DISPERSIVE POWER

OBJECT:

To determine the dispersive power of the material of the prism mercury light with the help of a spectrometer.

APPARATUS REQUIRED:

Spectrometer, prism, mercury source and reading lens.

FORMULA USED:

The dispersive power ω, of the material of the prism is given by the formula

$$\omega = \frac{\mu_v - \mu_y}{\mu - 1}$$

Where

μ_v = refractive index of the material of the prism for violet colour.

μ_y = refractive index of the material of the prism for yellow colour.

$$\mu = \frac{\mu_v + \mu_y}{2}$$

The refractive index of the prism is given by

$$\mu = \frac{sin\left(\frac{A+\delta m}{2}\right)}{sin\left(\frac{A}{2}\right)}$$

Where

A = Angle of the prism

δ_m = Angle of minimum deviation

PROCEDURE:

The procedure is as follows:

(i) Adjustment of the spectrometer
(ii) Measurement of angle of prism A
(iii) Measurement of angle of minimum deviation δ_m for violet and yellow colours. For details see Experiment No.1

OBSERVATIONS:

Make the table similar to those in Experiment No.1.

CALCULATIONS:

Find out the value of μ_v and μ_y using the relation.

` $\mu = \frac{sin\left(\frac{A+\delta_m}{2}\right)}{sin\left(\frac{A}{2}\right)}$

μ_v = …

μ_y = …

$\mu = \frac{\mu_v+\mu_y}{2}$

$\omega = \frac{\mu_v-\mu_y}{\mu-1}$

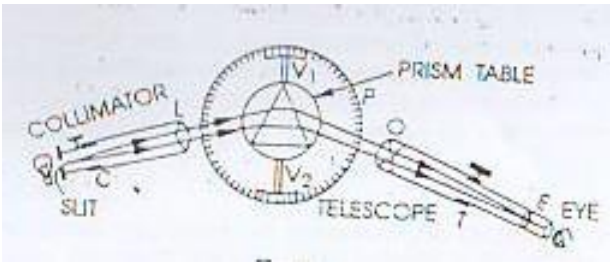
RESULT:

The dispersive power of the given prism = …

PRECAUTIONS AND SOURCES OR ERROR:

Same in the experiment No.1.

DESCRIPTION OF THE APPARATUS:



SPECTROMETER:

The spectrometer consists of the following parts:

(i) The Collimator C
(ii) The prism table P
(iii) The Telescope T

(i) The Collimator (C):

The collimator C consists of two hollow concentric metal tubes, one being longer then the other. The longer tube carries an achromatic lens L at one end and the smaller tube on the other end. The smaller tube is provided with a slit of the outer end (width of the slit can be adjusted with the help of a screw attached to it) and can be moved in or out the longer tube with the help of rack and pinion arrangement. The slit is adjusted in the focal plane of the lens L to obtain a pencil of parallel rays from the collimator when

light is allowed to be incident upon slit. The collimator is also provided with two screws for adjusting the inclination of the axis of the collimator. This is rigidly fixed to the main part of the apparatus.

(ii) The Prism Table (P):

It is a circular table supported horizontally in the centre of the instrument and the position can be read with the help of two verniers attached to it and moving over a graduated circular scale carried by the telescope. The levelling of the prism table is made with the help of three screws provided at the lower surface. The table can be raised or lowered and clamped in any desired position with the help of a screw. The prism table is also provided with a tangent screw for a slow motion. There are concentric circles and straight lines parallel to the line joining two of the levelling screws on the prism table.

(iii) The Telescope (T):

The telescope consists of similar tubes as in case of collimator carrying achromatic objective lens O at one end and Ramsdon eyepiece E on the another side end. The eyepiece tube can be taken in out with the help of rack and pinion arrangement. Two crosswire are focused on the focus of the eyepiece. The telescope can be clamped to the main body of the instrument and can be moved slightly by tangent screw. The telescope is attached to the main scale and when it rotates, the graduated scale rotates with it. The inclination of telescope is adjusted by two screws provided at the lower surface.

ADJUSTMENT:

Before using the spectrometer, the following adjustments must be made.

(a) The axis of the telescope and that of the collimator must intersect the principal vertical axis on rotation of the telescope.

This adjustment is done by the manufacturer and can only be tested in the laboratory. For this purpose, a pin is mounted vertically in the centre of prism table and observing its image in the telescope tube without eyepiece and for a wide slit in the collimator. If the image appears in the middle, then the adjustment is perfect otherwise the image is made in the centre by using the screws supporting the telescope and collimator till the pin appears in the middle.

(b) Prism table should be levelled.

