**Observations of Emission Spectra**

Primary Purpose: To determine Rydberg’s constant.

Secondary Purposes: Compare Helium spectrum with that of Hydrogen. Determine 2p level splitting in Helium. Determine wavelength of brightest lines in Mercury and Sodium spectra and determine which energy level transitions produced these lines. Observe various emission spectra.

Warnings: Do not point fiber optics probe at very bright sources. Keep blue plastic cover on probe when not in use. Do not point fiber optics probe directly at laser. Spectrum tubes will be hot. Turn off power and use handkerchief or wash rag to hold tube when removing tube.

Note to Instructor: This experiment requires a computer that has the Red Tide spectrometer software installed. If not already done, software must be installed before attaching hardware.

Procedure

 Setup

1. Connect the fiber optics cable to the Red Tide Spectrometer. Connect spectrometer to computer. Turn on computer and log in. If the computer is not on the Auburn domain use the Physics Lab User account. If you do not know the password for this account, see the lab administrator.
2. Start the Spectra Suite software. A picture of the Red Tide spectrometer should be on the left side and a red line running across the graph area with probe cover off.

 Take Data

1. Put a Hydrogen tube in the power supply clips. Put power supply vertically. Using a rod and clamps place the end of the fiber optic cable about 6 inches from the spectrum tube. You may want to turn off the room lights or place a box around the tube and fiber optic cable to limit room light. Some of the lines are weak. Turn on tube power supply and adjust probe position so highest peak is near top of graph area. Get the wavelengths of the tallest peaks by putting mouse on the peak and clicking. The wavelength in nanometers is in a box along the bottom of the display. Adjust the position of the probe so you have wavelengths for 4 strongest lines in the visible part of the spectrum. Print the spectrum.
2. If the Hydrogen tube is new there will be 2 lines in the infrared region between 700-900 nm. Record wavelengths and use Internet to identify. If the lines are not present skip this step.
3. Turn off the power supply and replace the Hydrogen tube (t**ube will be hot**) with a Helium tube. Observe and print the spectrum. Adjust the probe positions as needed to obtain wavelength of at least 10 lines between 400-800 nm.
4. Turn off the power supply and replace the Helium tube (t**ube will be hot**) with a Mercury tube. Obtain wavelength of blue, green and yellow lines. Print the spectrum. See if the yellow line can be split by using zoom feature. Try to determine the wavelength of a weak line between 490 & 500 nm. Observe spectrum of fluorescent light. Can the Mercury lines be detected in the newer low mercury type fluorescent lights?
5. Observe and print the Sodium spectrum. Use the Red Tide display magnification to see if you can separate the yellow line into two lines.
6. When finished turn off emission tube and sodium power supplies.
7. As time permits obtain the following spectra.
8. Obtain spectrum of clear light bulb. Estimate the temperature of the filament from the peak wavelength assuming it can be treated as a blackbody.
9. Obtain the spectrum of a laser (green if available, if not use red). Shine the laser at a white piece of paper and point probe at reflection.
10. If a blue-violet laser and an orange piece of paper are available see what happens when you shine blue laser beam on orange paper. Get spectrum of reflected light from orange paper and white paper. If a blue-violet laser is available but not orange paper just get spectrum of light reflected from white paper.
11. Observe spectra produced by the Calibration Source LEDs one by one. Determine wavelengths. To save paper turn on all LEDs at the same time and print spectrum.
12. Which (step 10-13) produce continuous spectra, line spectra or a combination?
13. When finished put cover on probe tip. Turn off computer when through for the day. Turn off and unplug lasers and spectrum tube power supply. When finished with experiment unplug Red Tide spectrometer from computer.

Analysis of Hydrogen Spectrum

1. Look up the index of refraction for air and convert wavelengths to vacuum values and in meters not nm.
2. Use the formula below and some trial and error to find the value of the quantum number m for each wavelength. For visible light n=2. Determine the value of R. If you have the correct values of m the R values will be the same (within measurement uncertainty).
3. Compute average R value and compare to “book value”. For the “book value” use the reduced mass value of R not the value that treats mass of nucleus as infinite.
4. How much would the wavelength differ if you were looking at the Deuterium spectrum? Multiple the infinite mass value of R for Hydrogen by the reduced mass correction for Deuterium to get R for Deuterium. For one of the lines compute the wavelength the line would have in the Deuterium spectrum. Would the difference between the H and D lines be visible with device you are using?

 Analysis of Helium, Mercury & Sodium Spectra

1. In the row of blanks at top put your measured values of H wavelengths starting with the longest. In the vertical blanks enter your wavelength for the 4 numbered lines on the graph attached starting with longest wavelength. Convert all the wavelengths in the table below to energy in ev. The energy of the transitions due to the outer (valence) electron will be close to that of the Hydrogen electron with the same quantum numbers due to the inner electron “cancelling” one of the positive charges in the nucleus. The 2p energy level will differ some between H and He. Fill in the blanks on the diagonal with the energy difference between the wavelengths. It should be close to the same number but may differ due to uncertainty of wavelength measurements. There is another energy split of the 2p level that is only -0.03 ev. Compute the energy difference between the two levels and compare to “book value” of the1s2p level splitting in He. To get “book value” obtain the energy for the two levels from NIST spectra database for HeI in reciprocal cm (used for spectra). Use C below to convert to ev.
2. Determine which energy level transitions produced the brightest lines in the Hg spectrum. For example the weak line between 490 & 500 nm is due to an 8s to 6p transition. Look on the Internet for an energy level chart for Mercury. Try PHYWE company site.
3. Which energy level transitions produce the Sodium lines? What causes the upper energy level to be split?

 Formulae

1. 1/λ = R( 1/n2 – 1/m2) m>n
2. Reduced mass = mass of nucleus / ( mass of nucleus + mass of electron)
3. energy in ev = energy in reciprocal cm multiplied by 1. 2398 x 10 -4

 H wavelengths \_\_\_\_\_ \_\_\_\_\_ \_\_\_\_\_ \_\_\_\_\_

He wavelengths

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