# STELLAR SPECTRA

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## 1. General Information

**Purpose:** To see and use first-hand stellar spectra. You'll learn about spectral type, luminosity and brightness, and Wien's Law.

**Method:** Analyze the data from real stellar spectra using a common set of real stars. You'll need to print out all the spectra to compare them side-by-side. All of these questions will be transferred to BlackBoard. This is just a reference for you to use. The spectra for this lab are derived from the data of D.R. Silva, & M.E. Cornell's catalog of stellar spectra. You need to download this entire lab and print it out. It cannot be done without printing it out. This activity is broken up into three parts. Complete each one sequentially.

Use these Stellar spectra examples to help you with determining what kind of star each spectrum shows:

http://classic.sdss.org/dr5/algorithms/spectemplates/index.html

In all the spectra given, they all have had the brightness normalized (set to the same arbitrary value) to 100 at 5450 Ångstroms. (Here, 1 Ångstrom or Å is equal to $10^{-10}$ meters.) In so doing, weve lost the information about how bright they really are with respect to each other, leaving us only with relative differences across the entire wavelength group. So, the stellar spectra will appear to pivot around 5450 Ångstroms. Each graph has arbitrary units of flux on the left subject to the normalization above, and wavelength from 3500 Ångstroms to 9000 Ångstroms. You'll notice very soon that you can compare stars graph-to-graph only if their temperatures are close. Otherwise, it doesn't work well.

**References:**

http://zebu.uoregon.edu/spectra.html

http://articles.adsabs.harvard.edu//full/1992ApJS...81..865S

## 2. Hot to Cold

First arrange them in order from hot to cold stars.

(1) What is the range of temperatures for stars of spectral type O to M?

(2) Compare your spectra to the ones on the reference graph.
- Two stars are O stars. Which ones?
- Two stars are B stars. Which ones?
- Three stars are A stars. Which ones?
- Two stars are F stars. Which ones?
- Either two or three stars are G stars. Which two or three?
- Either two or three stars are K stars. Which two or three?
- Two stars are M stars. Which ones?

(3) Name two stars that are most like the Sun in their spectra. How can you tell?

## 3. Lines in the Spectra

Next, look at the details in the spectra themselves.

(1) Describe the process that makes absorption lines in a star's spectrum.

(2) Name three stars in your set that appear to peak in or near to the infrared.

(3) Name three stars in your set that appear to peak in or near the ultraviolet.

(4) Compare stars 15 and 4. How can you tell which one is brighter in the ultraviolet, and which one is it?

(5) Name three stars that have their peak right in the middle of the visible region.

(6) Which three stars have the "cleanest" spectra, i.e. with the fewest or shallowest absorption lines?

(7) Which three stars have the most prominent Hydrogen absorption lines? (We are looking specifically for the Balmer series of hydrogen absorption.)

(8) What spectral class are the stars with the most prominent Hydrogen lines?

(9) Find two cool stars whose spectra do not seem to show any hydrogen absorption lines.

(10) All of the stars in this lab have about the same amount of hydrogen, roughly 75% in their atmospheres. Why do the coolest ones show no hydrogen absorption?

(11) All of the stars in this lab have about the same amount of hydrogen, roughly 75% in their atmospheres. Why do the hottest ones show no hydrogen absorption?

(12) Molecules absorb light at many different long wavelengths, so many that they blend together. Which stars from your set seem to show really big molecular absorption features?

(13) Which spectral class(es) show these molecular absorption features?

(14) Why don't molecular absorption features appear in the other spectral types?

(15) Of the stars you've been working with in this lab, what kinds of stars are the most luminous and why?

## 4. Stars as Blackbodies

Now we use the rules of Blackbody radiators to learn about the temperature and luminosities of stars.

(1) Look up and draw the shape of a perfect blackbody spectrum.

(2) For the stars listed in the table below, draw a SMOOTH line over the top of the spectrum which just touches the tops of the bumps in the spectrum. Force your line to look as close to a blackbody spectrum as you can. There may be big gaps where the spectrum does NOT touch the line you draw. In fact, in a few cases, the EXACT peak of the curve you draw might not touch the spectrum. Determine the peak wavelength for each one of the stars. Use Wien's Law to find the inferred temperature of that blackbody. Assume that all the stars have the same radius as the Sun. Calculate their luminosities in terms of the Sun. You'll need to use the full luminosity equation with the Stephan-Boltzmann constant or an equation that just gives it in terms of Solar units. Your numbers at the end will be somewhere in the range of 0.001 to 1000. No big powers.

| Star | Peak Wavelength: $\lambda_{max}$ | Temperature (T) | Luminosity (L) |
|---|---|---|---|
| Sun | | 5778 K | 1 Solar Luminosity = 1 $L_\odot$ |
| 3 | 4500 Ångstroms | 6439 K | 1.5 Solar Luminosities = 1.5 $L_\odot$ |
| 4 | | | |
| 7 | | | |
| 10 | | | |
| 13 | | | |
| 14 | | | |
| 16 | | | |

(3) We say that stars are close to perfect blackbodies. Why would we say that?

(4) Why do you think we didn't choose some of the other stars to find their temperatures and luminosities in this way?

(5) As a final caveat, the Sun's temperature is known to be 5778 K. All of the temperatures you calculated for the stars like the Sun were higher than 5778 K. Why is this an error? Speculate on where this error came from. It has a LOT to do with the hydrogen interaction with light in the ultraviolet and blue ranges of light.

## 5. Relevant Formulae

We are assuming that $R = R_\odot = 1$, and that $L_\odot = 1$, so we can rewrite the relationship of luminosity, temperature and stellar radius in Solar Units:

$$\left(\frac{L}{L_\odot}\right) = \left(\frac{R}{R_\odot}\right)^2 \left(\frac{T}{T_\odot}\right)^4 \quad \longrightarrow \quad L = \left(\frac{T}{5778}\right)^4 L_\odot$$