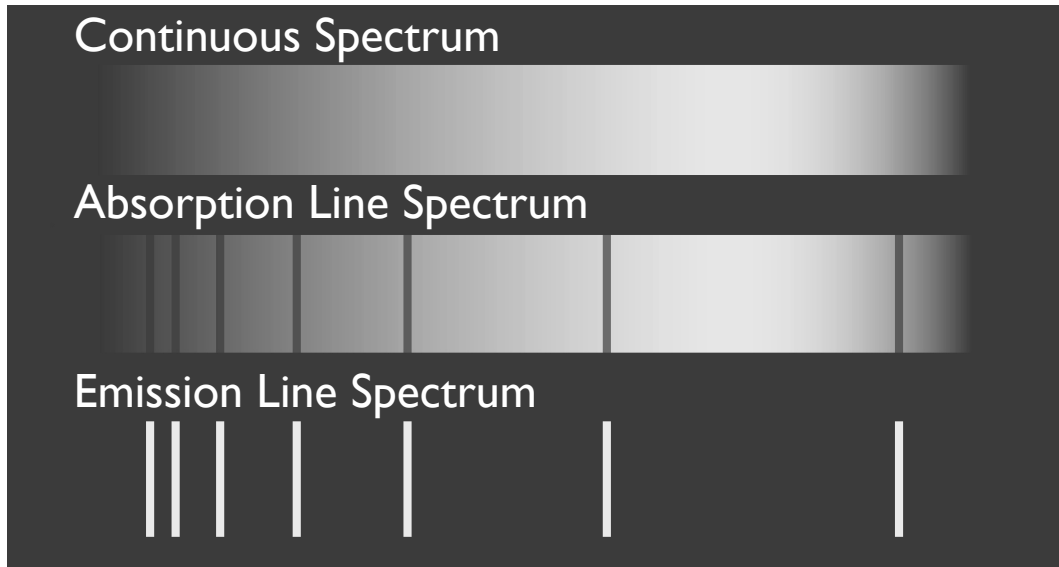


Spectral Classification I

The purpose of this exercise is to acquaint you with the visual appearance of various types of spectra and to introduce you to astronomical spectroscopic classification.



I. Terrestrial Sources:

Sketch and describe briefly the observations made with your homemade diffraction grating spectroscope of the following sources (be sure to indicate the position of the slit in your sketch):

a. Gas Discharge Tubes (emission line spectra):

Helium and one of

1. Mercury
2. Nitrogen
3. Neon

b. Room fluorescents

c. Daylight. Do you observe any absorption lines. Do you expect to? Why or why not?

II. Stellar Sources (mostly absorption line spectra)

Some good examples of stellar spectra are shown in the Sky & Telescope reprint entitled Spectral Classification. The photograph is an objective prism plate of the region of the sky near γ Cygni.

When looking at the spectra, take note of the overall appearance of the spectrum, the relative strengths of the red and blue portions of it as well as the positions and relative strengths of the lines.

a. Rank the following spectra according to the relative strength of their Balmer lines (strongest to weakest): spectrum #6, #16, #21, #23, and #29

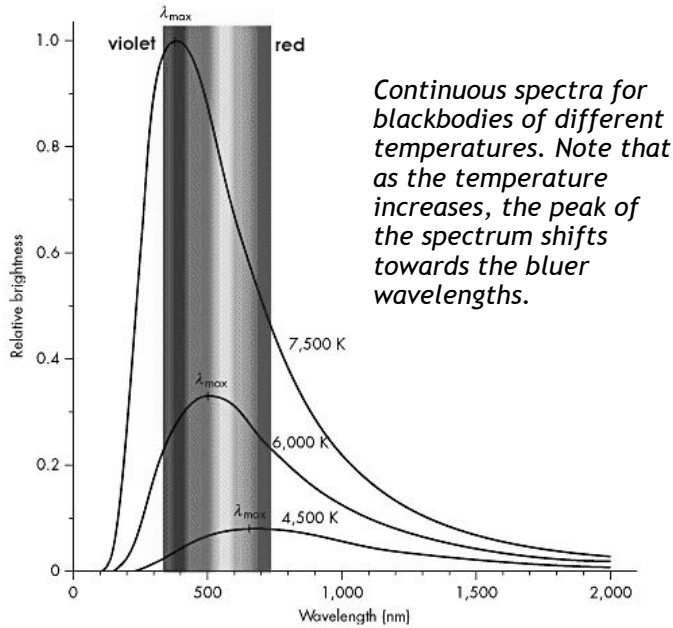
b. Find at least two examples of spectra that have the *same* spectral type as spectrum #7.

c. Find at least two examples of spectra that show *emission* lines.