(i) The prism table is levelled with the help of three screws supporting the prism table. A Spirit level is placed along a line joining the screws and the two screws are moved till the air bubble appears in the middle. Now place the spirit level along a line perpendicular to the previous line and adjust the third screw such that again the air bubble appears in the middle. Here one thing should be remembered that the first two screws should not be touched this time. The prism table is now levelled.

(ii) The second method which is generally used is optical levelling of the prism table. In

this method the prism is placed on the prism table with its refracting edge at the centre of the prism table and one of its polished surface perpendicular to the line joining the two levelling screws P and Q as shown in fig. 2(a).

Now rotate the prism table in such a way that refracting edges AB and AC face towards the collimator and light falling on the prism is usually reflected on both the sides as shown in fig. 2(b).

The telescope is moved to one side to receive the light reflected from the face AB and the levelling screws P and Q are adjusted to obtain the image in the centre of the field of view.

Again the telescope is moved to the other side to receive the light reflected from the face AC and the remaining third screw R is adjusted till the image becomes in the central field of view of the telescope.

The procedure is repeated till the two images from both the reflecting faces are seen in the central field of view of the telescope. The prism table is now levelled.

(c) Telescope and collimator are adjusted for parallel light by Schuster's method.

First of all, the prism is placed on the prism table and then adjusted approximately for minimum deviation position. The spectrum is now seen through the telescope. The prism table is rotated slightly away from this position towards collimator and the telescope is brought in view. The collimator is well focused on the spectrum. Again rotate the prism table on the other side of minimum deviation position, i.e., towards telescope and focus the telescope for the best image of the spectrum. The process of focusing the collimator the telescope is continued till the slight rotation of the prism table does not make the image to go out of focus. The means that both collimator and telescope are now individually set for parallel rays.

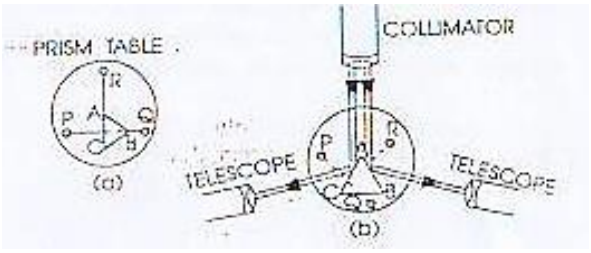


Fig. (2)

PROCEDURE:

(A) Measurement of the angle of the prism:

(i) Determine the least count of the spectrometer.

(ii) Place the prism on the prism table with its refracting angle towards the collimator and with its refracting edge A at the centre as shown in fig. (3). In this case some of the light failing on each face will be reflected and can be received with the help of the telescope.

(iii) The telescope is moved to one side to receive the light reflected from the face AB and the crosswires are focused on the image of the slit. The reading of the two verniers are taken.

(iv) The telescope is moved in other side to receive the light reflected from the face AC and again the crosswires are focused on the image of the slit. The readings of two verniers are noted.

(v) The angle through which the telescope is moved or the difference in the two positions gives twice the refracting angle A of the prism. Therefore, half of this angle gives the refracting angle of the prism.

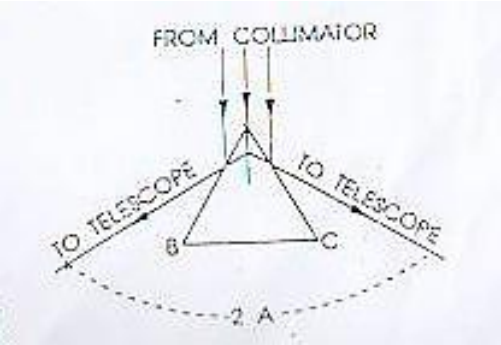


Fig. (3)

(B) Measurement of the angle of minimum deviations:

(i) Place the prism so that its centre coincides with the centre of the prism table and light falls on one of the polished faces and emerges out of the other polished face, after refraction. In this position the spectrum of light is obtained.

(ii) The spectrum is seen through the telescope and the telescope is adjusted for minimum deviation position for a particular colour (wavelength) in the following way:

Set up telescope at a particular colour and rotate the prism table in one direction, of course the telescope should be moved in such way to keep the spectral line in view. By doing so a position will come where the spectral line recedes in the opposite direction although the rotation of the table in the same direction. The particular position where the spectral line begins to recede in opposite direction is the minimum deviation position for that colour. Note the readings of two verniers.

(iii) Remove the prism table and bring the telescope in the line of the collimator. See the slit directly through telescope and coincide the image of slit with vertical crosswire. Note the reading of two verniers.

