8.

Determination of Cauchy's Contants

8.1 Objective:

To determine Cauchy's Constants using a prism and spectrometer.

Apparatus:

Glass prism, spectrometer and mercury vapour lamp.

8.2 Theory:

The wavelength dependence of refractive index of a dielectric medium can be approximated by

$$\mu = A + \frac{B}{\lambda^2} \tag{8.1}$$

where μ represents the refractive index at wavelength λ and A and B are constants. The Eq.(8.1) is known as Cauchy's formula and A and B are known as Cauchy's constants. As is

obvious from the above formula, a curve between μ and $1/\lambda^2$ is a straight line whose intercept with the y axis gives A and slope with respect to the x-axis gives B. Thus we can easily find Cauchy's constants as discussed below.

A parallel beam of white light from a source (mercury lamp) is passed through a prism. One would observe a spectrum on the other side of the prism (Fig.8.3). The prism is then set in the position of minimum deviation and the angle of minimum deviations corresponding to different colors are measured with the help of the spectrometer. The refractive index at different wavelengths can be calculated using the following well known formula:

$$\mu = \frac{sin\frac{A_0+D_m}{2}}{sin\frac{A_0}{2}}$$

Here A_0 is the angle of the prism and D_m is the angle of minimum deviation. [Note: The wavelengths of various lines observed in light from mercury vapour lamp are provided in the laboratory.]

8.3   Experiment:

A spectrometer consists of a collimator which is mounted on the rigid arm and a telescope mounted on the rotation table arm which can rotate in a horizontal plane about the axis of the instrument. A prism table of adjustable height is mounted along the axis of rotation of the telescope. A circular scale and vernier arrangement is provide to enable measurement of the angle through which the telescope arm or the prism table is rotated.
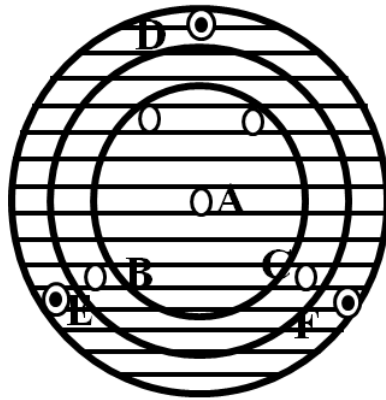
Figure 8.1: Top view of the prism table showing relevant details. A - rotation axis of the prism table. B,C - Threaded screw holes to fix grating stand. D,E,F - Leveling screws.
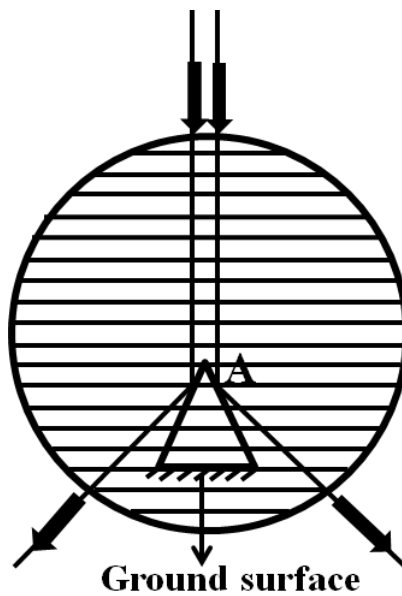

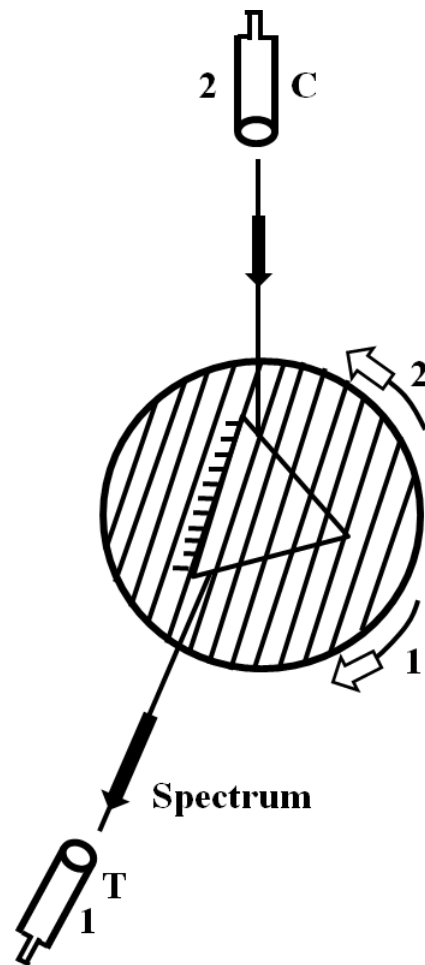Figure 8.2: Positioning of the prism for optical alignment.

