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Rotatory Polarisation and Optical Activity

When a plane Polarised light is mad to Pass through some substance, the direction of vibration of incident light rotated by certain angle. This is K/a optical activity. The substance which rotates the Plane of Polarisation in the clock wise w.r. to observer K/a dextro-rotatory and the substance which rotates the plane of Polarisation in the anticlockwise w.r. to observer K/a Levorotary

The rotation is directly proportional to the concentration 'c' of the solution $\theta \propto c$ and it is also ~~con~~ proportional to the length 'l' of the medium.

$$\theta \propto lc$$

The rotation is directly proportional to the wave length λ of polarised light $\theta \propto \frac{1}{\lambda^2}$

Fresnel's Explanation of optical activity

Assumption of Fresnel's theory:

(i) When a plane-polarised beam enters an optically active substance, it is broken up into clockwise and anticlockwise circularly polarised beam.

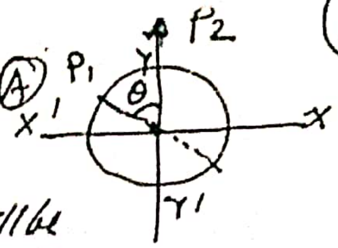
(ii) In dextro rotatory the velocity of clockwise is greater than the velocity of anticlockwise circularly polarised light

(iii) In an optically inactive crystal, the two circularly polarised light travel with same frequency.

(iv) The two circularly polarised beam on emerging from the optically active substance, recombine to form a plane polarised beam

When the plane Polarised light entering the quartz plate, the beam is split up into two ~~optica~~ opositly cicularly polarised light represented by equation.

$x_1 = a\cos\omega t$ & $y_1 = a\sin\omega t$ for R.H.S] (A)
& $x_2 = a\cos\omega t$ & $y_2 = a\sin\omega t$ for L.H.S]



When the wave is transmitted with Phase difference δ then the equation will be

$$x_2 = a\cos(\omega t+\delta) \text{ and } y_2 = a\sin(\omega t+\delta)$$

$$\& \; x_1 = a\cos\omega t \quad \text{and } y_1 = a\sin\omega t$$

The resultant Vibration will be represented by

$$x = x_1 + x_2 = a\cos\omega t - a\cos(\omega t+\delta)$$
$$= 2a\sin\delta/2 \, \sin(\omega t+\delta/2) \quad \text{— (B)}$$

The resultant Vibration along Y axis

$$Y = 2a\cos\delta/2 \, \sin(\omega t+\delta/2) \quad \text{— (C)}$$

The Phase difference between X & Y component

$$\tan\theta = X/Y = \tan\delta/2 \Rightarrow \theta = \delta/2$$

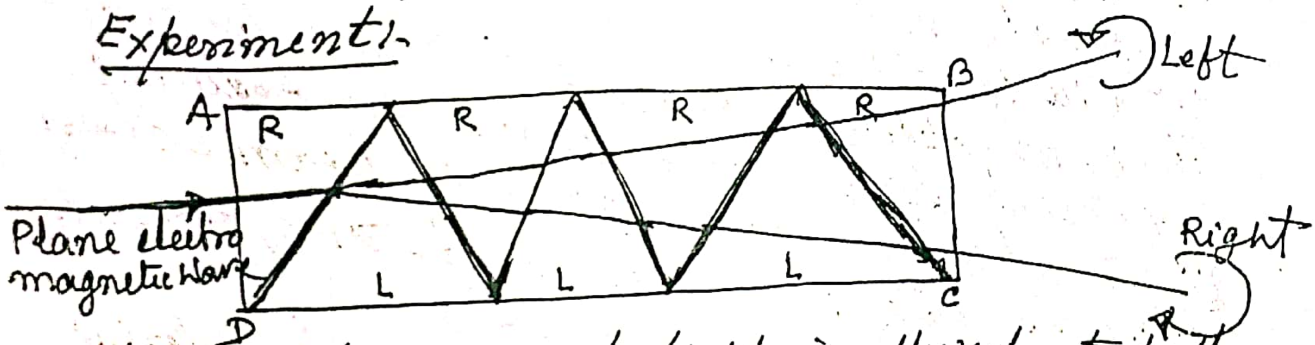
If μ_a and μ_c are the refractive indices of quartz in the direction of optic axis for anticlockwise and clockwise circularly polarised light and t is the thickness of crystal then its Phase difference

$$\delta = \frac{2\pi}{\lambda}[\mu_a - \mu_c]t$$

The rotation of Plane of Polarisation is given by

$$\boxed{\theta = \delta/2 = \pi/\lambda \, (\mu_a - \mu_c)t}$$

Experiment:-



A beam of Plane Polarised light is allowed to fall normally on a rectangular block A.B.C.D. The block is made of alternative Prisms of right handed quartz and left handred quartz. All the prism having their optic axis.

perpendicular to the end face AD or BC.
Let V_R & V_L are the velocity in 1st prism & 2nd prism.
If $V_R > V_L$ for 1st prism. The velocity interchanges
when passes through the next prism and right
handed will be turned downward and left handed
ray will be turned upward.

when these two waves are analysed by a
quarter wave plate and Nicol prism, it is observed
that both are circularly polarised light
in opposit direction. This verifies the Fresnel's
theory