

The Prism Spectrometer and the Dispersion Curve of Glass

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Objectives

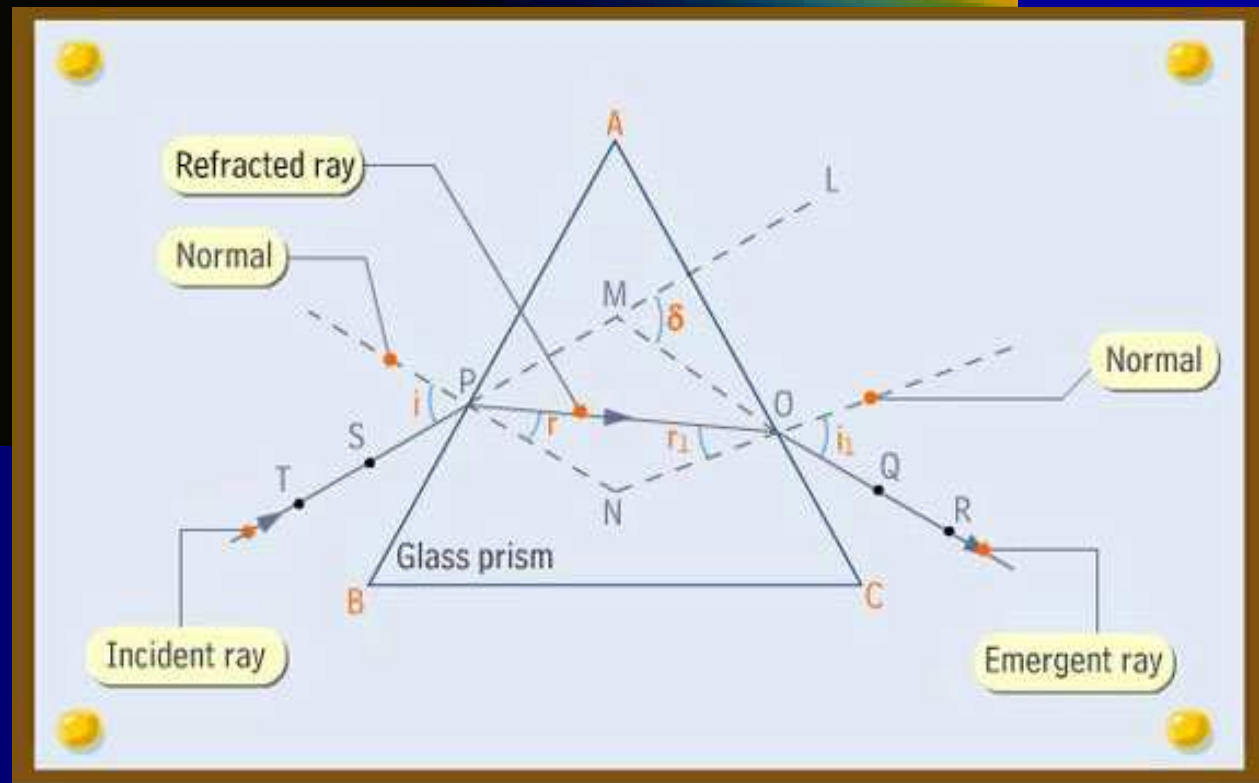
- Using a spectrometer:
- Find the refracting angle of a prism by
 - Angle of reflection of the incident light off the prism's faces
 - Angle between each prism face lying perpendicular to telescope
- Find the angle of minimum deviation for the spectral lines from a mercury light source
- Calculate the index of refraction for each line
- Calculate their Cauchy coefficients