Figure 8.3: Top view of the set up for Schuster's method.

1. Setting the prism table

The prism table AB is made horizontal with the help of a spirit-level by adjusting the leveling screws D,E,F (see Fig.8.1). To start with, the prism table is rotated about its axis and adjusted in such a way that the parallel straight lines along with the two screw E and F are perpendicular to the axis joining the collimator and the telescope pointing directly opposite. A three way spirit level is kept on the prism table with its edge XY along the parallel lines

Further adjustment of the prism table is done using the method of optical alignment. The given prism is placed such that the ground surface is facing towards the telescope and is perpendicular to the axis of the collimator. Adjust the position of the prism such that the edge of the prism opposite to the ground surface lies approximately along the axis of the prism table as shown in Fig.8.2. If you now rotate the telescope arm, you would be able to see the reflected images of the slit appears symmetrically placed about the horizontal cross wire when viewed from both sides. The prism table adjustments are complete now.

2. Schuster's method of focusing a spectrometer for parallel light:

When a distant object is not available or the spectrometer is too heavy to be carried outside the dark room where the experiment is being performed, the setting of the spectrometer is done by the Schuster's method. the slit is kept facing the brightest portion of the mercury lamp and its width adjusted to permit a thin line of light to act as incident light.

Prism is now kept on the prism table with its ground face along the parallel lines ruled on the prism table. The prism table is rotated so as to obtain mercury light incident from the collimator on the prism. Telescope arm is moved to a suitable position to see the spectrum through it. the prism table is rotated to achieve the position of minimum deviation (of course, you will have to rotate the telescope arm also, as you rotate the prism table, to retain the spectrum in the field of view of the telescope). At this position, the spectrum which appeared to be moving in the telescope in one direction (say left to right) reaches an extreme limit and retraces its path on further movement of the prism table in the same direction.

Prism table is rotated away from this position of minimum deviation. bringing the refracting angle towards the telescope and the telescope is now focused on the image as distinctly as possible. Prism table is then rotated to the other side of the minimum deviation position towards the collimator and the collimator is focused to obtain a sharp image of the spectrum. The process is repeated till the motion of the prism does not affect the focus of the spectrum (please see Fig.8.3). The collimator and the telescope are then set for parallel light and their settings are not to be disturbed during the course of the experiment.

Measurements of angle of minimum deviation D_m and prism angle A_0:

The prism is again set in the position of minimum deviation as discussed above. Now measure the positions of various lines

(colors) of the spectrum on the circular scale without disturbing the prism table. Now remove the prism from prism table and rotate the telescope to see the slit directly and measure its position. The difference between this last reading and the readings corresponding to various colors in the position of minimum deviation will give us the angles of minimum deviations for different colors.

This given prism is now again placed on the prism table such that the ground surface is facing towards the telescope and is perpendicular to the axis of collimator. Adjust the position of the prism such that the edges of the prism opposite to the ground surface lies approximately along the axis of the prism table as shown in Fig.8.3. Rotate the telescope arm and measure the position of reflected images of the slit on both sides of incident beam. The difference between the two readings is equal to angle $2A_0$.

8.4   Observations:

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Readings for the measurement of angle of minimum deviation:

Reading of telescope position for direct image of the slit:
Left scale (θ_L):
Right scale (θ_R):

Sr. No.	color of light	Reading for telescope position	$D_1 = \theta_L \sim \theta_1$	$D_2 = \theta_R \sim \theta_2$

		Left scale θ_1	Right scale θ_2		
1.	Violet I				
2.	Violet II				
3.	Blue				
4.	Green				
5.	Yellow I				
6.	Yellow II				
7.	Red				

Readings for measurement of prism angle A_0:

Sr. No.	Position of telescope for reflected slit from		$A_0 = \frac{a \sim b}{2}$
	Left face (a)	Right face (b)	

Calculations:

Sr. No.	Color	$D_m = \frac{D_1 + D_2}{2}$	$\mu = \frac{sin\frac{A_0 + D_m}{2}}{sin\frac{A_0}{2}}$	$1/\lambda^2$

Using the above values draw a graph between μ and $1/\lambda^2$ and determine A and B.

Precautions: Care should be taken to ensure proper setting of the spectrometer. It should be ensured that the settings of the telescope and collimator are not touched during the course of taking the various readings.

Source of errors: Think and find out yourself after doing the experiment.