(iv) The difference in minimum deviation position and direct position gives the angle of minimum deviation for that colour.

(v) The same procedure is repeated to obtain the angles of minimum deviation for other colours.

OBSERVATIONS:

(i) Value of the one division of the main scale = 0.5 degree.
Total number of Vernier divisions = 30
Least count of the Vernier = 0.5/30 = 1 minute

(ii) Table for the angle (A) of the prism:

S. No.	Vernier	Telescope reading for reflection from first face			Telescope reading for reflection from second face			Differ--ence (a-b) = 2A	Mean value of 2A	A	Mean A Degrees
		M.S. reading	V.S. reading	Total (a) Degree	M.S. reading	V.S. reading	Total (b) Degree				
1.	V_1	…	…	…	…	…	…	…	…	…	…
	V_2	…	…	…	…	…	…	…	…	…	…
2.	V_1	…	…	…	…	…	…	…	…	…	…
	V_2	…	…	…	…	…	…	…	…	…	…
3.	V_1	…	…	…	…	…	…	…	…	…	…
	V_2	…	…	…	…	…	…	…	…	…	…

(iii) Table for angle of minimum deviation (δ_m):

S. No.	Colour	Vernier	Dispersed image, Telescope in minimum deviation position			Telescope reading for Direct image			Differe--nce (a-b)	Mean deviation δ_m degree
			M.S. reading	V.S. reading	Total (a) Degree	M.S. reading	V.S. reading	Total (b) Degree		
1.	Violet	V_1	…	…	…	…	…	…	…	…
		V_2	…	…	…	…	…	…	…	…
2.	Blue	V_1	…	…	…	…	…	…	…	…
		V_2	…	…	…	…	…	…	…	…
3.	Green	V_1	…	…	…	…	…	…	…	…
		V_2	…	…	…	…	…	…	…	…
4.	Yellow	V_1	…	…	…	…	…	…	…	…
		V_2	…	…	…	…	…	…	…	…

CALCULATIONS:

Angle of minimum deviation for violet = …

μ for violet = $\dfrac{sin\left[\frac{A+\delta_{m_1}}{2}\right]}{sin(A/2)}$

= …

Angle of minimum deviation for blue = …

μ for blue = $\frac{sin\left[\frac{A+\delta m_2}{2}\right]}{sin(A/2)}$

Similarly find the value of μ for other colours.

RESULT:

Refractive index for the material of the prism.

S.No.	Colour	Calculated μ	Standard μ	% Error
1.	Violet	…	…	…
2.	Blue	…	…	…
3.	…	…	…	…
4.	…	…	…	…
5.	…	…	…	…

PRECAUTIONS AND SOURCES OF ERROR:

(i) The telescope and collimator should be individually set for parallel rays.
(ii) Slit should be as narrow as possible.
(iii) While taking observations, the telescope and prism table should be clamped with the help of clamping screws.
(iv) Both verniers should be read.

The prism should be properly placed on the prism table for the measurement of angle of the prism as for the angle of minimum deviation.

PRACTICAL ERROR:

Refractive index of the material of the prism is given by the expression.

$$\mu = \frac{sin\left[\frac{A+\delta m}{2}\right]}{sin(A/2)}$$

Taking logarithms of both sides and differentiating

$$\frac{\delta\mu}{\mu} = \frac{cos\left[\frac{A+\delta m}{2}\right]}{sin\left[\frac{A+\delta m}{2}\right]} \frac{\delta(A+\delta m)}{2} + \frac{cos\left[\frac{A}{2}\right]}{sin\left[\frac{A}{2}\right]} \frac{\delta(A)}{2}$$

$$\frac{\delta\mu}{\mu} = cot\left[\frac{A+\delta_m}{2}\right] \frac{\delta(A+\delta_m)}{2} + \cot\left[\frac{A}{2}\right] \delta\left[\frac{A}{2}\right]$$

$\left.\begin{matrix} \delta A = 2' \\ \delta(\delta_m) = 2' \end{matrix}\right\}$ As the least count of the spectrometer = $1''$ and there are two verniers.

$\frac{\delta(A+\delta_m)}{2} = 2'$ and $\delta\left[\frac{A}{2}\right] = 1'$

$$\frac{\delta\mu}{\mu} = cot\left[\frac{A+\delta_m}{2}\right]2' + cot\left[\frac{A}{2}\right]1'$$

$$= \frac{\pi}{60 \times 180}\left\{2cot\left[\frac{A+\delta_m}{2}\right] + cot\left[\frac{A}{2}\right]\right\}$$

= …

= …%.