Prism Spectrometer

Setup Part A

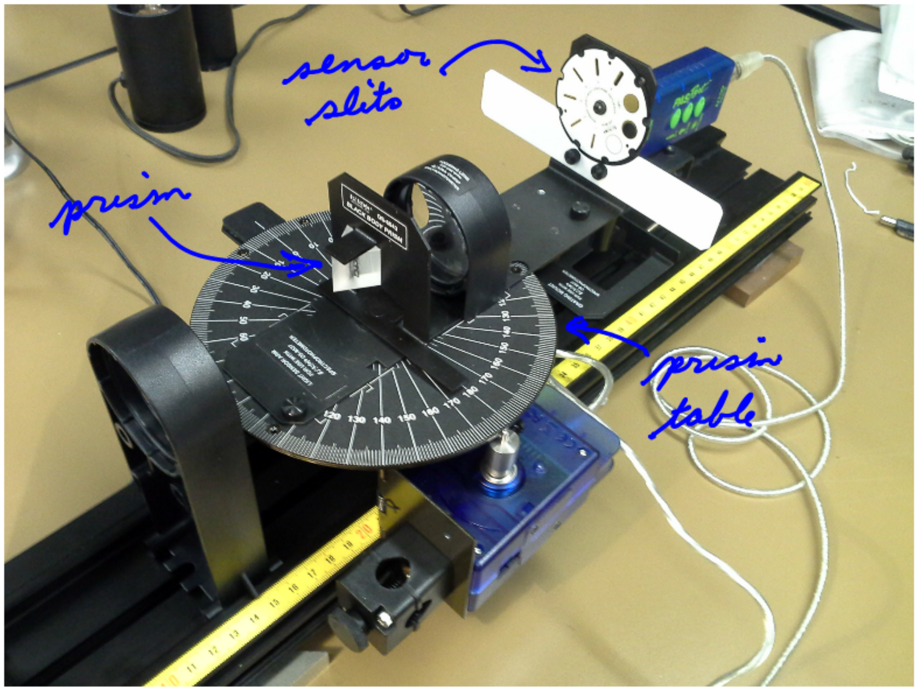


Figure 1: Complete Setup

1. Set up the Prism Spectrophotometer as shown in Figure 1, 2 and 3
   Light Source close to the left end of the track and the Collimating Slit closer to it than is shown in the picture to maximize the intensity. Detailed instructions for mounting the Rotary Motion Sensor and the Degree Plate and Light Sensor Arm to the spectroscopy table may be found in Appendix 3.

Appendix 3: Remove the two screws attaching the black mounting block. Either use them to connect the RMS sensor to the spring loaded plate or the supplied screws on the side of the table. Figure 1 above shows the mounting block in use.

3. Mount the Beveled Stop Piece on the bottom of the Light Sensor Arm with the two supplied bolts (see Figure 2). Position the beveled edge so it will hit against the angle indicator on the spectroscopy table.

