Endings, Spring 2006 Names:

In-class exercise 3: The very idea of a spectrum

In the previous exercise, you found some "big ideas" in science – the fundamental forces and the three laws of thermodynamics. But as you saw in the first exercise, it is the change in form of energy (first law) through the process of absorption and emission of electromagnetic radiation (a fundamental force) by objects that allows for information (energy) to be communicated around the universe.

In this exercise, you will experimentally investigate objects that emit light energy and objects that absorb light energy, and how you measure this absorption or emission. To do this, you will need to know the term "**electromagnetic spectrum**" which is the whole range of energies (wavelengths, frequencies) that light can have. For this experiment, we will be interested primarily in the **visible** spectrum, a tiny subset of the electromagnetic spectrum.

The device you will use to measure the spectrum is the **spectroscope** (called the SCSpec in this experiment), which is basically a smart **prism**. A prism because, like its glass cousin, it separates light into its component colors (ROYGBV), and smart, because it can tell you what wavelengths are present in the spectrum.

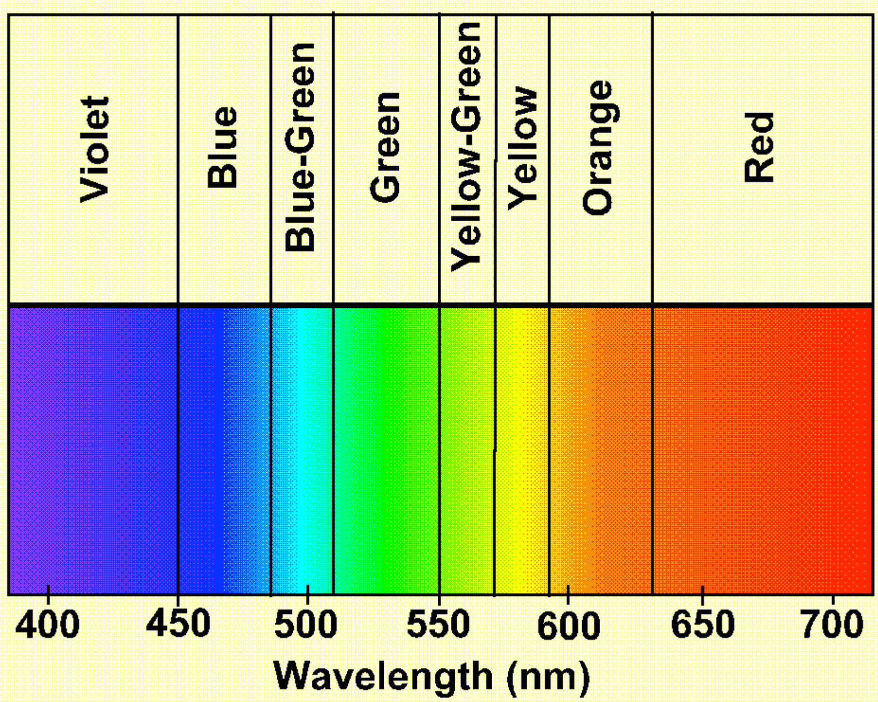

Figure 3: The visible spectrum

Work in groups of three or four; the order in which you do questions #1–#6 does not matter.

Needed:
- Laptop computer from the cart (pick from #1 to #7)
- SCSpec spectroscope kit (in plastic tub)

Set up the spectroscope and laptop as stated in the laminated sheet that comes with the spectroscope kit. Make sure that you have a Desktop visible on the laptop before you plug the USB cable from the spectroscope into the laptop. Make sure the spectroscope is actually plugged into an electrical socket.

Follow the instructions on the laminated sheet to start up the software “SCSpec”. After clicking on the “Connect” button, it should quickly turn into a “Disconnect” button. If this does not happen, let me know! You should see a rainbow-like set of colors appear on the left of the screen.

Do not worry about “Calibration”; after setup, go directly to the back of the sheet to “Capturing Spectra”. You will not need to Save any of the data you collect since you’ll be writing it down, but you will need to make sure that Graph is visible. After clicking “Graph”, you should see a graph appear on the right of the screen.

