Investigating Stars Name:____Block:____________

FYI: Spectral Classification & Stellar Spectra E3:R1

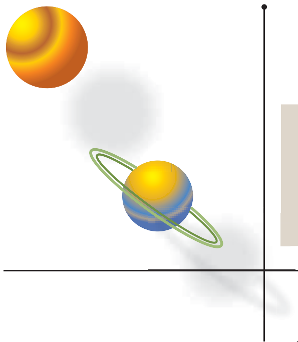
1. Read FYI: *Spectral Classification—A Look Back* **and** FYI: *Stellar Spectra—What's in a Star?*

   As you read use the spaces below to write down any information you find especially interesting. Also define the bold terms used in the text. If you run across any other words that you don't know the meaning of, write those down and ask your teacher to help you with them.

Word/Term	Definition
Harvard Group	What woman headed the group at Harvard that led to our modern star classification scheme? --
Letters	What seven (7) letters did Antonia Maury (in order) use to help classify the stars from hot to cool temperature? --
Luminosity Classes	Stars are also categorized by brightness and size into **Luminosity Classes**. List what each luminosity class means: Ia = III = Ib = IV = II = V =
Absorption Lines	**Absorption Lines** are ______lines where the electromagnetic radiation at a particular __________________ is ________________ by the cooler gas in the star's ____________________.
Emission Lines	**Emission Lines** are ________ colored lines where the electromagnetic radiation at a unique color is emitted by each element. They show up as _________ on line graphs of spectra. By contrast, absorption lines show up as valleys on similar line graphs.
Extra space for additional words or interesting information.	

1. Our Sun is classified as what letter star?

2. What causes absorption lines in a star's spectrum?



FYI

Spectral Classification — A Look Back

The first effort to classify stars was begun in the late 19th century at the Harvard College Observatory. The work was funded by a grant from the estate of Henry Draper, a well-known astronomer of the time. A group of women, headed by Annie Jump Cannon, were chosen to do the menial work of classifying as many stars as they could. They began by classifying stars by the strength of their hydrogen lines, labeling stars with the strongest lines A, next strongest B, and so on.

Figure 2-2: Photograph of Annie Jump Cannon busy classifying stellar spectra from glass plates

Canon became so proficient at classifying stars that soon she was examining several hundred stars per hour! In 1918, after 25 years of hard work, Canon's team published the Henry Draper catalog, which described the spectra of a quarter of a million stars. A co-worker of Cannon's—Antonia Maury—reordered the spectra so that all the elements visible in the spectra smoothly transitioned from class to class. The sequence became OBAFGKM—at one end were the O stars, the hottest, having just a few spectral lines; at the other end of the classification were the M stars, the coolest, with the most spectral lines. Each class is further divided into ten subclasses—0 to 9. For instance, B stars are divided into B0, B1, B2, to B9. A B9 star is very close in spectral composition to the next subclass, an A0 star.

Maury also noticed that spectral lines for the same class of star differed depending on the size of the star, with the larger stars having broader lines than the smaller stars.