may be installed already (verify) →

Figure 2: Beveled Stop Piece

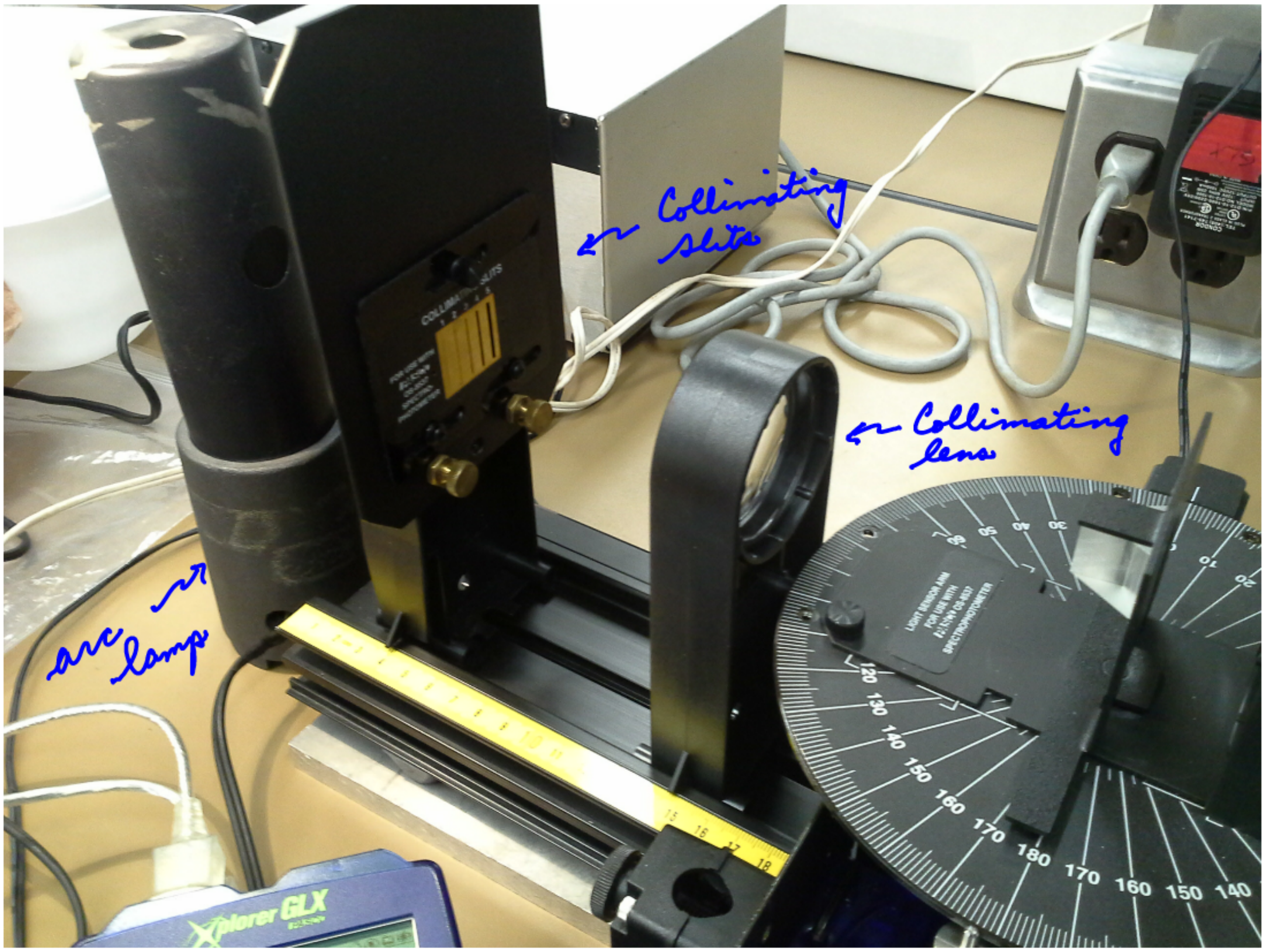
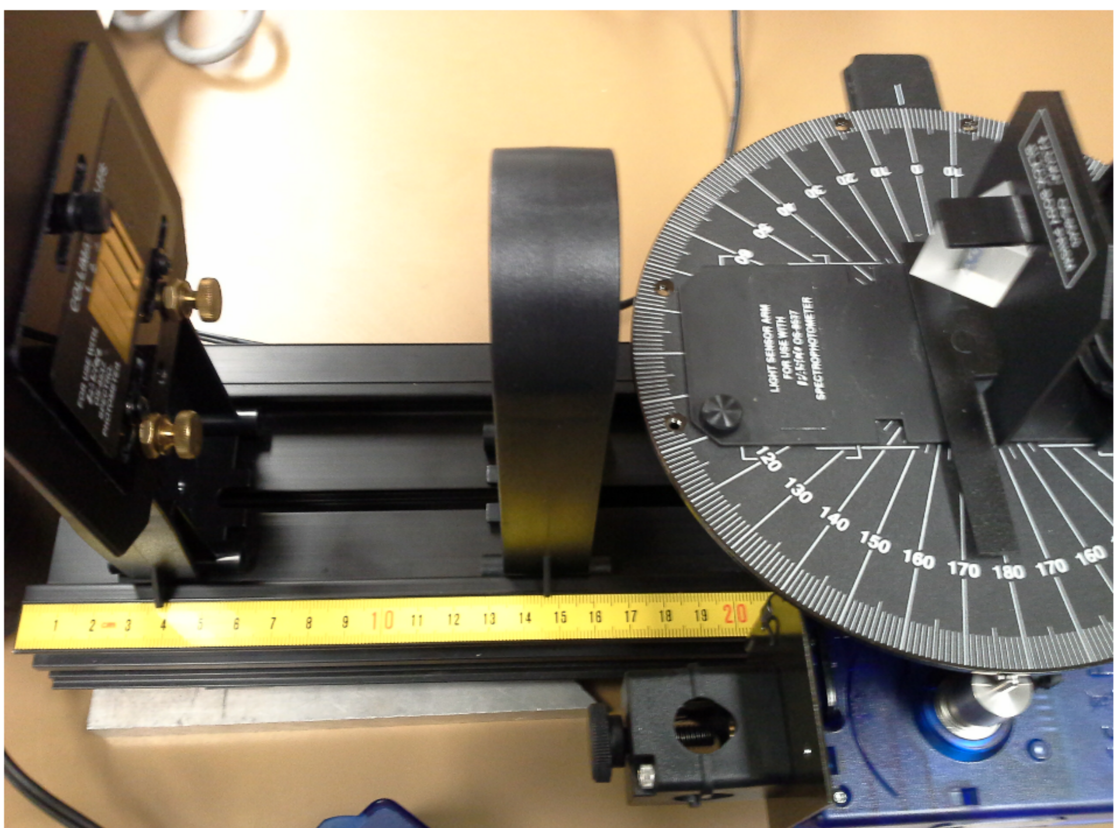


