WHAT IS IN A STAR?
CULMINATING PROJECT

WHAT DO WE KNOW ABOUT STARS FROM STELLAR SPECTRA?

Throughout this module we have learned how to extract information about the temperature and composition of a star from its spectrum. This culminating project asks you to apply the knowledge and skills you have learned to the analysis of a group of different stars.

You will work both ***individually*** and in ***groups of 3*** for this project. The first part of the project requires you to work individually, analyzing the spectra of 3 stars. Your group will then come together to share individual results and test your understanding of the information contained in stellar spectra.

In conference today, your group will receive a packet of 9 stellar spectra (numbered 1-9). You will receive *two* spectra for each star. One spectrum will have peaks labeled by arrows in the range 390-670 nm. The other copy will be the spectrum for the same star, but plotted over a larger range of wavelengths.

Each person in the group should select one of the following sets of stellar spectra to analyze fully.

- Set A: 1, 2, 3
- Set B: 4, 5, 6
- Set C: 7, 8, 9

INDIVIDUAL STELLAR SPECTRAL ANALYSIS

DUE IN YOUR CONFERENCE SECTION: SEPTEMBER 19/20, 2007.

The first part of this project is an *individual* effort. We expect that you complete this work on your own without consulting anyone else. Feel free to consult the Star Module, your notes, or your text where needed. Put your name on the 3 spectra you analyze on your own, and provide your individual answers to the questions below. *Note:* To answer question 1 below, use the spectra *without* arrows. In questions 2 and 3, focus your attention on the spectra *with* arrows.

For each of your 3 stars, answer the following questions:

1. Estimate the temperature of your star using its spectrum. Explain your reasoning and show a calculation with units to support your answer. Also, briefly indicate how sure (or not) you are of this temperature estimate and why.

2. Identify which elements are in your star. Briefly explain your reasoning process and support your identifications with data (a table form is ideal). Label your spectra with measured wavelengths for easy visual comparison when you join your group.

3. Write the electron configuration of all the *atoms* and *ions* in your stars. You do not need to repeat this for elements that are in more than one star.

GROUP QUESTIONS AND ANALYSIS

DUE AT THE BEGINNING OF LECTURE: MONDAY, SEPTEMBER 24, 2007.

You will begin the group analysis in conference the week of September 19/20, 2007. Come prepared with your individual results. You can only succeed as a group if everyone has analyzed his or her individual stars. If you need to finish the group analysis, you will have to schedule a time for everyone to meet outside of class. This part of the project will be written up as a group response and turned in with all members' names on it. You group may select a scribe(s) to record responses to the group questions below. Please note the name of the scribe on each question.

Share individual results for your 3 stars with your team members. You will have to teach each other about your individual set of 3 stars. Check each others' work for logic, explanations, and correctness. *Note:* You may modify your individual answers if you change your mind about something based on group discussion, but note both your original answer and how you changed it.

4. As a group, rank all 9 stars in order of increasing temperature. Explain your reasoning. Is there any uncertainty in the ranking, and if so, why? (You need to be confident of your ranking before going on to the next two questions.)

5. Consider the ions in stars:

   a) Describe the overall trend in the prominence of Ca^+ and He^+ ions for the set of 9 stars. Do you notice these ions in all 9 spectra?

   b) Use your understanding of the electron configurations and relative sizes of Ca and He atoms to explain the difference in ionization energy between Ca and He. Then, use this information to explain the trends you noted in part 5a for Ca^+ and He^+. Your answer should also include consideration of star temperature.

   c) Do you expect to see absorption lines due to H^+ in a stellar spectrum? Explain why or why not. (*Hint:* What effect does absorption of energy have on electrons within an atom or ion?)

6. Consider hydrogen in stars:

   a) Catalogue in a table all the H absorption lines in the group of 9 stars and assign them to specific transitions in H with the notation $n_{initial} \longrightarrow n_{final}$. Note the equation that you used to support your assignments.

   b) Draw an energy level diagram of hydrogen that shows the transitions (using arrows) occurring in H atoms in stars.

   c) Look at the prominence or strength of the H lines in the star spectra. Describe the trend you see as you move from cool to hot stars.

   d) Make a proposal for why some of the 9 stellar spectra have weak H Balmer absorption lines while others have strong Balmer lines. Consider star temperature, our model for a star, and the atomic processes that create the lines in the spectrum. Assume that hotter stars provide more thermal energy to bump electrons in atoms away from the nucleus, and that there can be enough thermal energy in a star to ionize atoms. (*Hint:* What do the Balmer absorption lines of hydrogen have in common? You may also want to use your reasoning from problem 5c above.)