ASTRONOMY 101A (Fall Semester 2002)

SPECTRA AND SPECTROSCOPY

Objective: Despite tremendously large telescopes which help to detect faint and distant objects in the universe, most stars and galaxies are so far away that they appear only as points of light even in the largest telescopes. Even so, **from that light we can still learn things about what a star or galaxy is made of, how far away it is, how fast it is moving, how hot it is, and many other properties.**

The most useful technique for analyzing light is ***spectroscopy***, which involves breaking the light we receive into its distinctive colors. To see the spectra of a star, all one has to do is shine the starlight through a triangular shaped piece of glass, called a *prism*, such that the different colors making up that starlight are separated and we can see the *spectrum* of that star. Any such device which spreads out light into its spectrum is called a *spectrometer*. In this class, we will use an inexpensive spectrometer which instead of a prism consists of a slide frame with a specially prepared piece of plastic, called a *diffraction grating,* that spreads all (visible) light passing through it into a spectrum.

Today you will see that spectrometers can be used to identify different chemical elements present in nearby objects like the sun, or distant galaxies on the edge of the observable universe. All you need is enough light to use a spectrometer.

Procedure: **Part 1: Practicing with the Spectrometers using the overhead lights.**

a) Make sure you have one of the spectrometers. Practice using the spectrometer by looking at the florescent lights overhead. Notice that in order to see the spectrum of the overhead lights properly, you must look through the spectrometer (slide frame) at the light source. Two spectra will appear, one to the left and another to the right of the light source. **For consistency, please sketch the spectra to the <u>left</u> of the light source**, such that the reddest colors in the spectra are the farthest to the left.

b) Draw the spectrum of the overhead lights into the figure below.

Overhead Lights:

750 nm 700 nm 600 nm 500 nm 350 nm

Red Orange Yellow Green Blue Violet

Add any additional descriptive comments here:

Part 2: Obtaining Spectra

Now use your spectrometers to look at the spectra produced by various gases at the six "stations" set up in the lab room).

a) Using your spectrometer, you should observe the light source at each station and make a drawing of the spectrum in the diagrams provided below Include any other descriptive comments. **You will need to pay particular attention to:**

- **line colors**
- **intensities (faint or bright)**
- **relative spacing of lines.**

Make written comments if that helps describe the spectra.

When you are finished with all the tubes, **compare your sketches with those of other students to confirm all the features you have seen were also seen by others.**

Hydrogen (H): The most common element in the universe (but not on earth)

750 nm 700 nm 600 nm 500 nm 350 nm

Red Orange Yellow Green Blue Violet

Additional Descriptive Comment

Helium (He): The second most common element (but not on earth)

750 nm 700 nm 600 nm 500 nm 350 nm

Red Orange Yellow Green Blue Violet

Additional Descriptive Comment

Mercury (Hg): The only liquid metal at room temperature

750 nm 700 nm 600 nm 500 nm 350 nm

Red Orange Yellow Green Blue Violet

Additional Descriptive Comment

Argon (Ar): Like Helium, Argon doesn't engage in many chemical reactions.

750 nm 700 nm 600 nm 500 nm 350 nm

Red Orange Yellow Green Blue Violet

Additional Descriptive Comment

Sodium (Na): Most common form of street lamp and a light pollution problem.

750 nm 700 nm 600 nm 500 nm 350 nm

Red Orange Yellow Green Blue Violet

Additional Descriptive Comment

Light Bulb Filament: A dense filament…what kind of spectra should we see?

750 nm 700 nm 600 nm 500 nm 350 nm

Red Orange Yellow Green Blue Violet

Additional Descriptive Comment

Part 3: Classifying Your Spectra

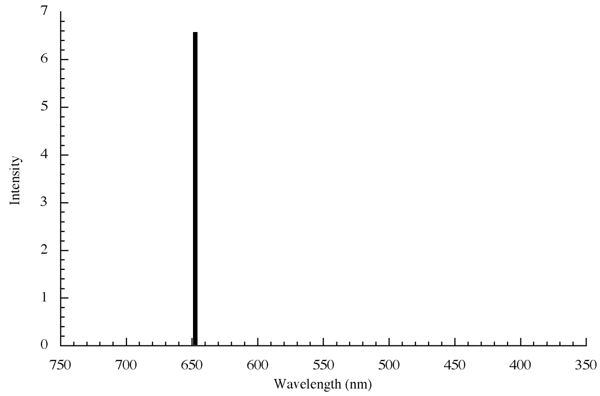
Now carefully look over your observations and answer the following questions:

a) There are three kinds of spectra in nature: *continuous* (which contains all the colors of the rainbow), *emission* (in which only certain colors are visible), and *absorption* (in which most colors are visible, but certain specific colors are missing). Of the spectra you observed, which ones were of which type?

