Wavelength 'λ' of the sodium source $= 5893$ Å.
The value of Y is determined from the formula

$$Y = \frac{2gl}{\pi a^4 \lambda}(4bL - a^2)\left(\frac{M}{n+f}\right)$$

Result : The value of the Young's modulus of the material of the rod$=(\ldots \pm \ldots)$ dyne/cm^2.

Precautions : (i) All the rods should be perfectly straight.

(ii) The weight should be released showly by catch and release arrangement so that the number of collapsing rings can be counted accurately.

(iii) The apparatus should be kept on a rigid support.

EXPERIMENT No. 30

Object : (*a*) *To determine the wavelength of a monochromatic source of light with the help of Fresnel's biprism.*

(*b*) *To determine the thickness of mica sheet.*

Apparatus : Optical bench, biprism, slit, micrometer eye-piece and monochromatic source of light (either sodium lamp or a bulb with a filter), convex lens with small aperture having small focal length.

The *biprism* consists of two prisms, each of very small refracting angle (of the order of 1° or even less than 1°) placed base to base. In practice, the biprism is constructed from a single plate of glass by suitable grinding and polishing; the obtuse angle of the prism is only slightly less than 180°.

The *optical bench* consists of two metal rails graduated accurately in millimeters. The bench is provided with three metal uprights which can slide along the rails and their positions can be accurately read by vernier attached to each of them. The uprights

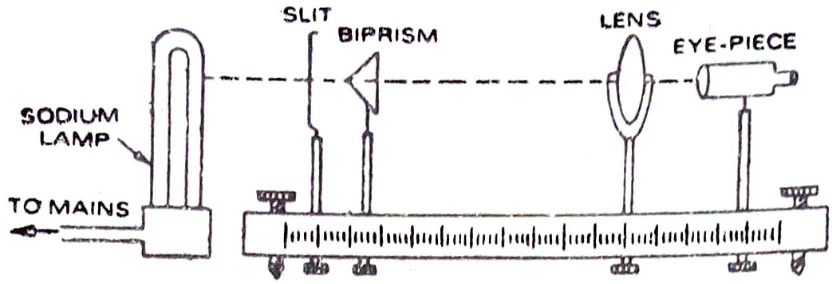

Fig. 30.1

can also be given transverse displacement with the help of a screw. The top portions of the uprights carrying the biprism and the slit can be rotated about an axis parallel to the optical bench. The third upright carries a Ramsden's eye-piece. By means of rack and pinion arrangement the uprights can be moved vertically and adjusted to suitable heights. A spare upright without rack and pinion arrangement, is also used to mount the lens.

Ramsden's eye-piece : A cross-wire or a line scratch made on a glass piece is fitted at some distance in front of the field lens of this eye-piece. It is provided with a spherometric arrangement having a divided circular head reading a very small least count. The eye-piece can be moved at right angles to the length of the optical bench by giving rotations to the spherometric screw.

The whole arrangement has been shown in fig. 30.1.

Theory : Suppose that the monochromatic light from a slit S, perpendicular to the plane of the paper, falls symmetrically on the biprism, the refracting edge of which is perpendicular to the paper. The edge B of the biprism divides the incident wave-front into two parts which passing through the upper-half and the lower-half of the biprism appear to diverge from the virtual images S_1 and S_2. These two images now serve as the two coherent sources produced from the same source and are very close to and equi-