Theory - Dispersing Prisms

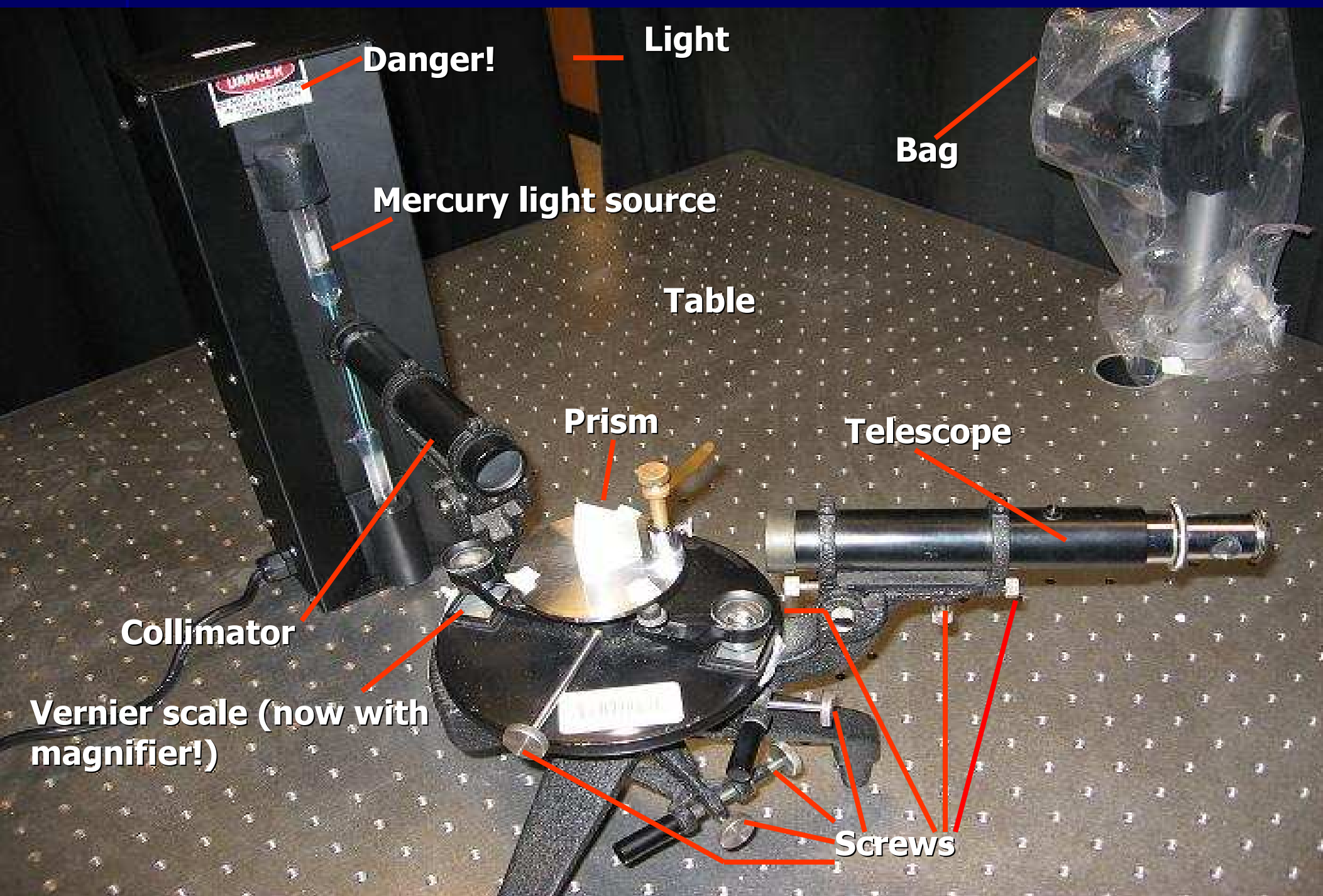
$$n_1 \sin(\theta_1) = n_2 \sin(\theta_2)$$

- The angle PNO is the supplement of prism angle A
- δ is the angle of minimum deviation – angle where refracted line reverses direction