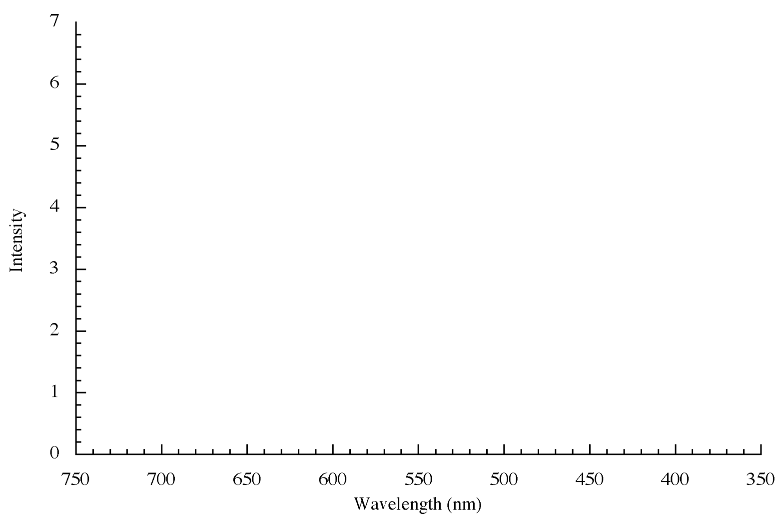
b) We didn't actually observe an **absorption spectra**, can you speculate on the difficulties of setting up a situation in the lab where you can see an absorption spectra?

Part 4: Another Way to Record Spectra

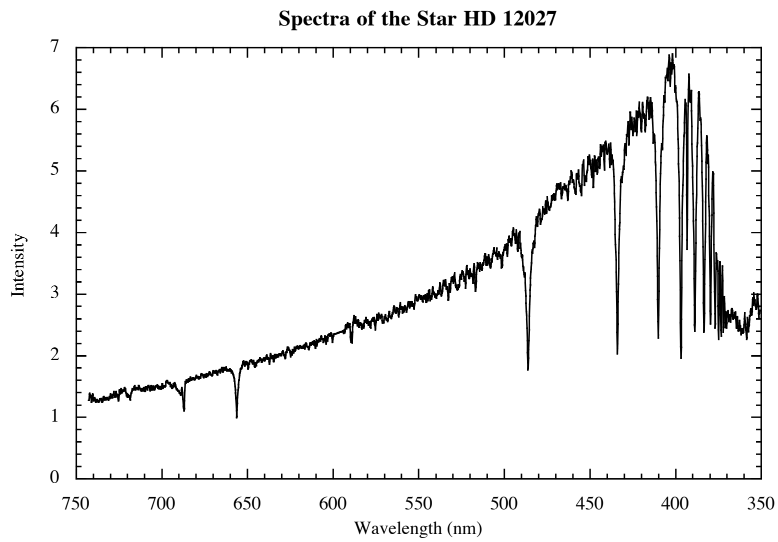
Astronomers typically don't record spectra by using hand drawings, instead, we carefully trace out the intensity of light (how bright it is) versus the wavelength of light, as shown in class. So for example, if an object only gave off red light (like a laser), its spectra would only have a high intensity at one wavelength, so it would look like this:



a) Replot your Hydrogen spectrum as an intensity (*y-axis*) versus wavelength (*x-axis*) plot in the graph below. By intensity, I mean coming from the spectra at each given wavelength (*aka* color). **Understand that you will not exactly match each spectral line color to its wavelength, this will be a source of error…**



b) Contrast the hydrogen spectra you drew to the spectra of the faint star HD 12027 below, specifically **compare the wavelengths absorption lines in the star's spectra to the emission lines in the hydrogen spectra you observed in lab**.



c) It is observed in lab (and believed on theoretical grounds) that absorption and emission spectra for the same material will have their spectral lines at the same wavelengths. Using this information, can you speculate on whether or not there is Hydrogen present in the atmosphere of HD 12027? *Be sure to explain your reasoning below.*