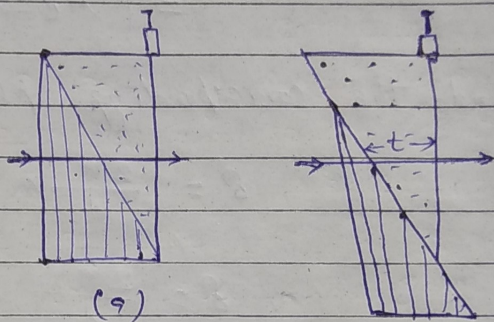
optics

Babiner's Compensator, analysis of elliptically Polarised light

Babiner's compensator → It is a device by means of which a desired path-difference can be introduced between the O-ray & E-ray for light of any wave length.

Construction → This consists of two quartz prisms of wedge shape mounted in a holder with their hypotenuse faces adjacent and so that their optic axes are mutually perpendicular & both are perpendicular to the incident light. The faces of the wedges are cut parallel to the respective optic axis. The wedge is fixed in the holder and the other one can be moved by a micrometer screw so that its hypotenuse face slides over that of the adjacent fixed wedge.



(a) (b)

Theory → Quartz is a positive crystal. The incident light is split up into E-ray and O-ray. The O-ray travels faster than E-ray in the wedge I. On transmission through the interface between the wedges, the O-ray in wedge I becomes the E-ray in wedge 2 because the optic axis of wedge 2 is ⊥r. to that of wedge 1. The speeds of two rays are interchanged at the interface.

Let t_1 and t_2 be the thickness of the two wedges traversed by transmitted light. Let μ_e and μ_0 be the r.i. indices of quartz for the E-ray and O-ray respectively. The path difference introduced between the two components by the first wedge is :

$$\Delta_1 = (\mu_e - \mu_0) t_1 \qquad (\because \mu_e > \mu_0 \text{ for the positive crystal})$$

and that introduced by the second wedge is,

$$\Delta_2 = (\mu_o - \mu_e) \cdot t_2 = -(\mu_e - \mu_o) t$$

Hence the total path difference

$$\Delta = \Delta_1 + \Delta_2$$
$$= (\mu_e - \mu_o)(t_1 - t_2)$$

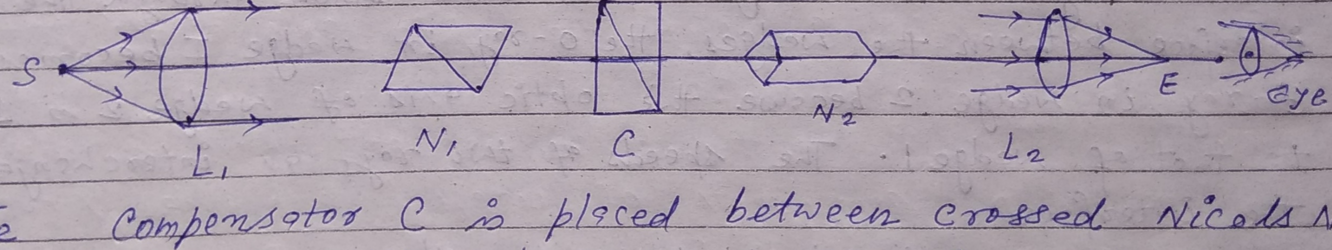
And the corresponding phase difference is

$$\delta = \frac{2\pi}{\lambda} \times \text{path difference}$$

$$\text{or, } \delta = \frac{2\pi}{\lambda} (\mu_e - \mu_o)(t_1 - t_2)$$

At the centre of the compensator $(t_1 = t_2)$, the resultant path difference is zero so that the emergent light is plane-polarised. On either side of this point the path difference gradually increase and the emergent light is polarised in various ways.

Analysis of Elliptically polarised light :→



The compensator C is placed between crossed Nicols N_1 & N_2, oriented so that the optic axis of the wedge makes an angle of 45° with the vibration plane of the incident monochromatic light from N_1. Then a set of alternate dark and bright bands are seen. The cross-wire is placed on a dark band and the micrometer screw is moved through an angle until the next dark band is under the cross-wire. Several values of θ are determined and mean θ is evaluated. Hence the rotation θ of the micrometer eyepiece corresponds to a phase change of 2π. This serves as the calibration.

(i) Determination of Phase Difference :

The compensator is illuminated with white line polarised light. The micrometer screw is adjusted to bring the central dark band under the cross-wire. The white light is replaced by the given elliptically polarised light. The central band shifts to a point where the original phase difference ϕ between the two components of elliptic vibration is annulled by the phase difference introduced by the compensator. The screw is rotated by θ_0 so that the central band again comes under the cross-wire. Then

$$\frac{\phi}{2\pi} = \frac{\theta_0}{\theta} \qquad \therefore \phi = 2\pi \cdot \frac{\theta_0}{\theta}$$

The value of θ is obtained from calibration.

(ii) Position of Axis :→ The compensator is again illuminated with white plane-polarised light. The micrometer screw is adjusted to bring the central dark band under the cross-wire. The screw is then turned by $\frac{\theta}{4}$ so that the compensator introduces a phase difference of $\pi/2$. The central dark band now is not on the cross-wire.

The given elliptically polarised light is allowed to fall normally on the compensator. The compensator is rotated to bring the central dark band on the cross-wire. The axes of the incident elliptically polarised light are parallel to the optic axis of the wedges of the compensator.

(iii) Ratio of Axes :→

let α is the angle through ~~wich~~ which the compensator has been rotated then the ratio of axes is given by

$$\frac{b}{a} = \tan\alpha .$$

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