Spectral Classification II

Background

The purpose of this exercise is to acquaint you with the characteristics of the spectra of stars having different temperatures. A spectrum of a star is composed of its continuum emission as well as a number of 'lines' which can be either emission or absorption lines. The continuum emission is a product of the blackbody radiation at specific frequencies, caused by electrons in atoms dropping down into lower energy levels. They can also be caused by molecular transitions to lower energy levels. This sort of line appears brighter compared to the region of the spectrum around it. Absorption lines cause dark features in the continuum emission where the radiation is removed. This is caused by atoms (or molecules) absorbing radiation, and moving to a higher energy state. This process causes the lines to look darker when compared to the region of the spectrum around them.



The overall shape of each spectrum is very similar to a continuous spectrum of a blackbody having a temperature approximately equivalent to that of the star. The overall shape changes quite significantly as the temperature of the star changes leading to seven main *spectral classes* that are labeled by the letters: O, B, A, F, G, K, and M.

The spectra also have many absorption lines caused by the presence of particular atoms and molecules in the star. Using these features the spectral classes have been further divided into *spectral types*. Specifically, each spectral class is sub-divided into 10 spectral types indicated by including a number; i.e. spectral class "O" is divided into the spectral types O0, O1, O2, O3, O4, O5, O6, O7, O8 and O9. Spectral type O9 is followed by type B0 and so on. The terms *early* and *late* are used to refer

O0



B0



A0



F0



G0



K0



M0

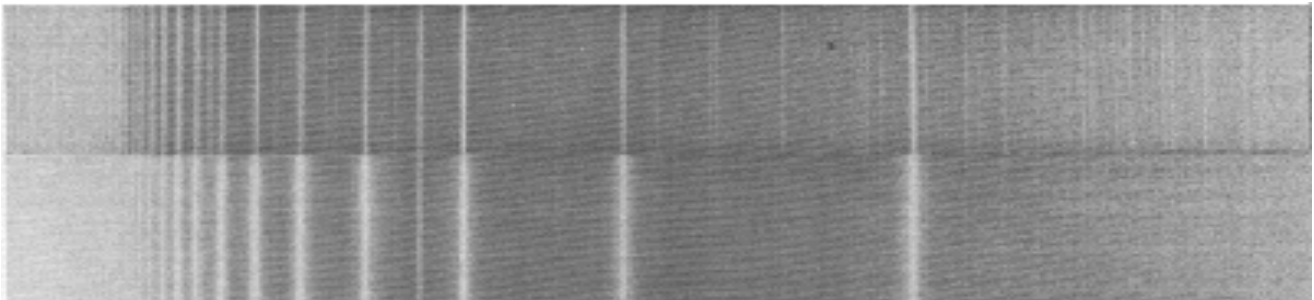


to the relative position in the spectral sequence. For example, O1 is *earlier* than O8; and B3 is *later* than O8.

Stars come in a wide range of sizes and temperatures. The hottest stars in the sky have temperatures in excess of 40,000 K, whereas the coolest stars that we can detect optically have temperatures on the order of 2,000-3,000 K. The appearance of the spectrum of a star is very strongly dependent on its temperature. For example, the very hottest stars (O-type stars) show absorption lines due to ionized helium (He II) and doubly or even triply ionized carbon, oxygen or silicon. On the other hand, the coolest stars (M-type) show lines produced by molecules.

