backwards! As magnitudes increase, fluxes decrease!

- Later astronomers thought that the eye was logarithmic, and found that a magnitude difference of 5 corresponds to a brightness difference of 100

-Each magnitude corresponds to roughly 2.5 times the flux of the previous one; flux ratio of 100 is magnitude difference of 5 (2.5^5) $\simeq$ 100

- This leads to

$$m_1 - m_2 = -2.5 \log(F_2/F_1) \tag{9}$$

OR

$$F_1/F_2 = 10^{0.4(m_2-m_1)} \tag{10}$$

m_1 = magnitude of star #1
m_2 = magnitude of star #2

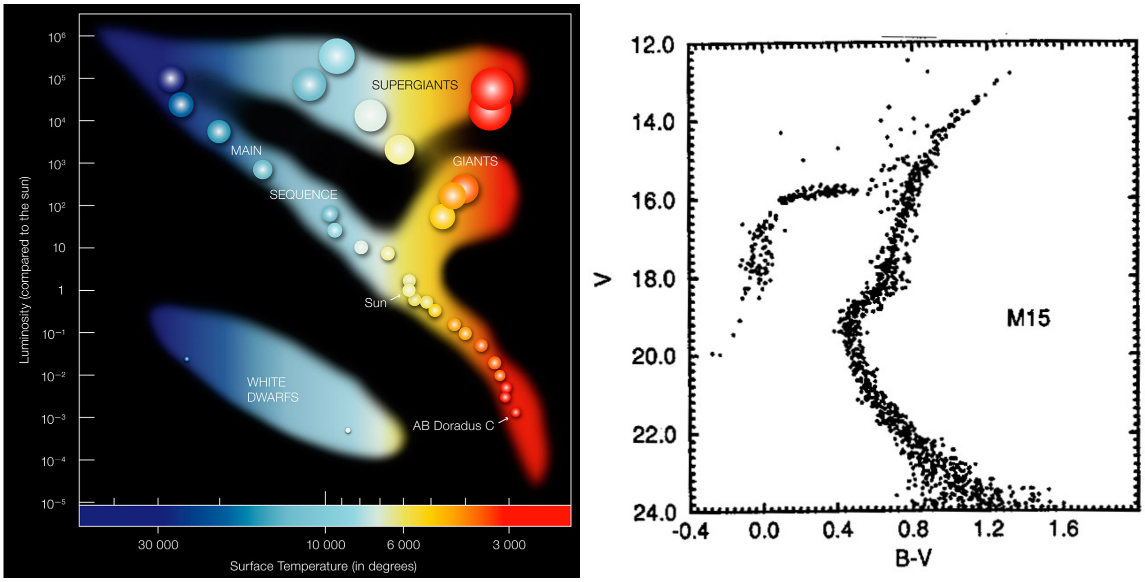

Figure 1: H-R diagram (left) and color-magnitude diagram (right).

F_1 = flux of star #1
F_2 = flux of star #2

While magnitudes were originally defined from direct observations, we can also define "absolute mannitudes," and these are related to luminosities. These are often just written with capital letters V, U, B, etc. We call the original magnitudes "apparent," and these are related to the flux. The absolute magnitude is the apparent magnitude of an object 10pc away. This leads to

$$m–M = 5\log(d)–5 \tag{11}$$

m = apparent magnitude
M = absolute magnitude
d = distance in pc
$m - M$ is the "distance modulus", μ

Remember than magnitude differences are flux ratios. These are called "colors", for example B-V. Large values of B-V means the B magnitude is larger than the V magnitude, or it is red. (C+O, 3.6, page 75)

Stars (C+O, 8.2, page 219)

HR Diagram
Axes (luminosity, temperature, spectral type, absolute magnitude)

What about for a cluster? We can use magnitude difference and apparent magnitude
MS, red giants, white dwarfs, where do stars evolve?
What makes SN Ia, SN II, WD, red giants, neutron stars, MS evolution?
Massive stars are short-lived, blue, rare, luminous, hot

Can also plot stars on color-color diagram (Fig. 3.11), or Color=Magnitude diagrams (CMDs; Figure 13.17).
A CMD is used for clusters of stars that are all at the same distance.

Virial Theorum (C+O, 2.4, page 50)

This holds for any gravitationally bound system.

$$2K + U = 0 \tag{12}$$

$K = 3/2kT$ OR $1/2mv^2$ per particle
$U \simeq GM^2/R$

Since $E = K + U$, we can write

$$E = 1/2U \tag{13}$$

For example, when a star collapses, the gravitational potential energy increases and the total energy decreases. This decrease in total energy requires that energy must escape the system, in this case in the form of radiation.

Metallicity

Astronomer-speak for amount of elements with masses greater than He, relative to H.

What creates metals? PN/SN

Stars are born with the composition of the medium around them.

If an area has had lots of processing, the stars born there have high "metallicity". Formula:

$$[Fe/H] = \log(N_{Fe}/N_H) - \log(N_{Fe}/N_H)_\odot \tag{14}$$

Always referenced to Solar metallicity. Stars like the Sun have $[Fe/H] = 0.0$. Values range from -4.5 (low metallicity) to $+1$ (high metallicity)

We can define stellar populations based on metallicity:
Population I: young, metal rich stars. Born most recently.
Population II: stars like the Sun with moderate metallicity
Population III; First stars ever made, with low (primordial) metallicity.

A Final Note

Know your logs! log almost always means $\log_{10}$ and ln means base e.