Figure 2: Source + Collimating slits + lens.

Figure 3: Positions are shown on cm scale and are for guidance only. Use the quality of the Hg emission lines as a way of tuning your spectrometer setup.



Rotary Motion Sensor (RMS)

Setup Part B

1. Attach the Mounted Prism to the spectroscopy table by screwing it into the hole in the center of the table. Screw it down until it almost touches the table. *It is critical that the Mounted Prism does not touch the table so the table is free to move without moving the prism.* Orient the prism with its apex toward the light source as shown in Figure 4. The prism base must be perpendicular to the incoming light beam. To do this set, turn the table until the index mark is on 0°, and then set the base of the Mounted Prism so it lies along the 0°-180° line on the table. Secure the prism in place using the wing nut and lock washer on the bottom of the bolt sticking through the spectroscopy table.

NOTE:

① The prism's position is set using the arm protruding out. It should align to the 180° marking

② The white light slit image should hit the sensor slit when the table is at zero degrees.

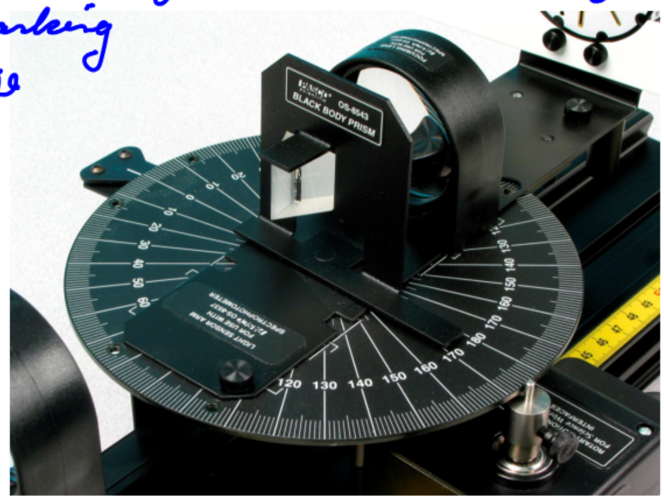


Figure 4: The prism apex should be *oriented toward the light source.*

Your lab instructor will provide guidance regarding the equipment setup. Spectra were initially obtained using the following choices:

1) Raise bench @ both ends ~ 3/4 inch using provided blocks to improve emission line - slit alignment.

2) Collimator slit: use #3

3) Sensor slit: use #1

4) Positions: i) Hg lamp ~3 cm from optics bench end.
ii) Collimator slits at 3 to 4 cm on scale.
iii) Collimator lens at ~14 to 15 cm on scale
iv) plate for RMS sensor at ~20 cm on scale. This sets position of table.

Procedure

The lab consists of three parts. These are:

1) Calibrating the prism table angle to the RMS output
2) Obtaining a mercury spectrum for calibrating λ to RMS angle ← no, want Table angle: the actual angle
3) Obtaining the spectrum of sodium to measure the D line(s) λ using the calibration from mercury.

A Prism table and RMS angle.

The RMS output will be taken in radians. The movement of the table will spin the RMS adapter many times for a relatively small change in position owing to the small circumference of the contact post touching the table head. Collect data as follows:

1. Put the GLX in "digits" mode from the home screen.
2. Ensure the RMS sensor is displaying. Add it if not.
3. Position the table @ 0° and record the angular pos'n from the RMS sensor. It will generally be zero if you start a new run. Estimate a reasonable error on table ∢'s.
4. Rotate the table to the 10° mark & record the RMS output.
5. Repeat for 20, 30, 40, 50, 60 + full-stop degree readings on the table scale.
6. Plot degree reading from the prism table as a function of RMS sensor angle. Find the slope with error from the grace console. Include this graph in your report.
7. Warm up the mercury source for 3 or 4 minutes
8. Position collimator hardware (slits/lens) to have a beam of light come to the prism and enter the sensor slit when the table is at zero degrees (This requires some care.)
9. Set the RMS + light sensor to sample @ 20 samples/sec: home, sensors.