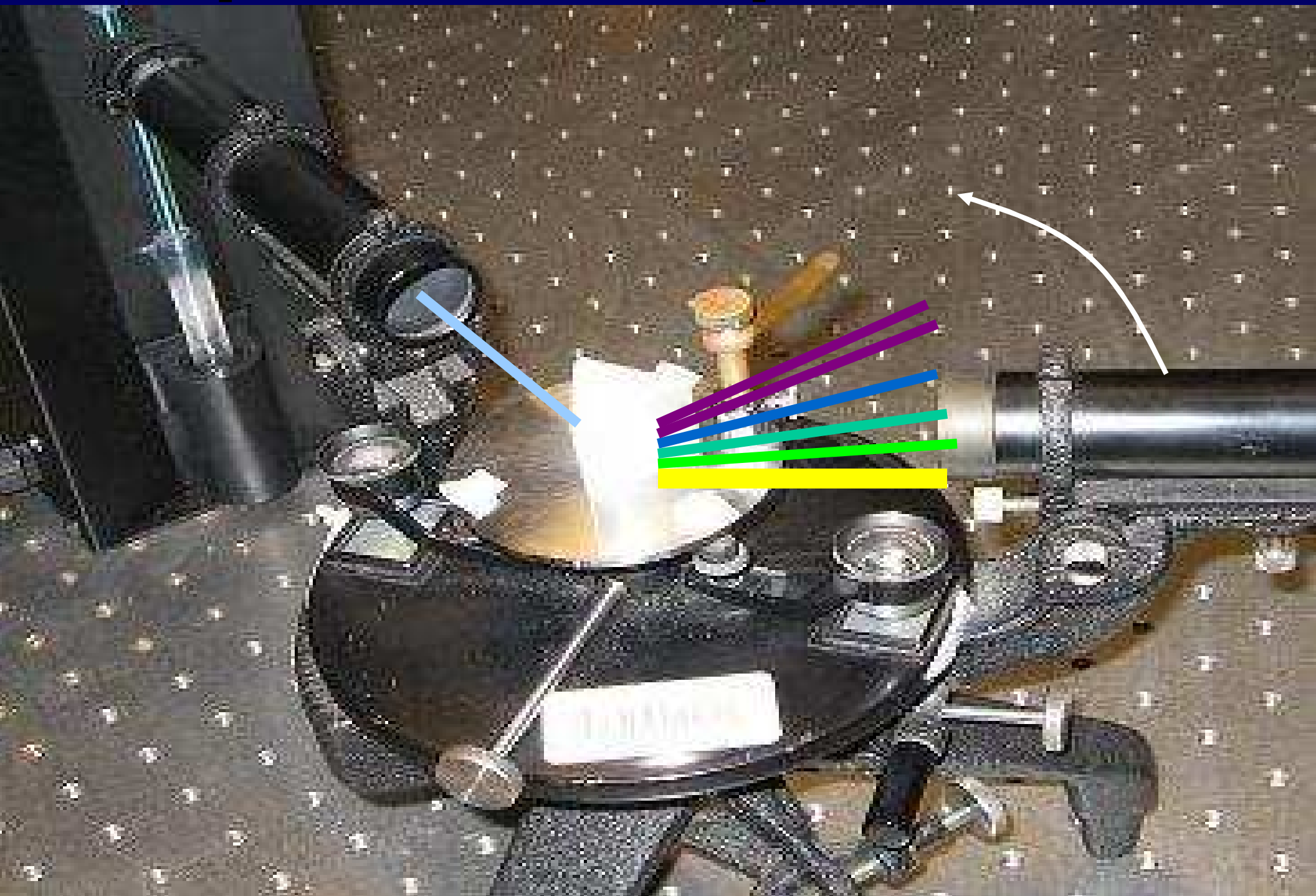
$$n = \frac{\sin((\alpha + \delta_{\min}) / 2)}{\sin(\alpha / 2)}$$



Experiment Setup



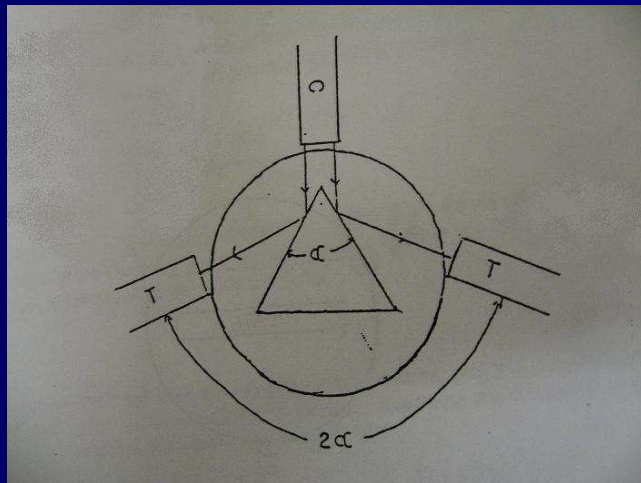
Experiment Setup



Procedure

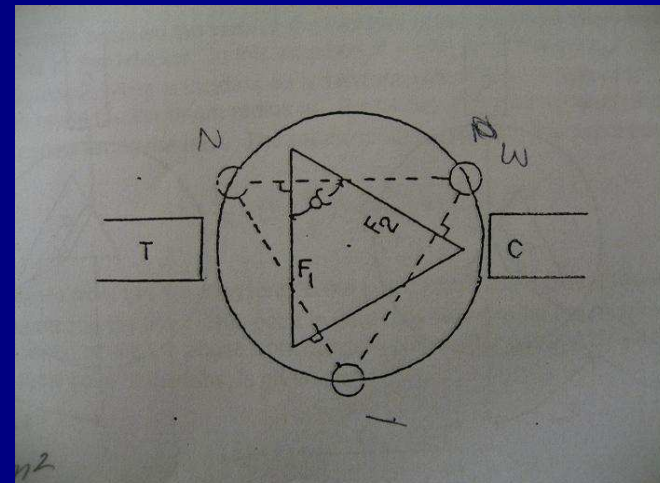
- Focus, calibrate, and level spectrometer
- Determine prism angle