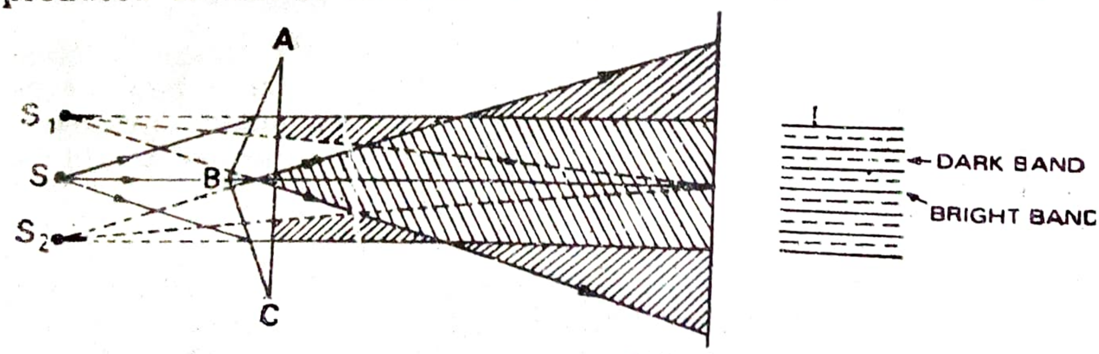

Fig. 30.2

distant from S. Consequently, interference fringes are observed on the overlapping region of the two emergent beams of light (fig. 30.2).

If β=fringe width i. e., the distance between two successive maxima or minima of the fringes,

d=distance between the two coherent sources $(=S_1S_2)$,

λ=wavelength of the monochromatic source of light, and

D=distance between the slit and the screen or eye-piece where fringes are observed and measured, then

$$\lambda=\beta\frac{d}{D}.$$

Procedure : Before performing the experiment, the following adjustments must be made :

(*a*) *The bed of the optical bench is levelled* by a spirit level and the levelling screws.

(*b*) The eye-piece is focussed on the cross-wires by moving the tube containing the lenses of the eye-piece until they are distinctly visible. *One of cross-wires is made exactly vertical* by observing a plumb line through the eye-piece and rotating the latter about its own axis until it coincides with the plumb line.

(*c*) A short focus lens is interposed between the slit and the eye-piece and an image of the slit is obtained on the vertical cross-wire. With the help of the tangent screw, *the slit is made vertical* by rotating it in its own plane till the image coincides with the vertical cross-wire.

(*d*) The slit is made narrow and illuminated with the monochromatic source of light. Eyes are moved across the bench when either the upper or the lower portion of any one of the vertical images may be found to cross the edge of the biprism. The biprism is rotated in its own plane by the tangent screw till the images as a whole appear to cross the edge. *Thus the edge of the biprism becomes parallel to the slit.*

(*e*) The eye-piece is then mounted on the optical bench at the centre of the bench. By moving the source little away or towards or sideways of the slit (and adjusting the biprism by tangent screw if required), the *clear bright and narrow fringes are seen in the eye-piece.*

(*f*) The eye-piece is moved away to the other end of the optical bench so that the distance between the slit and the eye-piece is greater than four times the focal length of the convex lens used for the measurement of 'd'. If the line joining the slit and the central edge of the biprism is not parallel to the length of the bench. fringes would shift laterally as the eye-piece is moved. To

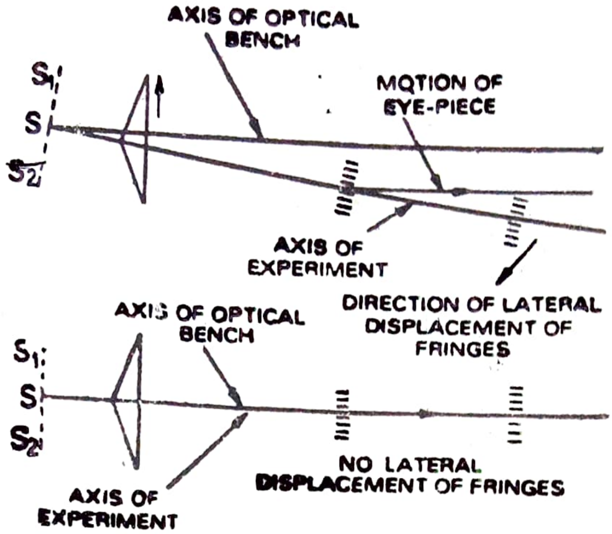

Fig. 30.3

remove this, the biprism is moved a small distance transversely to the bench in a direction opposite to the direction of the shift till this lateral shift vanishes (fig. 30.3).

Measurement of β

The cross-wire is set at the centre of the first bright fringe and the reading of the micrometer screw is taken.