1. a. Look at the graph and state what quantity the x-axis represents, and what units that quantity is in. Hint: see diagram on first page of this handout.

b. What quantity does the y-axis represent, and why might the units not be so helpful for this quantity?

2. a. Take the laptop and spectroscope outside (please be careful not to drop anything), and use the extension cord to plug in the spectroscope. Point the spectroscope at a piece of white paper that is reflecting sunlight. DO NOT POINT THE SPECTROSCOPE DIRECTLY AT THE SUN; the results are not useful. Sketch the graph below, giving numbers on the x-axis where useful.

b. While still outside, point the spectroscope at nearby shrubbery and sketch that graph below, again giving numbers on the x-axis where useful.

3. Indoors, point the spectroscope at the fluorescent light. Sketch the graph below, giving numbers on the x-axis where useful.

4. Indoors, obtain the ultraviolet (UV) box and carefully point the spectroscope up at the UV light. DO NOT LOOK AT THE ULTRAVIOLET LIGHT YOURSELF unless you wish to have cataracts. Sketch the graph below, giving numbers on the x-axis where useful.

5. a. Indoors, point the spectroscope at a **low** wattage light bulb. Try to do this in such a way as to minimize the amount of the fluorescent light pointed at the spectroscope. Sketch the graph below, giving numbers on the x-axis where useful.

b. Now point the spectroscope at a **high** wattage light bulb. Again, try to do this in such a way as to minimize the amount of the fluorescent light pointed at the spectroscope. Again, sketch the graph below, giving numbers on the x-axis where useful.

6. Just for grins, point the spectroscope at the surface of a dark object (like the table) and sketch its graph.

At this point, please put away neatly the laptop and spectroscope; make sure all the parts return to their rightful place.

Analysis of your sketch data:

7. a. First, do the Sun, light bulbs, and UV lamps **absorb** or **emit** light? Let's call these light **sources**.

b. Do surfaces like the table or the shrubbery absorb or emit light? Let's call these light **sinks**. How can you tell without using a spectroscope that they do?

8. a. Explore the phenomenon of absorption: In question 2 parts a and b, was there a difference in the graphs? State what difference(s) you saw in the graphs, and how this relates to absorption.

b. Specifically identify (using the aid of the diagram on the front page of this handout) what color was absorbed by the shrubbery. How does this make sense in light of the color you see reflected off the shrubbery?

9. Again, related to absorption, in question 2a, why did I have you use a white card to reflect sunlight into the spectroscope, as opposed to any other color card?

10. So when the graph of the spectrum of a light sink has a dip (that is, the intensity declines at some wavelength but recovers on either side of that wavelength), what does that tell you about the object that is the light sink?

11. a. Explore the phenomenon of emission: In question 5 parts a and b, was there an **intensity** difference between the two bulbs? Was there a **peak wavelength** (that is, the intensity increases at some wavelength but declines on either side of that wavelength) difference between the two bulbs?

b. What does this suggest to you about the material makeup (chemical composition) of the filament of both bulbs?

c. If what you say in part b is true, then would you expect the emission peak wavelengths from the fluorescent bulbs to be the same or different than the incandescent bulbs? How come?

d. Test your hypothesis from part c by looking at question 3. Were you right?

12. A friend of yours suffers from seasonal affective disorder (SAD) and says that her doctor prescribed sitting in front of a light source for an hour a day. She asks whether a fluorescent bulb or an incandescent bulb would be a better match for sunlight. Which would you recommend, and why?

13. Thus, the solar spectrum (the spectrum of the Sun) is a mystery indeed. How can the Sun's spectrum be so **continuous** (as opposed to the fluorescent or incandescent bulb, which have **discrete** spectra)? That is, what does the continuous nature of the solar spectrum tell you about the Sun? Hint: Have the instructor either drag out the "Spectra of Various Elements" chart or else display the spectra of various ionized gases.

14. So what is the cause of a graph of the spectrum of a light source having a dip? There are two possible answers, one of which is demonstrated by question 2b.

15. In what way was the result of question 4 surprising to you? In what way was the result not surprising?