Phys 4910 Spectroscopy
Monochromator Resolution

Introduction

In a previous laboratory you obtained the spectrum from a lamp containing both neon and sodium using the photomultiplier. In it you found the wavelengths of the two sodium D lines using the neon lines for calibration. In this new assignment you will use a similar experimental technique to record that portion of the spectrum which contains just the two sodium D lines, and use the results to determine the spectral width ($\delta\lambda$) of the lines as a function of the entrance slit width(1), and also the dispersion of the instrument.

The portion that you need to record is just that wide enough to include both the sodium D lines(2). They are approximately 17 cm^{-1} apart(3), which gives you the scale for your spectrum. You don't need the neon lines for calibration.

The entrance slit width is controlled by the micrometer located directly above the entrance slit. Each marking on the micrometer corresponds to 10 μ of slit width. One full revolution of the micrometer therefore corresponds to changing the slit width by 250 μ. The exit slit has been set to a width of 2 μ. Since is it difficult to access leave the exit slit at this value.

Definitions

- Resolving power: $\lambda/\delta\lambda = \nu/\delta\nu$ where $\delta\lambda$ is the minimum separation of two lines which can be distinguished as separate. We shall set this equal to the FWHM of one peak.
- Full width half maximum (FWHM): the width (measured as $\delta\lambda$ or as $\delta\nu$) at an intensity equal to ½ of the peak intensity
- Dispersion: the wavelength range (usually in nm) per unit of measurement.

Assignment

1. Position the neon/sodium lamp in front of the entrance slit, and adjust its position to get a good signal. (A neon line would work for this part.)
2. You will be repeatably recording the same portion of the spectrum, but with different sizes for the entrance slits.
3. Check that the reading on the micrometer is 1, that is the slit width is 10 μ.
4. Record a short section of the spectrum, a portion just wide enough to include both the lines that you selected. Record the spectrum slowly (say 5 minutes) so that the speed of the recording equipment does not affect your results. Also, sample the data as fast as possible. Since you are

1 Since you are using the diode array the concept of an exit slit width does not apply. Is is effectively the separation between pixels on the diode detector.

2 Although the D lines have wavelengths of approximately 589.0 and 589.6 nm, the calibration of the instrument is currently about 1 nm off. Expect to see the lines at displayed wavelengths of 588.0 and 588.6 nm.

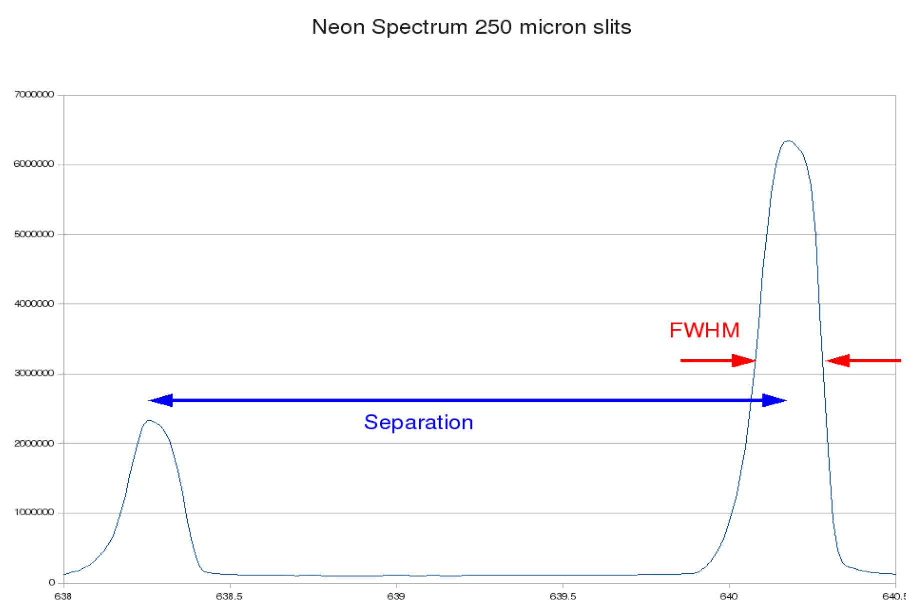
3 A more accurate number can be obtained from the energy levels of Na I, as the difference in energy of the first two excited levels, see http://physics.nist.gov/PhysRefData/ASD/levels_form.html

only recording a short section of the whole spectrum you can afford to sample quite quickly, ten times a second, even twenty times a second.

5. Repeat step 3 for slit widths between 10 μ (micrometer reading = 1) to 500 μ (micrometer reading = 50, corresponding to two full turns of the micrometer).
   a. Suggested slit widths, 10 μ, 20 μ, 50 μ, 100 μ, 150 μ, 200 μ, 250 μ, 350 μ, and 500 μ.
   b. As you increase the entrance slit width you will let in more light, and the peaks in your spectrum will get more intense. You might have to change either the voltage applied to the photomultiplier, or the sensitivity of the electrometer, or both.
6. Replace the neon/sodium lamp with a neon/ lithium lamp. Like sodium, lithium as a pair of D lines, but with shorter wavelength, around 6707 Å. Their separation is quite small. Try to resolve them as separate lines with slit widths of 10 μ, 20 μ, and 50 μ. (There are also pairs of lines at approximately 4602 Å and 6103 Å, which you might also try to resolve as separate lines. Note that each of these pairs is usually significantly less intense than the pair at 6707 Å.)

Sample Spectrum

Please refer to this diagram for a definition of terms.



Analysis

You will need to make a chart for each of the spectra (similar to the diagram above), one for each slit width and one per page. Then for each spectrum

1. Measure the distance between peaks (center to center).
2. Measure the width of the larger peak at the position half way down (the FWHM).
   Note: if your spectrum has a significant amount of noise then this is not at the intensity which is half the peak intensity. For example, if your peak has a peak intensity of 7000, but there is a noise (background) value of 1000, then the peak is 6000 high, and half of this is 3000. You should therefore measure the width at an intensity value of 4000, not at 3500 (½ the peak

value.)

3. Knowing the separation of the peaks, their difference in wavelength, and the width of the taller peak, calculate its width in terms of wavelength. Use that to obtain the resolution.
4. When you have analyzed all the spectra, plot the resolution as a function of entrance slit width.

Report

For inclusion in this week's lab I would like the following:

1. A representative graph of your spectrum. (Pick the best looking one!) There is no need to give me the raw data.
2. The plot of FWHM vs entrance slit width. (Again, I don't need to see raw data.)
3. A brief description of your experiment.
4. A discussion of results.