The screw is then moved in one direction so that the wire falls in succession at the centres of the bright fringes and the corresponding readings are taken. From these readings, the width of a number of fringes (say, 10) are calculated by subtracting the first fringe from eleventh, second from twelvth and so on. After taking the mean, fringe width β for one fringe is calculated.

Measurement of *d*

Without changing the positions of the slit, biprism and the eye-piece; a convex lens is mounted on the optical bench between the latter two. The distances d_1 and d_2 between the well-defined images of the two virtual slits S_1 and S_2 are measured with the micrometer screw for the two positions of the lens as shown in fig. 30.4. Then the distance between S_1 and S_2 is given by

$$d=\sqrt{d_1\, d_2}.$$

If the convex lens is not well chosen, the distance d_2 between the images of the slit in the second case (giving diminished images) becomes very small and the measurement become too erratic.

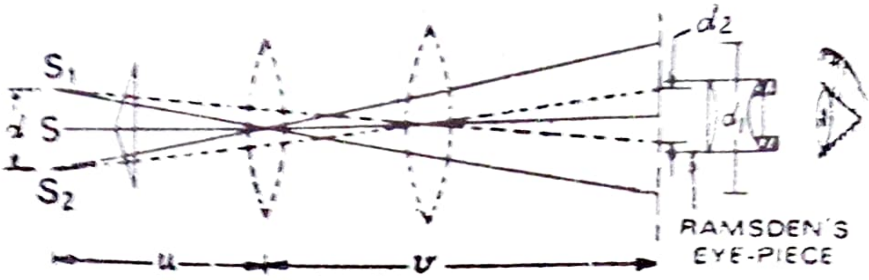

Fig. 30.4

To avoid this, the distance 'u' between the lens and the slit and 'v' between the lens and the eye-piece in the first case giving magnified images are measured. Then

$$\frac{d}{d_1}=\frac{u}{v} \quad \text{or} \quad d=\frac{u}{v}d_1.$$

Measurement of D

The positions of the slit and the eye-piece are noted. The distance between them gives observed value of D. Actual value of D is the distance between the slit and the focal plane of the eye-piece. To get this, bench correction may be applied as follows :

A rod of known length (say, p cm) is held parallel to the optical bench so that one of its end just touches the slit. The eye-piece is focussed on the other end. The positions of the slit and eye-piece are read. The difference gives the apparent length (say, q cm) of the rod. Then the bench correction$=(p\sim q)$ cm.

Observations :

[A] *Readings for the measurement of* β

Pitch of the screw $=$...cm

No. of divs. on the circular head $=$

Least count of the micrometer screw $=$...cm

No. of fringes	Micrometer reading (in cm) (a)	No. of fringes	Micrometer reading (in cm) (b)	Separation of 10 bands (in cm) ($b-a$)
1.		11		
2.		12		
3.		13		
...		...		
...		...		
...		...		
			Mean	

[B] *Readings for the determination of d*

S. No.	Micrometer readings when lens is near the slit (in cm)		$d_1 = c - d$ (in cm)	Micrometer readings when lens is near the eye-piece (in cm)		$d_2 = c' - d'$ (in cm)	$d = \sqrt{d_1 d_2}$ (in cm)
	1st image c	2nd image d		1st image c'	2nd image d'		

[C] *Readings for the determination of D*

Length of bench correction rod = ... cm

Corresponding distance on the bench = ... cm

∴ Bench error = ... cm

Position of the slit (in cm) x			Position of eye-piece (in cm) y			* Position of lens near the bi-prism (in cm) z			*	*		
	Vernier	Total	Main	Vernier	Total	Main	Vernier	Total	u $(x-z)$ (cm)	v $(y-z)$ (cm)	D $(x-y)$ (cm)	d (cm)

*These columns should be added if the distance d_2 between the two images of S_1 and S_2 is too small to be measured. In that case the latter half of the table [B] should not be used.

Calculations :

Mean fringe width for one fringe = ... cm

Value of D (correcting bench error) = ... cm

$\therefore \quad \lambda = \frac{d}{D}\,\beta = \ldots$ A.U.

% *error* :

Result : The wave length of the monochromatic source (correct to significant figures) = ... A.U.