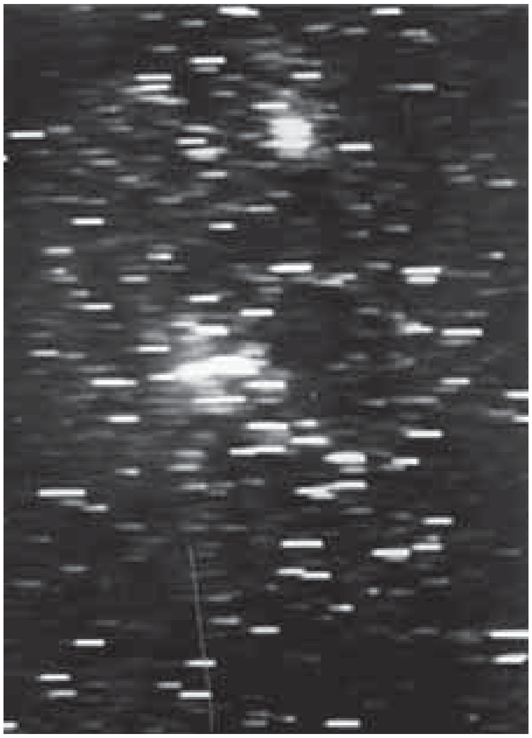
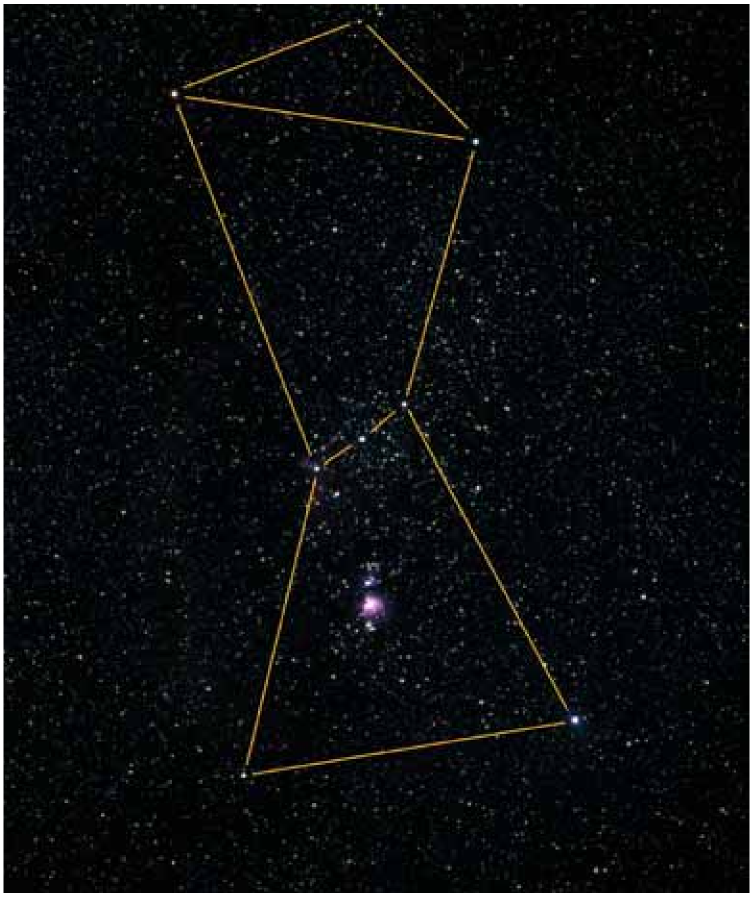


Figure 2-3: An example plate of some of the 250,000 stars that Annie Jump Cannon classified between 1911 and 1914. The spectra of many stars were captured on each image and exposed on glass plates. Annie could classify three stars per minute from these plates!

She proposed a second level of classification, termed **luminosity classes**. Luminosity class is designated by a Roman numeral for five classes:

Ia = bright supergiants
Ib = supergiants
II = bright giants
III = normal giants
IV = sub-giants
V = main sequence stars

Further elaboration of the two-parameter system took place in the 1940s and '50s by W. W. Morgan and P.C. Keenan. They introduced several additional spectral types such as C stars (stars with carbon lines), WR stars (after Wolf-Rayet stars that show emission lines), and D stars (white dwarfs). Under the new system of classification, a letter, a number, and a roman numeral designate a star's spectral class. Our sun is a G2 star on the main sequence (see Activity 3 in this Exploration), so it is classified as a G2V star.



The constellation of Orion

FYI

Stellar Spectra — What’s in a Star?

The electromagnetic radiation received from a star can be passed through a diffraction grating to produce a spectrum, which can be viewed as a graph (or image) of the brightness at each wavelength of radiation. Stars give off a continuous spectrum of electromagnetic radiation, which is a smooth curve with a peak that indicates the temperature of the star. In addition, many stars have **absorption lines** in their spectrum—dark lines where the electromagnetic radiation at a particular wavelength was absorbed by the cooler gas of the star’s atmosphere. The series of absorption lines is distinctive for each element, much like the fingerprint of a human being, in that the pattern of lines indicates what elements are present in the star’s atmosphere. Even though about 90% of each star is a mixture of hydrogen and helium gases, there are often traces of other elements that also appear in the spectrum of a star.

