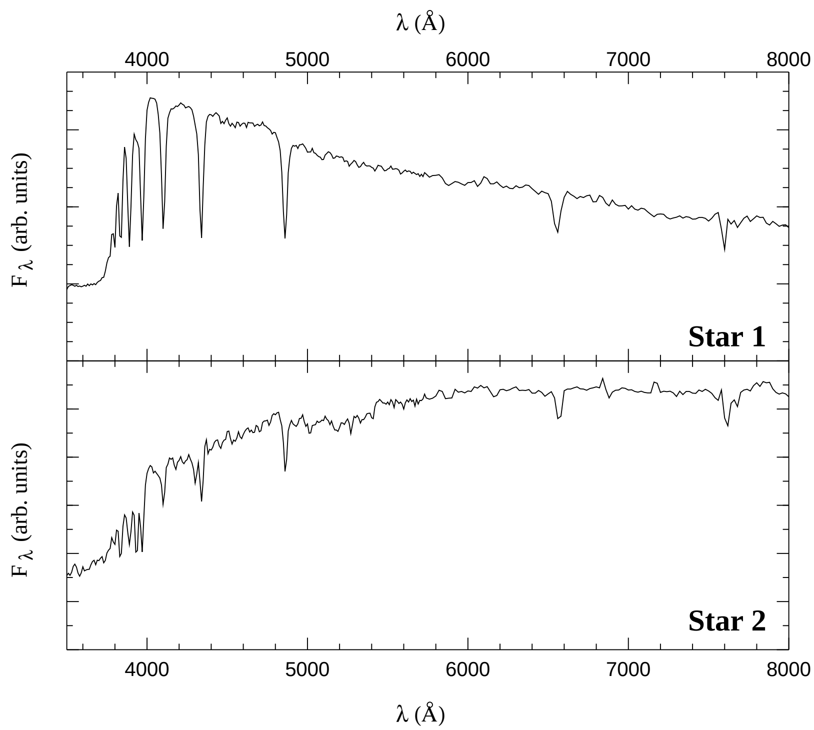
Astronomy 253 — Group Problems 1

Friday, January 23

Do the problems on separate sheets of paper. Each group will turn in only one set of solutions. Make sure your solutions are clear enough that I can understand what you were doing and what you were thinking! You probably won't get through all of these problems in an hour; that is OK. If you are *not* a Physics major, you may do the problems in any order, but should consider doing them in the order they are numbered. If you *are* a Physics major, do them in the following order: 7, 6, 2, 5, 4, 3, 1.

The primary goal of this exercise is to understand the problems and to learn something about the material of the course. Try to approach these problems with this mindset!

1. Remember that $F_\lambda(\lambda)$ is defined such that $F_\lambda(\lambda)\,\Delta\lambda$ is equal to the flux (rate that energy is collected by a 1 m^2 telescope) arriving at wavelengths between λ and $\lambda + \Delta\lambda$. Consider the two stars whose spectra are plotted below.



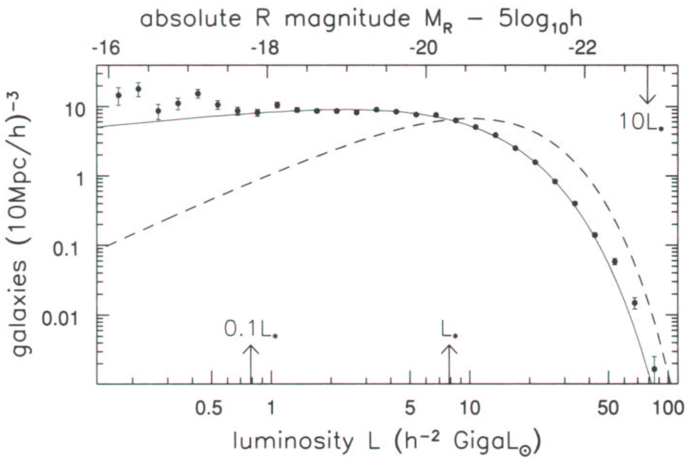
   (a) Suppose you can make a filter that is exactly 1 Å wide, that is, it will only transmit colors between λ_0 and $\lambda_0 + 1$ Å. If you were designing this filter to transmit the maximum amount of energy possible from Star 1, at what wavelength would you choose to make the λ_0 of this filter?

   (b) Consider the B and R filters (see Sparke & Gallagher, Figure 1.7). Will Star 1 have a greater flux through the B filter, or through the R filter? What about Star 2?

   (c) Which of the two filters will have a large value of B-R?

   (d) It turns out that Star 1 will bee whiteish in color. What would Star 2 look like to your eyes?

2. Look at Figure 1.16 in Sparke & Gallagher:



(a) Are there a greater number of galaxies in the Universe with luminosity higher than L_* or with luminosity less than L_*?

(b) Compare the total light in the Universe from relatively bright and relatively dim galaxies. Roughly what is the ratio of the total light emitted by galaxies with $L > L_*$ to the total light emitted by galaxies with $L < L_*$?

(c) Look at the table of galaxies in the Local Group on p. 134. Take the seven most luminous galaxies in the Local Group, and indicate their luminosities on Figure 1.16. What do you think a distant observer looking at the Local Group would see?

(b) The luminosity of the Milky way is about 2×10^10 $L_\odot$ (that's 20 billion times the luminosity of the Sun). How does the Milky Way's luminosity compare to L_*? How does the Milky Way's luminosity compare to most of the Galaxies in the Universe? Comment on what this may say about the Cosmological Principle (which may be briefly stated as "we are nowhere special"). (In so commenting, you might ask yourself: are we living around a typical star? What is the most common sort of star, and how does it compare to the one we live near?)

3. Sparke & Gallagher problem 1.4 (page 11). Also, do the calculation for an O5 star of mass $40M_\odot$ (see Table 1.1).

4. Sparke & Gallagher problem 1.6 (page 17).

5. Two stars are observed near to each other on the sky. One star's spectrum indicates that it's a main sequence O5 star, the other's spectrum indicates that it's a main sequence K2 star. The two stars have the same bolometric magnitude. Are the two stars at the same distance from the sun, or is one closer? If one is closer, which one, and what is the ratio of the distances?

6. You perform a survey of stars in a region of the sky that counts all stars down to visual magnitude 18. You want to know the relative frequency of main-sequence stars of spectral type A and G. In your survey, you find the same number of main-sequence A stars as you do main-sequence G stars.

   (a) What, qualitatively, can you conclude about the relative number of main-sequence A and G stars in the region of the galaxy you were looking at?

   (b) What, quantitatively, can you conclude about the relative number of main-sequence A and G stars in the region of the galaxy you were looking at?

7. Consider a Hydrogen gas.

   (a) At roughly what temperature do you think that much of the gas can be collisionally ionized? (The ionization potential of Hydrogen is 13.6 eV).

   (b) At roughly what temperature will a large fraction of the Hydrogen be found in the n=2 state? (The n=2 state is 10.2eV above the ground state.)

   (c) Consider a dwarf A-star and a giant A-star with the same surface temperature. Will these two stars have the same fraction of the Hydrogen at their surface in the n=2 state, or might you expect one to have a greater fraction in the n=2 state? If they differ, which one will have a greater fraction in the excited state, and why?

   (d) What implication would you expect your answers to (c) have for the relative strength of the Balmer absorption lines in the dwarf and giant stars?