(b) **Determination of thickness of mica sheet**

Suppose S_1 and S_2 are two coherent interfering sources, producing the central fringe at P (fig. 30.5).

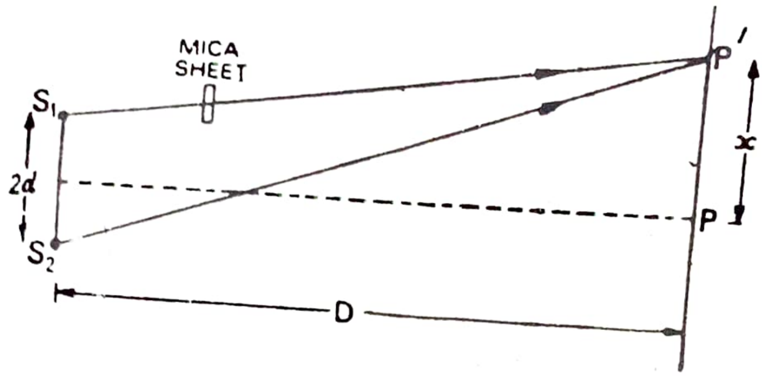

Fig. 30.5

If a thin mica sheet of refracting index 'μ' and of thickness 't' is introduced in the path of one of the interfering beams (say, S_1P), the waves from S_1 will be retarded as it travels in the mica medium. Hence the central fringe (and the whole fringe system along with it) laterally shifts to P' such that

time taken by wave from S_2 to P' in air = time taken by wave from S_1 to P' partly $(S_1P'-t)$ in air and 't' through mica medium.

i.e., $\quad S_2P'/c_0 \quad = (S_1P'-t)/c_0 + t/c$

where 'c' is the velocity of light in air and 'c' its velocity in mica.

Thus, $S_2P' = (S_1P'-t) + t(c_0/c) = S_1P' - t + \mu t$

or $\quad S_2P' - S_1P' = (\mu - 1)t$. $\quad [\because \mu = c_0/c]$

If P' is the point originally occupied by the nth bright fringe,

$$S_2P' - S_1P' = n\lambda = (\mu - 1)t.$$

Also, the distance 'x' through which the fringe is shifted is given by

$$x = n\lambda D/d = D(\mu - 1)t/d.$$

Thus, measuring x by micrometer screw and D, d as in [a] part, t may be calculated if 'μ' is known.

Procedure : (i) All the preliminary adjustments are done as in the previous part of the experiment.

(ii) White light is used as the illuminating source so that all the other fringes except the central one will be coloured. Thus the central fringe can easily be distinguished from its neighbours.

(iii) The values of 'd' and 'D' are measured as in the previous part (a).

(iv) The mica sheet is placed in between the two halves of a cork and clamped in a stand. The sheet is carefully introduced in one of the interfering beams and the displacement 'x' of the central fringe is measured with the micrometer screw.

Precautions :

(i) The adjustments mentioned in the procedure should be accurately done.

(ii) While using the micrometer screw, back-lash error should be avoided by moving the screw in one direction.

(iii) The eye-piece stand should be so fixed that the movement of the eye-piece is at right angles to the optical bench.

(iv) The slit should not be too narrow as the light will be so feeble that it will be difficult to see the bands. The slit also should not be too wide as the interference band will vanish and the diffraction bands with varying width may appear.

Questions

(i) Q. (i) to (iii) as in expt. no. 29. (ii) What is a biprism and how is it made? Why should the refracting angle be so small? (iii) What do you understand by coherent sources and how do you get them in this case ? (iv) Explain the functions of the various motions which are provided with each upright. (v) Why should a short focus lens be employed in this experiment ? Why do you suppose that the two virtual sources are formed in the plane of the slit ? (vi) What happens if the slit is too narrow or two wide ? (vii) Where are the fringes formed in this case ? (viii) Show how to find the angle of the biprism if λ and μ of the prism be given in this experiment. (ix) What happens if white light is used in this expt. and why ?

EXPERIMENT No. 31

Object : (a) *To determine the wavelength of a monochromatic source of light (e.g., green radiation of mercury arc or sodium yellow light).*