Spectra can be displayed and analyzed in several ways. Astronomers normally use a graphical display to investigate stellar spectra. Instead of brightly colored or dark lines situated at particular positions along a rectangular array, astronomers measure the positions of peaks (**emission lines**) or valleys (absorption lines) that appear along the continuous spectrum of the star. See the comparison of the linear and graphical spectra of a star in Figure 2-4 below.

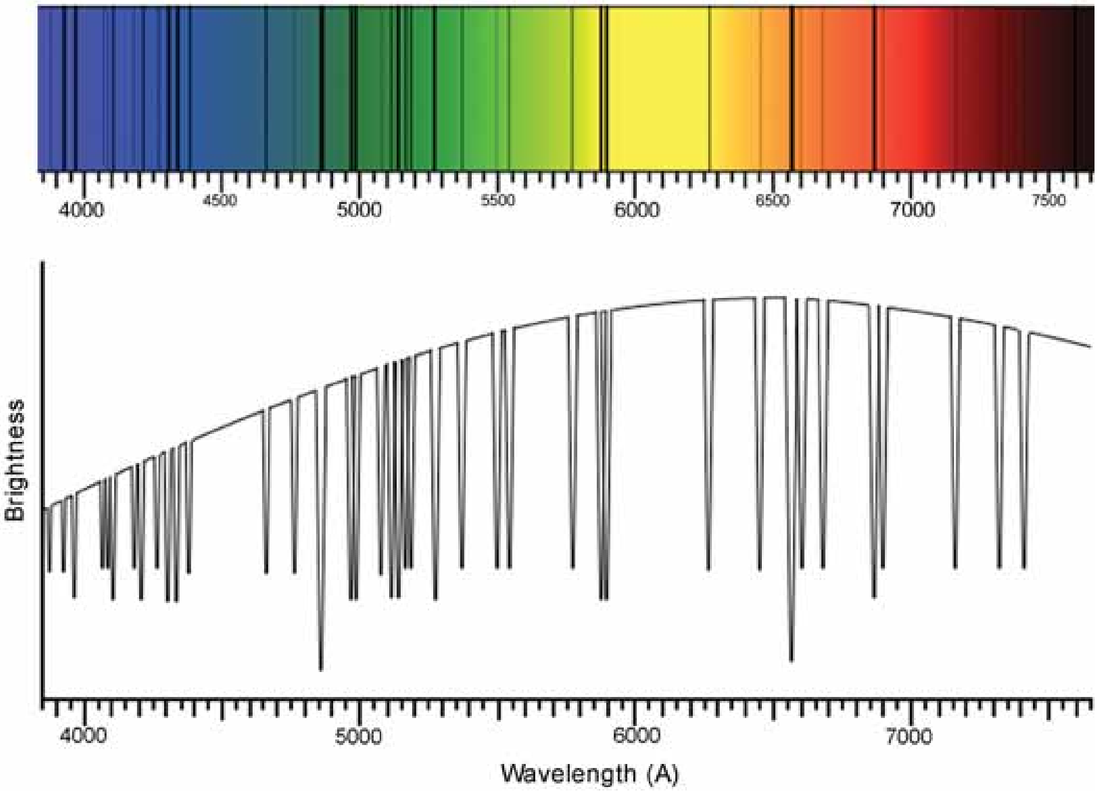


Figure 2-4: Linear and graph versions of a stellar spectrum. The dips and valleys in a graphical spectrum are in the same position as the dark lines of a star’s linear spectrum.