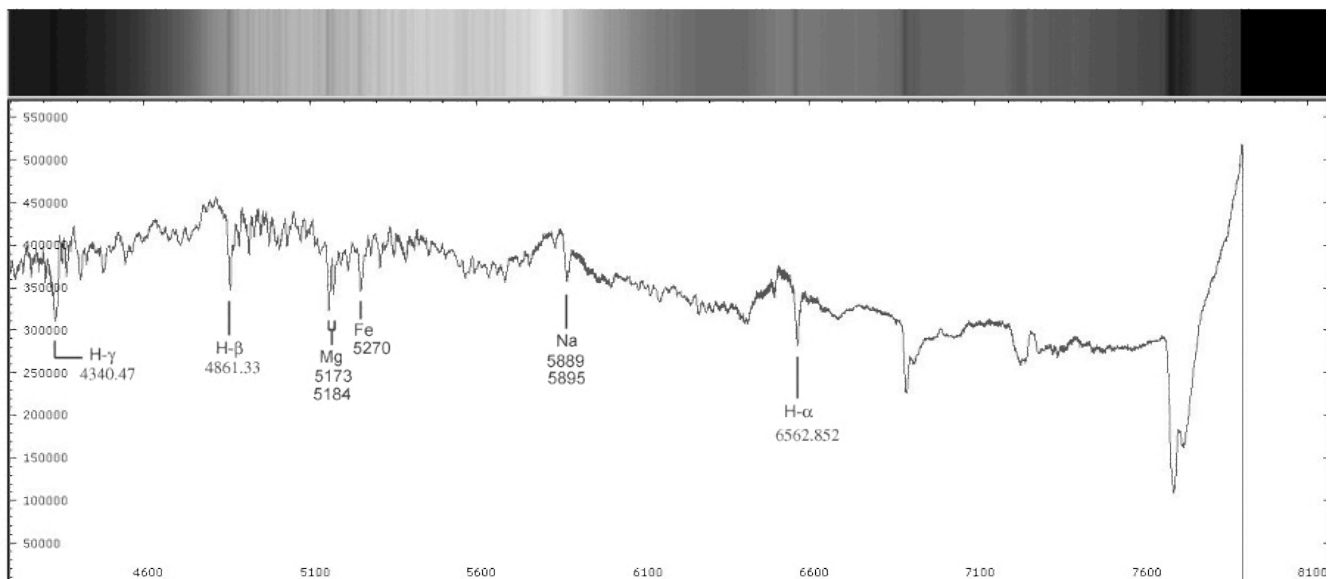
The width of an absorption line will give a measure of luminosity of the star. The line width depends on both the temperature and the density in the photosphere. The temperature affects the width because of Doppler broadening. Increasing the density will broaden the lines because of the subsequent increase in collision rate between atoms. All stars of a given spectral class have the same temperature, so the width of the absorption lines is a direct measure of the density. But the larger stars have a more tenuous atmosphere than the smaller stars so the larger star is more luminous and has narrower spectral lines than the smaller star.

The figure below shows the transition from luminosity classes Ia (Supergiant) to IV (Subgiant) for spectral type A2.



An Atlas of Stellar Spectra with an Outline of Spectral Classification by W. W. Morgan, Philip C. Keenan & Edith Kellman

You will classify unknown stellar spectra by comparing their traces to a sequence of known spectral traces. Below is an example of a portion of the solar spectrum with its associated spectrophotometric trace.



None of the unknown spectra will look exactly like the ones in Figure 1. This is because all of the spectra are for different stars and no two stars will be exactly the same. You should attempt to classify each spectrum by finding the standard spectrum(s) that most closely resembles the unknown spectrum.

Look first at the overall shape and from this you should be able to roughly classify the spectra to within one spectral class. By making this rough classification, you are also roughly determining the temperature of the star. Next, examine the individual absorption lines present. You should concentrate on lines that are important to a particular spectral class (for example, if you have decided that the spectrum is either an F or G class then you probably want to look carefully at the G band and Ca II lines). Compare the lengths of specific lines. If a line appears to have a length that is between that in two of the known spectra, then the spectral type probably falls between those two known spectral types.

Lines due to hydrogen (the so-called *Balmer* series) are present in almost all of the spectra, but you should notice that the Balmer lines are particularly prominent in some of the spectra and difficult to detect in others. The Balmer lines (their length and relative prominence) are often a very useful feature for classifying spectra and you should include a discussion of them for each unknown spectrum.

Questions

1. Compare the unknown spectra in Figure 2 with the labeled standards in Figure 1 and assign a spectral type to each unknown spectra. You should be able to determine the correct classification to within 2 or 3 spectral types. **Describe how you arrived at your classification.**
2. Classify the spectra in the figure on the last page. Which star is the largest and which is the smallest? Explain your reasoning.
3. What would the spectrum of a galaxy look like? (What lines would be prominent?) Explain.

