Experiment 2
Radiation in the Visible Spectrum

In the following experiments we will examine the radiation given off by sources radiating in the visible region. We will be using a spectrometer produced by Ocean Optics. Light enters the spectrometer via a fiber optic cable. Inside the spectrometer a diffraction grating diffracts the different frequencies onto a CCD. The CCD basically "counts" the photons according to wavelength. The data is transfered via a usb port to a PC. The Ocean Optics software displays the spectrum as counts versus wavelength. The wavelength bin size is 0.5 nanometers.

After the spectrum is collected, we will save it in text format. We will import the text files into Excel for data analysis. After instruction on how to use the software, we will examine the spectra given off by the following sources: incandescent light filament, hydrogen, helium, various light emitting diodes, and a laser pointer. These experiments will be carried out over three lab periods.

Operating the Spectrometer

The spectrometer is operated using the PC.

1) Boot up in Windows2000.
2) "Double-click" on the Ocean Optics icon on the desktop.
3) When the softwear boots up, the spectometer should automatically start taking data.
4) When you have a good spectrum, save the data in text format.
5) Import the data into excel for data analysis.

Incandescent Light Source

Our incandescent light source will be a tungsten filament.

1. Data Collection: Record and save the spectra for the light bulb when it is operating at its "normal" brightness.

2. Qualitative Assessment: Describe (in words) the nature of the spectrum. (e.g. is it continuous or discrete). Do you notice any unusual features? Do you think it is

representative of perfect "black body" radiation? Why or why not.

3. From the spectrum, estimate the temperature of the filament. This can be done by modeling the filament as a "black body" radiator. In this case, the Wien displacement law is $kT = 0.2014hc/\lambda_{max}$.
From your spectra estimate as best you can what λ_{max} is. Is your result chose to what is listed in the literature as the temperature of a light bulb?

4. Reduce the voltage across the filament, and repeat Part 3 above. You might have to increase the collection time, since the intensity will be less with a dimmer light bulb. Is λ_{max} the same, less, or greater as in part 3? Is your observation consistent with the change in temperature?

Hydrogen Spectrum

In this experiment we will examine the radiation given off by a hydrogen discharge tube.

1. Data Collection: Record and save the spectra for the hydrogen tube.

2. Qualitative Assessment: Describe (in words) the nature of the spectrum. (e.g. is it continuous or discrete).

3. Print out a graph of the spectrum (from Excel) and on the graph write down the atomic transition that is producing each peak. For example $3p \rightarrow 2s$. You can use the file next to this writeup to help you identify the transitions.

4. Identify as many peaks from the Balmer series as you can. For these Balmer transitions, use the text file of the data to estimate the wavelength of the peak center. Make a data table of these wavelengths and the corresponding photon energies (in eV). Make a graph of $1/\lambda$ versus $1/n_i^2$, where n_i is the "quantum number" of the initial state. The Balmer equation is:

$$\frac{1}{\lambda} = R_H(\frac{1}{n_f^2} - \frac{1}{n_i^2}) \quad (1)$$

where n_f is the quantum number of the final state.

5. From the slope of your graph, determine the Rydberg constant R_H.

6. From the intercept of the vertical axis, and your value for R_H, determine n_f which is the "quantum number" of the final state.

7. Do the values you obtained for R_H and n_f agree with those stated in the literature? What are some of the reasons that they might be a little bit different?

Helium Spectrum

In this experiment we will examine the radiation given off by a helium discharge tube.

1. Data Collection: Record and save the spectra for the helium tube.

2. Qualitative Assessment: Describe (in words) the nature of the spectrum. (e.g. is it continuous or discrete).

3. Print out a graph of the spectrum (from Excel), and on the graph write down the atomic transition that is producing each peak. For example $1s3p \rightarrow 1s2s$. Also note if the initial and final states are in the "singlet" or "triplet" spin configuration. You can use the file next to this writeup to assist you in identifing the transitions.

As was done in class, you can make a table of some of the important transitions for both He and H. In the visible region, many important lines are due to the final state being $n = 2$ in the "radial" quantum number. In particular, for He the final state of $1s2p$ has many visible transitions. A suggested table is:

Transition	He Singlet	He Triplet	Hydrogen
$3s \rightarrow 2p$	—-	—-	—-
$3d \rightarrow 2p$	—-	—-	—-
—-	—-	—-	—-

LED Spectrum

In this experiment we will examine the radiation given off by different Light Emitting Diodes (LED).

1. Data collection: For each LED, you will slowly increase the voltage across it. For each step in voltage, you will also record the current through the LED. Keep recording voltages and currents until the LED lights up. Do not put too much voltage, as you might damage the LED. The goal of this exercise is to determine at which voltage the diode starts conducting. The charge of an electron, e, times this starting voltage should be equal to the energy of the photon that is emitted.

2. When the LED is producing light, record and save a spectrum with the spectrometer.

3. Qualitative Assessment: Describe (in words) the nature of the spectrum. (e.g. is it continuous or descrete).

4. For each LED, determine the wavelength that has the most counts. This is the characteristic wavelength of the LED. Estimate the **F**ull **W**idth at **H**alf **M**aximum (FWHM) of the peak in nanometers. This is the range of wavelength for which the counts drop to 1/2 the maximum value to the left and right of the peak.

5. If you examine the graph of current versus voltage for each LED, you will be able to estimate the voltage at which the current starts. This starting voltage times the charge of the electron should equal the energy of the photons emitted. That is,

$$eV = \frac{hc}{\lambda} \tag{2}$$

6. Make a graph of voltage V versus $1/\lambda$ for each LED. Do your data points lie in a straight line? If so, find the slope of the line. Does it agree with the literature value?

Laser Spectrum

In this experiment we will examine the radiation given off by a diode laser.

1. Data Collection: Collect and save the spectrum from a laser pointer. **BE CAREFUL NOT TO HAVE TOO MUCH LIGHT INTENSITY GOING INTO THE FIBER**. For the laser, you will need to put the cloth provided over the laser light to difuse the light before it enters the optical fiber.

2. Qualitative Assessment: Describe (in words) the nature of the spectrum. (e.g. is it continuous or discrete).

3. Print out a graph of the spectrum (from Excel). From the text file, determine the wavelength of the peak(s) and estimate the width of the peak(s).

Florescent Light

In this experiment we will examine the radiation given off by the florescent lights in the classroom.

1. Data Collection: Collect and save the spectrum from the florescent lights in the room.

2. What are the main wavelengths (three) present in the spectrum? Are they approximately the same intensity? What colors do these wavelengths correspond to? Why do you think the florescent light manufacturer designed the light to give the spectrum it does.