10. Obtain a spectrum for mercury. Note there is a strong emission next to the orange emission line that is difficult to see. Include it. Starting at zero degrees table angle is not needed but the angle must be recorded

Starting table angle ______

Hg Run(#'s) ______________

11. Change the source to sodium and obtain its spectrum Starting table angle ______. Na Run(#'s) ______________

12. Export the spectra (Hg + Na) to a USB stick
Export Table as Ascii. Look in home, table on the GLX.

13. Import the mercury data into grace.
Data, Import, Ascii, Load as: Block Data, select file, Ok, X from column 3, Y from column 2, Accept.

14 Use the text tool to label the peaks with their colors. No fit is required.

15. Complete the table below: Use the mouse on the grace graph.

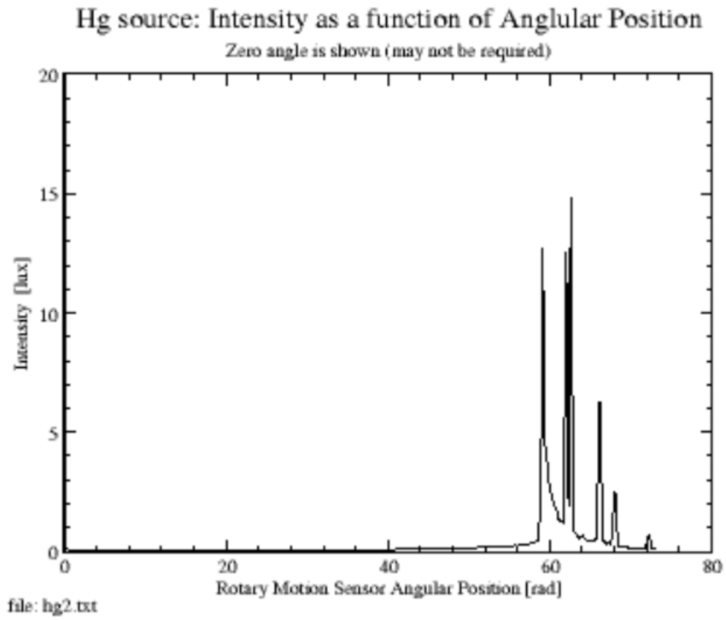
λ nm	λ color	θ_{RMS} [rad] RMS	θ table from calibration
(?) 607 nm	red		
578.2	orange		
546.1	green		
435.8	blue/purple #1		
404.7	blue/purple #2		
365.4	blue/purple #3		
253.7	not visible		

15. Photograph your setup.

16. Use the photograph to determine the angle at which the light enters the prism with respect to the normal to the prism surface. Call this θ_i:

θ_i = __________ ± __________

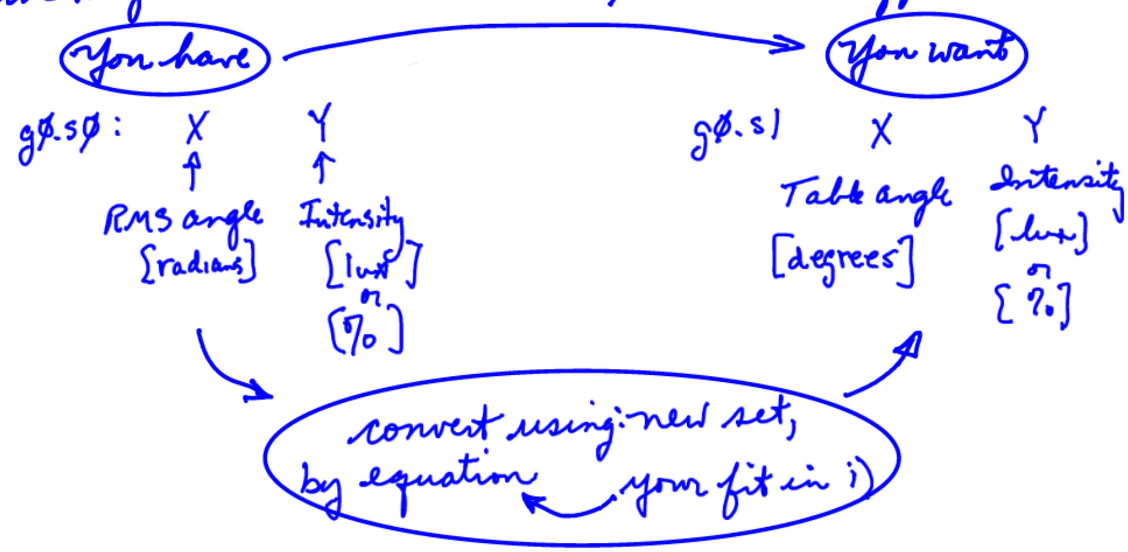
Example Spectrum of Mercury:



Report: Brief purpose, method, conclusions. Don't repeat all the steps in the above pages in the method, no need to.

