Fresnel’s biprism:

A Fresnel Biprism is a thin double prism placed base to base and have very small refracting angle (0.5°). This is equivalent to a single prism with one of its angle nearly 179° and other two of 0.5° each.

The interference is observed by the division of wave front. Monochromatic light through a narrow slit *S* falls on biprism, which divides it into two components. One of these component is refracted from upper portion of biprism and appears to come from S_1 where the other one refracted through lower portion *and* appears to come from S_2. Thus S_1 and S_2 act as two virtual coherent sources formed from the original source. Light waves arising from $S_1$and S_2 interfere in the shaded region and interference fringes are formed which can be observed on the screen.

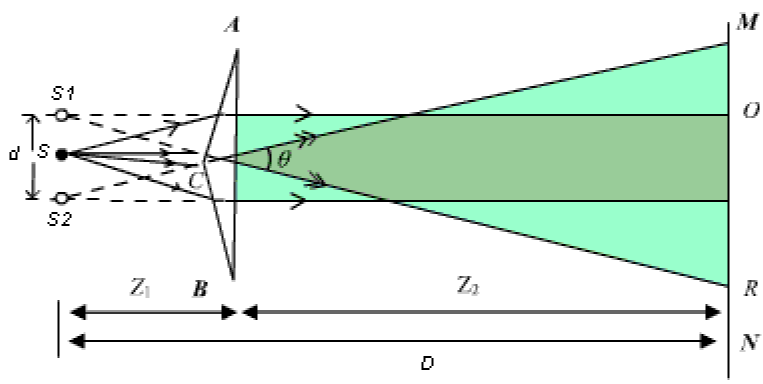


Fig. 1 Fresnel Biprism

Applications of Fresnel's Biprism

Fresnel biprism can be used to determine the wavelength of a light source (monochromatic), thickness of a thin transparent sheet/ thin film, refractive index of medium etc.

A. Determination of wave length of light

As expression for fringe width is $\beta = \frac{D\lambda}{d}$

Biprism can be used to determine the wavelength of given monochromatic light using the expression.

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

Experimental Arrangement. Light from monochromatic source is made to fall on a thin slit mounted vertically on a rigid optical bench fitted with a scale. The biprism and the screen (in this case an eye piece) are also mounted vertically. The eye piece can be moved in the plane perpendicular to the axis of bench using a micrometer based translation stage.

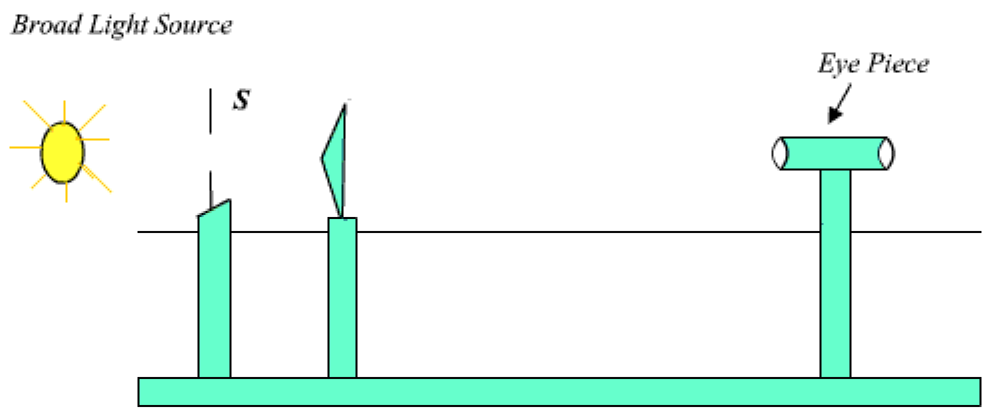


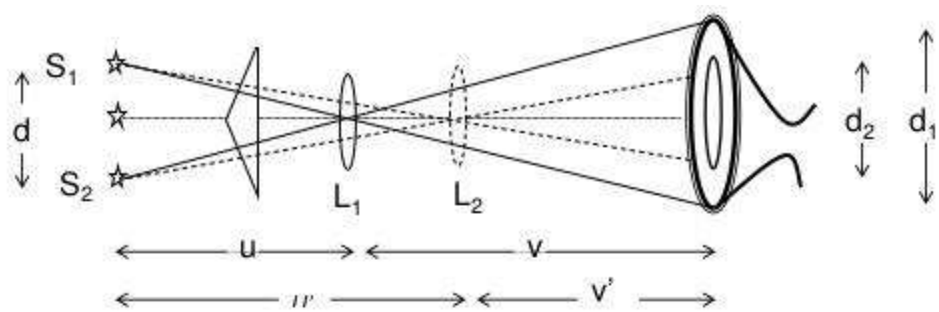
Figure 2: Experimental Set-Up: Fresnel Biprism Experiment

