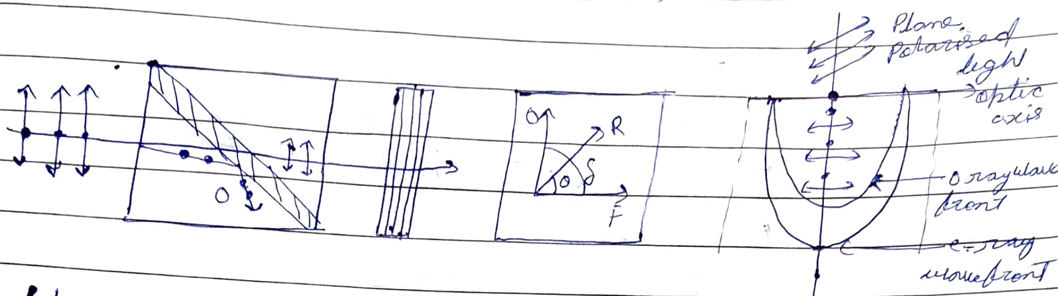
B.Sc - II

20/1/22

Production of (i) Plane polarized (ii) circularly polarized & (iii) Elliptically polarized light



Let a beam of monochromatic light of wavelength λ be made to fall on Nicol prism N as shown in fig. The light transmitted by Nicol prism is plane polarized light. Let this plane polarized light is incident normally on uni-axial doubly refracting crystal (P) with its face cut parallel to optic axis. Let vibrations of plane polarized light are inclined to the optic axis of P at some angle θ.

The plane polarized light incident on crystal (P) splitted into E & O ray which travel along same direction with different velocities. After travelling a path length 'd' in the crystal, a phase difference of δ is introduced b/w O & E components. Let A be amplitude of plane polarized light incident on the crystal Q. The amplitude of O-ray vibrating along PO is A sinθ & amplitude of E-ray vibrating along PE is A cosθ. If phase difference δ is introduced by crystal (P) b/w O & E components, then O & E components coming out of crystal (P) can be expressed as

$$y = (A\sin\theta)\sin\omega t \quad \text{—— (1)} \quad (\text{O ray})$$

$$x = (A\cos\theta)\sin(\omega t + \delta) \quad \text{—— (2)} \quad (\text{E-ray})$$

The eqn of wave is $y = a\sin\omega t$

Let $A\cos\theta = a$ —— (3) & $A\sin\theta = b$ —— (4)

using (3) & (4) in (1) & (2)

$$y = b\sin\omega t \quad \text{—— (5)}$$

$$x = a\sin(\omega t + \delta) \quad \text{—— (6)}$$

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From (5)

$$\frac{y}{b} = \sin\omega t \quad \text{--- (7)}$$

Now

$$\cos\omega t = \sqrt{1-\sin^2\omega t} \quad \text{--- (8)}$$

using (7) in 8

$$\cos\omega t = \sqrt{1-\left(\frac{y}{b}\right)^2} \quad \text{--- (9)}$$

From (6)

$$\frac{x}{a} = \sin(\omega t + \delta)$$

$$\frac{x}{a} = \sin(\omega t)\cos\delta + \cos\omega t \cdot \sin\delta \quad \text{--- (10)}$$

using (7) & (9) in (10)

$$\frac{x}{a} = \frac{y}{b}\cdot\cos\delta + \sqrt{1-\frac{y^2}{b^2}}\,\sin\delta$$

$$\frac{x}{a} - \frac{y}{b}\cos\delta = \sqrt{1-\frac{y^2}{b^2}}\,\sin\delta \quad \text{--- (11)}$$

Squaring both sides

$$\left(\frac{x}{a} - \frac{y}{b}\cos\delta\right)^2 = \left(\sqrt{1-\frac{y^2}{b^2}}\,\sin\delta\right)^2$$

$$\frac{x^2}{a^2} + \frac{y^2}{b^2}\cos^2\delta - 2\frac{x}{a}\frac{y}{b}\cos\delta = \left(1-\frac{y^2}{b^2}\right)\sin^2\delta$$

$$\frac{x^2}{a^2} + \frac{y^2}{b^2}\cos^2\delta - \frac{2xy}{ab}\cos\delta = \sin^2\delta - \frac{y^2}{b^2}\sin^2\delta$$

$$\frac{x^2}{a^2} + \frac{y^2}{b^2}(\cos^2\delta + \sin^2\delta) - \frac{2xy}{ab}\cos\delta = \sin^2\delta$$

$$\boxed{\frac{x^2}{a^2} + \frac{y^2}{b^2} - \frac{2xy}{ab}\cos\delta = \sin^2\delta}$$