

Experiment 4A

Prism Spectrometer

This week's lab covers dispersion in a prism and the prism spectrometer.

1. Spectrometer Alignment

Procedure In the first section, you will align the spectrometer with the prism. The spectrometer has three major components. First there is a collimator. This is a slit and a lens with the slit at the focal point of the lens, so that the lens will produce parallel light from the slit. Next there is a table which will hold the prism. Finally there is a telescope, which can rotate about the central axis. It has a vernier scale marked in degrees and minutes. The telescope is aligned first.

- Check to make sure that the crosshairs in the telescope are in focus. If they are not, move the eyepiece until they are. Remember, once set, the eyepiece should not be moved.
- Now you can focus the telescope for infinity using autocollimation. Take the small metal mirror and place it on the spectrometer table.
- The eyepiece has an illuminator on it. Make sure that this is on and that light is shining into the telescope.
- Rotate the mirror until the light is reflected back into the telescope. You should be able to see the light in the telescope. If the telescope is still in focus, you will see an image of the crosshairs. If not, you will need to adjust the telescope. Do not move the eyepiece to do this; if you do, the crosshairs will be out of focus. There is a screw on the side of the telescope which locks the objective into place. Loosen the screw and move the eyepiece tube until the reflected image of the crosshairs is in focus, then tighten the screw again.
- Next check the adjustment of the collimator. Remove the mirror and point the telescope directly at the collimator.
- Place a helium lamp directly behind the slits. Move it around a little until you find the spot where the most light comes through the slit.
- The slit should be in focus. If it is not, adjust the distance between the slit and the collimating lens.
- Place the prism on the table.
- Rotate the prism until you find the reflected image of the crosshairs. The image should be at the same height. If not, adjust the leveling screw on the prism table until the reflected image moves half way to the direct image of the crosshairs.
- Now rotate the prism to the other polished face and repeat this procedure. Then go back to the first face and do it again and so forth, until adjustment is no longer required. Your instructor will help you with this. Once this is done, the prism table should be level. You will not need to repeat the alignment procedure if you don't bump anything; *so be careful*.

2. Angle of Minimum Deviation

Procedure You will now measure the *angle of minimum deviation* for the spectral lines of helium. In order to do this, you must first find and identify the various lines in the helium spectrum.

- Place the telescope at about 130 degrees. (This assumes a starting reading of 180 degrees.)
- Rotate the prism until you find the spectrum. Examine the spectrum carefully. There should be three red lines, a yellow line, two greens, two blue-greens, and about 4 violet lines visible. If not, ask your instructor for help.
- Note how the lines move as you rotate the prism. Note that there is an *angle of minimum deviation*.
- Rotate the prism until the weakest red line, 7281Å, is at its angle of minimum deviation. You will need to move the telescope to follow this movement.
- After you have found the place where the red line will not move any farther, move the telescope until the crosshair is on top of the line. There is a screw on the base of the telescope for fine adjustment of position.
- Record the position of the telescope (R_1).
- Now rotate the prism until you find the angle of minimum deviation for the next red line. Measure this angle with the telescope.
- Repeat this for all of the lines.
- Next move the telescope to the other side of the spectrometer. Again measure the angle of minimum deviation for all spectral lines (R_2). This is done on both sides to eliminate any offset in the instrument scale.

Analysis From the two telescope readings compute the average angle of minimum deviation for each spectral line.

$$D = \frac{R_2 - R_1}{2}$$

where R_1 and R_2 are the two readings. Now from D , calculate the refractive index of the prism for each of the spectral lines.

$$n = \frac{\sin \frac{1}{2}(A + D)}{\sin(A/2)}$$

where D is the angle of minimum deviation, and A is the prism angle (60°). Now plot two graphs. The first graph is n as a function of A , the wavelength. This will be used as a calibration curve for the next section. Next plot a graph of n vs. $(1/\lambda^2)$. This graph should produce a fairly straight line. If your points curve off the line you may have made an incorrect wavelength assignment to one or more of your helium lines. From this graph find the constants a and b for the equation,

$$n = a + b/\lambda^2$$

This equation is called the Cauchy relation. If you know it for a prism, you can calculate the wavelength of an unknown source given the angle of minimum deviation. Estimate the error in a and b using a least square fit. Also draw error bars on your plot by estimating the error in your calculated values of n .

3. Resolving Power

Procedure

- Replace the helium lamp with a sodium lamp.
- Find the yellow spectral line.
- Observe if the line is resolved or not. Before you draw your conclusion, rotate the prism and observe the yellow line at *grazing emergence* (ask your instructor for help).
- Measure the size of the base of the prism and the diameter of the collimator lens.

Analysis Calculate the resolving power of the prism from the Cauchy coefficients from Section 2 and the size of the base of the prism. The resolving power is given by;

$$\frac{\lambda}{\Delta\lambda} = B \frac{dn}{d\lambda}$$

where B is the "effective" size of the base of the prism, n is the refractive index as computed in the Cauchy relation, and λ is the wavelength. If the collimator fills the face of the prism with light then B is the actual prism base. However, if the prism is not fully illuminated then the effective size of the prism is reduced and you will have to estimate how much of the prism is used and scale the value of B down to an effective size. From this calculation, should the two lines of the sodium doublet be resolved? Compare this to what you observed.