1. By angle light reflects off of prism faces



α is half of rotation angle

2. By angle light projects reflected image of cross-hair



α is supplement of rotation angle

Procedure

- Determine angle of minimum deviation for 7 spectral lines of mercury source
 - Rotate prism until the lines reverse direction
 - Measure angle to each line from the left and right
 - Angle of minimum deviation is half of the difference
- Calculate index of refraction for each wavelength using the prism angle and the angles of minimum deviation
- From the plot of index of refraction vs. wavelength, determine the Cauchy coefficients

Results

Prism Angle

Method 1: $a = 59.9958^\circ$

Method 2: $a = 59.9583^\circ$

Average: $a = 59.9771^\circ$

Results – Mercury Spectral Line Measurements

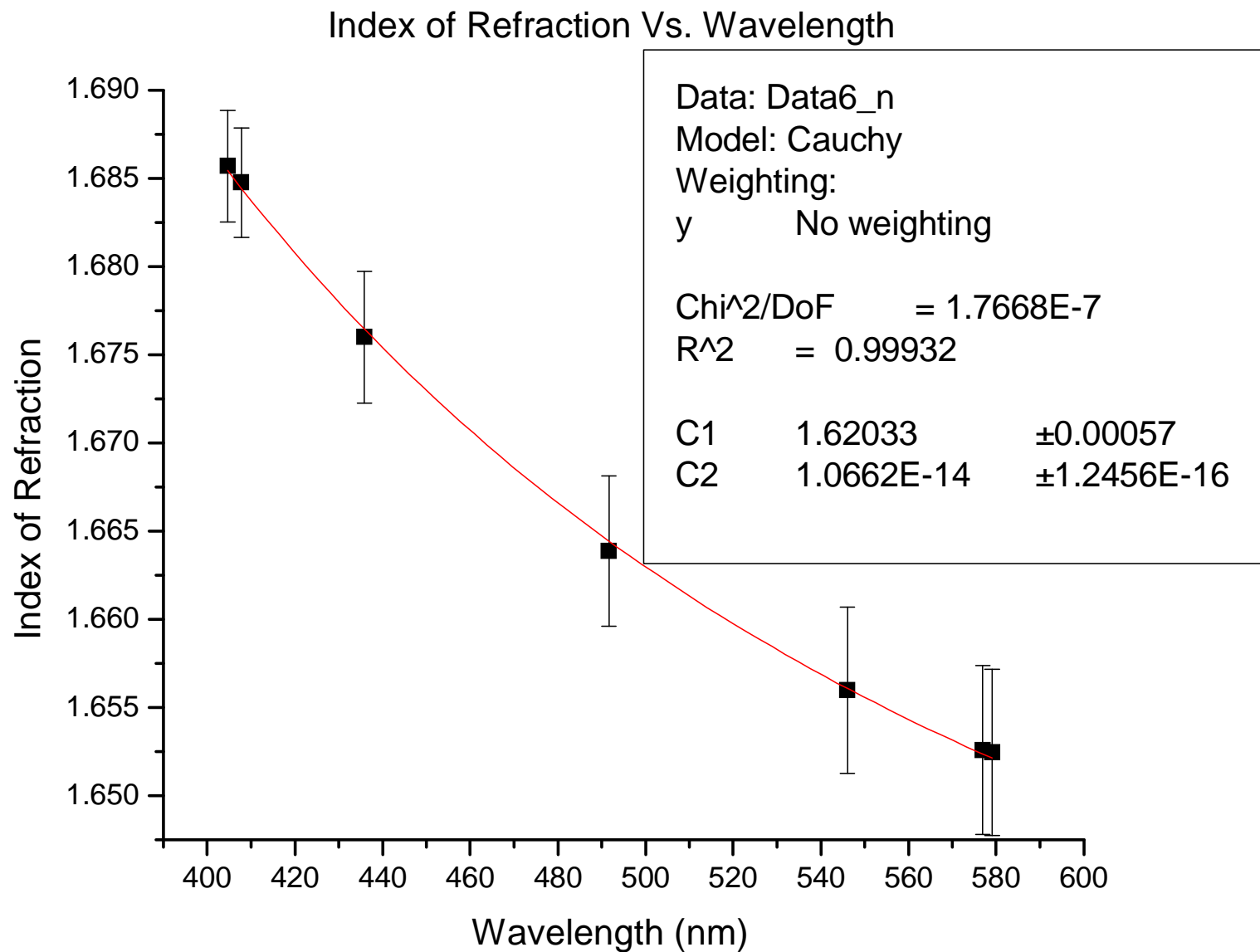
Trial 1	L	R	δ_{\min}	Trial 2	L	R	δ_{\min}
yellow1	166.55833	64.3	51.12917	148.25	44.35833	51.94583	
yellow2	166.575	64.30833	51.13333	148.26667	44.325	51.97083	
green	166.88333	63.95833	51.4625	148.575	43.95833	52.30833	
blue green	167.69167	63.13333	52.27917	149.29167	43.15833	53.06667	
blue	168.98333	61.825	53.57917	150.425	41.875	54.275	
violet1	169.93333	60.88333	54.525	151.21667	40.96667	55.125	
violet2	170.04167	60.69167	54.675	151.30833	40.84167	55.23333	
Trial 3				L	R	δ_{\min}	
yellow1	261.3	159.1	51.1				
yellow2	261.31667	159.08333	51.11667				
green	261.675	158.70833	51.48333				
blue green	262.53333	157.86667	52.33333				
blue	263.78333	156.55833	53.6125				
violet1	264.73333	155.55833	54.5875				
violet2	264.68333	155.425	54.62917				