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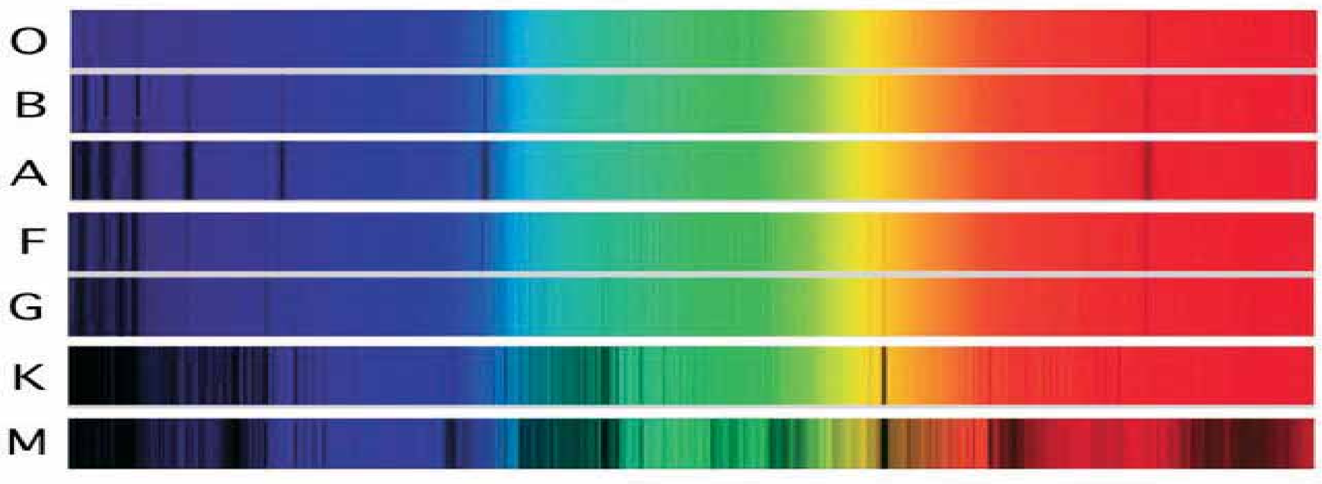

Figure 2-5: The stellar classification system in linear style

Stellar Classification

A non-graphical way of looking at the 7 major stellar classes plus some subclasses and unusual types of stars is shown in Fig. 2-5.

We can classify most stellar spectra by looking at three or four prominent spectral lines. The most obvious is the series of hydrogen lines (Hα, Hβ, and Hγ). Virtually absent in O stars, hydrogen grows strong through B and A stars, and weakens in F and G stars. The double sodium lines (in the yellow) are weak in A stars and increase in strength in the progression toward M stars. The cooler the star, the more difficult it is to ionize gases. Instead, molecular lines are often seen. A group of titanium oxide (TiO) lines are prominent only in M stars (in the green-yellow portion) and weak or nonexistent in all the other classes.

In Figure 2-6, absorption lines are seen as dips in the curve. The curves represent the continuous portion of the spectrum and illustrate that O stars' spectra are much brighter than the spectra of K or M stars. The Hα is lost in the representation, but Hß is clearly visible in the B, A, and F stellar spectra at 4863 Å. The sodium line in the M star's spectrum is clearly visible at 5900 Å. Notice also that the cooler the star, the more lines it has. Another clue to classifying spectra is judging average temperature from the peak of the continuous spectrum of the star.

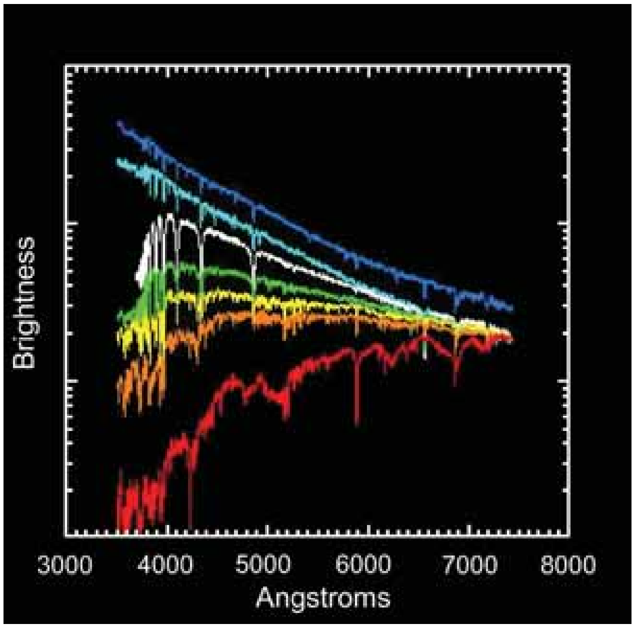

Figure 2-6: Graph of the seven stellar classes—the same ones as shown in Figure 2-5