References

University of Washington, Astronomy Department, Introductory Astronomy Clearinghouse
<http://www.astro.washington.edu/labs/clearinghouse/labs/Spectclass/spectralclassweb.html>

Silva, D. R. & Cornell, M. E. 1992, ApJS, 81, 865S

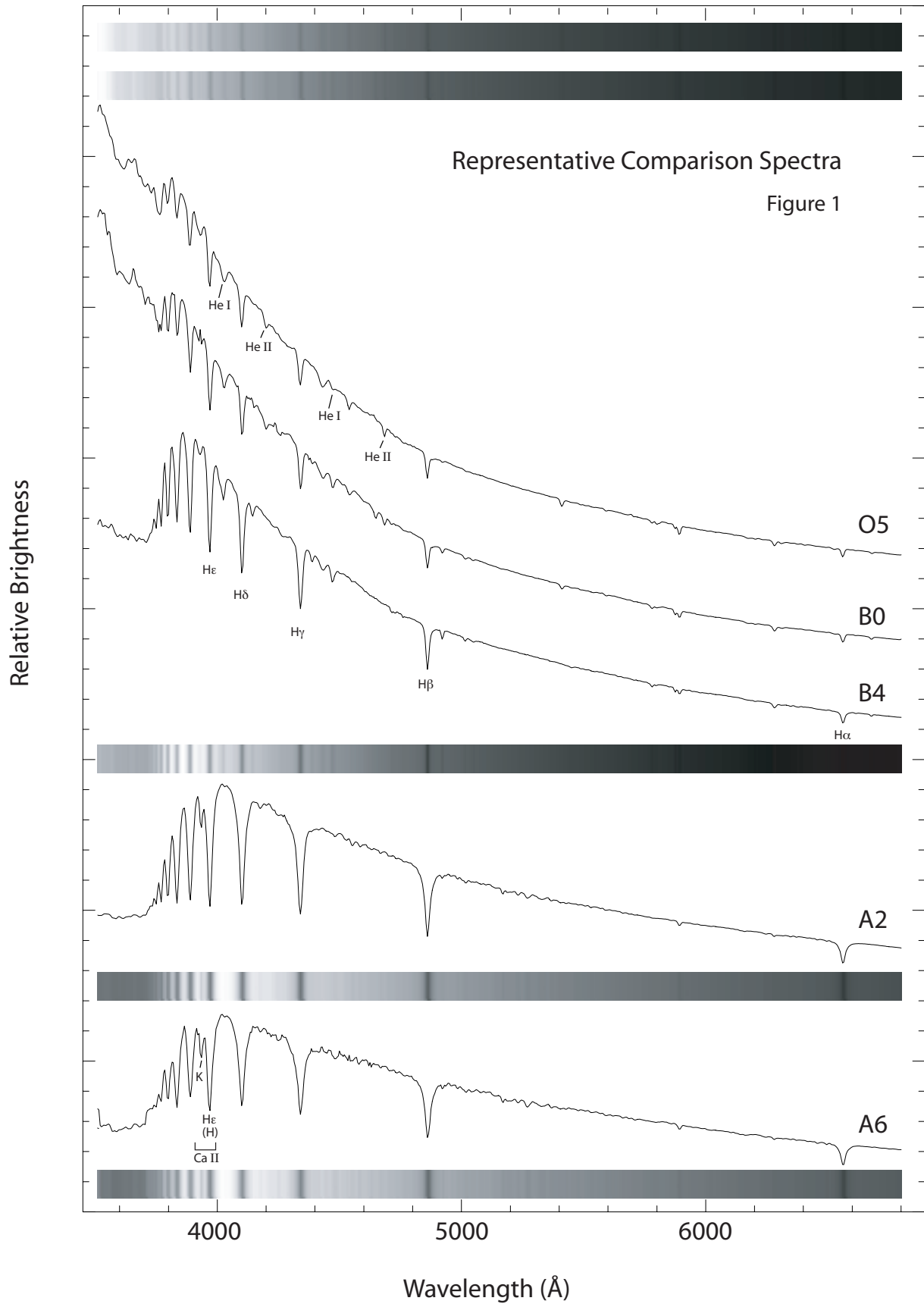


Figure 1 cont.