Results - Index of Refraction

Wavelength (nm)	n (avg.)	Standard Deviation
579.065	1.65245	0.00472
576.960	1.6526	0.0048
546.074	1.65598	0.00472
491.604	1.66386	0.00426
435.835	1.676	0.00374
407.781	1.68476	0.0031
404.656	1.6857	0.00316

Results

$$\text{Cauchy Formula: } n = C_1 + C_2/\lambda^2$$



Sample Calculation

Trial 2, blue green line

Left: 149.29167°

Right: 43.15833°

$$\delta_{\min} = (149.29167^\circ - 43.15833^\circ) / 2$$

$$\delta_{\min} = 53.06667^\circ$$

$$a = 59.9771^\circ$$

$$n = \frac{\sin((59.9771 + 53.06667) / 2)}{\sin(59.9771 / 2)}$$

$$n = 1.66877$$

Conclusion

Glass type	C1	C2
light flint	1.5542	0.00710
BaF11	1.6670	0.00723
BaF10	1.6700	0.00743
BaFN10	1.6700	0.00745
BaF13	1.6690	0.00778
dense flint	1.5961	0.00880
F2	1.6200	0.00892
LaSFN30	1.8030	0.00906
heavy flint	1.6221	0.00970
SF2	1.6480	0.01001
SF5/FDS	1.6730	0.01091
SF8	1.6890	0.01156
SF18	1.7220	0.01290
SF10	1.7280	0.01342
FD10	1.7280	0.01347
LaSFN9	1.8500	0.01382

Our values:

$C1 = 1.62033$

$C2 = 0.01066$

Prism material likely to be heavy flint

- Results were consistent across all trials

Sources of Error

- Problems lining up Spectrometer
 - Glass mirror piece cut unevenly, reflected images of cross-hair at an angle
- Flaws in Prism
 - Chips in prism produced curved spectral lines
- Proximity of Spectral Lines
 - Difficulty to distinguish between each violet, each yellow could affect their results
- Cross-hair visibility
 - Required outside light, limited focusing simultaneously with spectral lines
- Eyestrain
- Parallax

References

Advanced Optics Laboratory Lab Manual

<http://electron9.phys.utk.edu/phys135d/modules/m10/images/prism.jpg>

<http://www.tutorvista.com/content/science/science-ii/human-eye-colourful-world/tracing-light-prism.php>

<http://astro.u-strasbg.fr/~koppen/discharge/>

<http://www.physics.uc.edu/~bortner/labs/Physics%203%20experiments/Dispersion/Dispersion%20htm.htm>