Analysis + Graphs: Required for Report

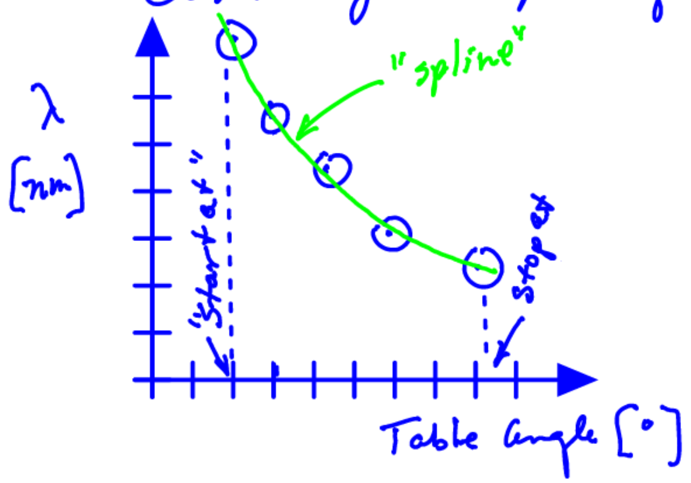
1. Graph of Table angle (degrees) as a function of RMS sensor angle [radians]
   i) Slope + intercept must be stated with error from fit: watch rounding and put your units in behind the values.
2. Hg plot: Intensity [lux or % as available] as a function of Table angle in degrees. Your GLX data will have the position from the RMS sensor. Use your equation from i) above to convert RMS Angle to Table Angle. Note how your units of the slope in i) above will guide you. Use xmgrace and a new set, it is not difficult:



3. Na: Plot the same as above for Hg: Intensity [lux] or [%] as a function of Table Angle. Again you will use the step involving the conversion from RMS angle to Table angle. State the Table Angle of the Na peak or peaks.

4. Hg: A table of Table angle in degrees & the given λ [nm]. Note: I had indicated a red line existed in the Hg spectrum. This red line was actually from the fluorescent lights and must be ignored: No 607nm line exists in the Hg spectrum. Apologies :-)

5. A plot of the data above: λ [nm] as a function of Table angle [degrees] for Hg:



Use an "Akima Spline": Data, Transformations, Interpolations/Splines

"Start at" and "Stop at" are values from the x-axis as shown on the left. A "length" of 50 or 60 will give a smooth curve. No Set should be hi-lited in the "Destination" "Set" window.

6. Using the graph in Step 5, find the λ of the Na line(s). No equation is available, use the graph's spline to guide you.

7. Your estimation of errors terms of the Table angle values. Consider the set up: i) direction of incoming light:
ii) position of the prism
iii) scale of table angle [degrees]
iv) Any other alignment issues.

8. Compare your Na line(s) values to accepted value:
Na doublet is: 588.99 nm & 589.59 nm & likely not resolved.

I believe we can stop here: too long

PRISM

The prism used is a dense flint prism of glass type SF10. Its $n(\lambda)$ equation is:

$$n^2 - 1 = \frac{1.62139\,\lambda^2}{\lambda^2 - 0.0122241} + \frac{0.256278\,\lambda^2}{\lambda^2 - 0.0595737} + \frac{1.644476\,\lambda^2}{\lambda^2 - 147.4688}$$

This equation is shown on an interactive plot at https://refractiveindex.info/?shelf=glass&book=SCHOTT-SF&page=N-SF10

1. For each Mercury emission line, complete the table below:

λ [nm]	n
607.	
578.2	
546.1	
435.8	
404.7	
365.4	
253.7	

General angle of deviation δ:

$$\delta = \phi_1 + \arcsin\left(\sin\alpha\left(n^2 - \sin^2\phi_1\right)^{1/2} - \cos\alpha\cdot\sin\phi_1\right) - \alpha$$

α = prism angle (60°)
ϕ_1 = incident angle.