(i) Measurement of fringe width: To get β, fringes are first observed in the field of view of the microscope. The vertical wire of the eyepiece is made to coincide with one of the fringes and screw of micrometer is moved sideways and number of fringes is counted.

β =Distance moved / number of fringes passed

(ii) Measurement of D: This distance between source and eyepiece is directly measured on the optical bench scale.

(iii) Determination of d: To determine the separation between the two virtual sources (d), a convex lens of short focal length is introduced between the biprism and the eye piece, keeping the distance between the slit and eyepiece to be more than four times the focal length of lens. The lens is moved along the length of bench to a position where two images of slits are seen in the plane of cross wires of eye piece. The distance between these two images of slit is measured by setting the vertical cross wire successively on each of images and recording the two positions of cross wire using micrometer. Let this separation be d_1 . Now the lens is moved such that for another position of lens, again two images of slit are seen on eye piece. Let d_2 be the separation between these two images.



$$\frac{d_1}{d} = \frac{v}{u} \qquad (1)$$

$$\frac{d_2}{d} = \frac{v'}{u'} \qquad (2)$$

Since these two positions of lens are conjugate, the separation between the virtual source 'd ' is given by using equations 1 and 2 as

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

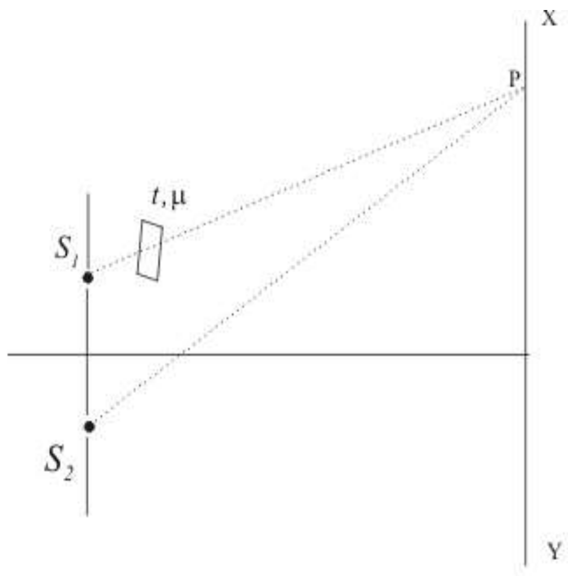
where d1 and d2 are the distance between S_1 and S_2 for two position of lens.

B. Determination of thickness of a thin film:

To determine the thickness of transparent thin sheet (mica), the monochromatic source is replaced by white light source.

The position of this central white fringe is recorded by focusing the cross wire of eye piece on it and taking this reading of micrometer scale. Now mica sheet is introduced in the path of one wave. (such that it blocks the one half of biprism). By doing it the one wave traverse an extra optical path and the path difference between the two waves is not same and entire fringe pattern shifts. The central white fringe is now shifted to another position of cross wire. If 'S' is the shift in position of white fringe and μ be the refractive index of mica sheet, thickness 't' of mica sheet is given by

$$t = \left(\frac{S}{D}\right)\frac{d}{\mu - 1} \text{ cm}$$



Time required by light to reach from S_1 to point P

$$= \frac{S_1P - t}{c} + \frac{t}{v}$$

where v=c/μ

$$T = \frac{S_1P + t(\mu - 1)}{c}$$

Hence equivalent path that is covered by light in air is $S_1P+t(\mu-1)$

Optical path difference at P

$$= S_2P - [S_1P + \mu t - t]$$
$$= S_2P - S_1P - [\mu -]t$$
$$= \frac{xd}{D} - [\mu -]t$$

Therefore nth fringe shift is given by

$$\Delta x = \frac{D(\mu - 1)t}{d}$$

as,

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

$$\Delta x = \frac{\beta(\mu - 1)t}{\lambda}$$

where λ is the wavelength of the wave; Δx is displacement of fringes and β is fringe width.