Also, the O and B class stars peak far into the ultraviolet part of the spectrum. The peaks of the progressively cooler stars appear farther and farther toward the red, or cooler end of the spectrum. The point at which the wavelength peaks can be used in conjunction with Wien's Law to give a rough idea of the star's surface temperature and stellar class.

In the Figure 2-7 graph, the absorption lines are shown with the continuous spectrum of the star. The **continuum** peaks at about 5200 Å (or 5.2 x 10^{-5} cm). This temperature is typical of a G-type star. In other stars' spectra, the peak doesn't appear on the graph. This is particularly true for very hot stars whose continuum peaks in ultraviolet. If the peak of the star is in the ultraviolet area of the spectrum, the star must be a class O, B, or A.

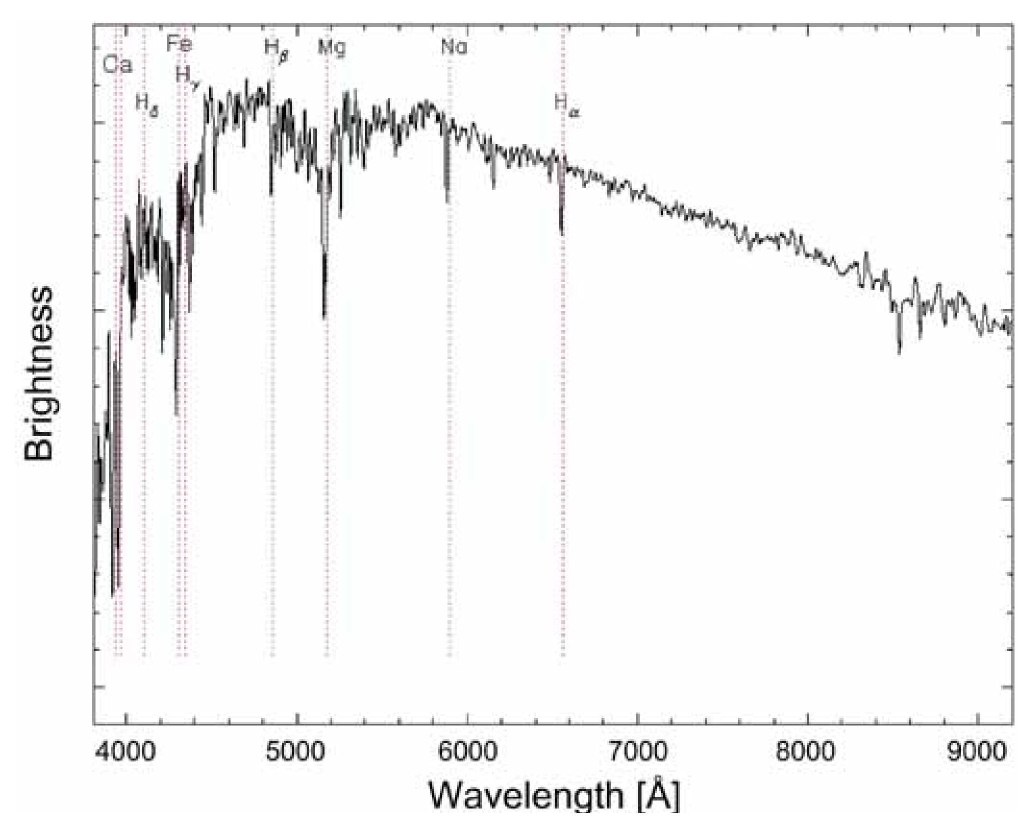

Figure 2-7: Graph of the spectrum of a typical star