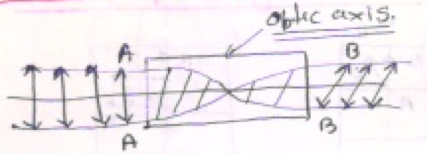
: Optical Activity :

Rotation is about the optic axis.



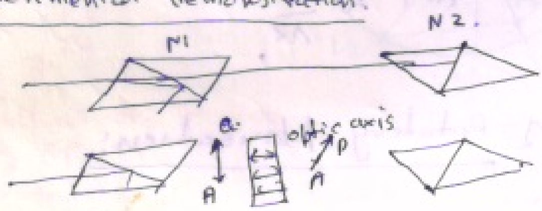
Plane of vibration and plane of polarisation also undergo a rotation: This phenomenon is called optically activity.

(i) $\phi \propto$ thickness of crystal. (length of medium).
(ii) $\propto \frac{1}{\lambda^2}$ $\propto$ concentration of solute.

turpentine, sugar solution, solids :→ due to crystalline structure.

(a) Left handed rotation. in liquids.(ii). molecular structure.
(b) Right handed rotation.

Experimental demonstration:

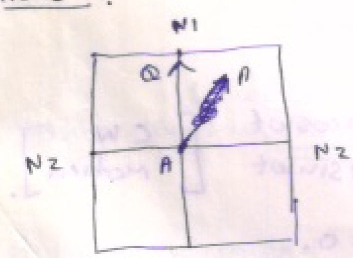


No light. (a) optic axis ⊥ vibration.

light. (b)

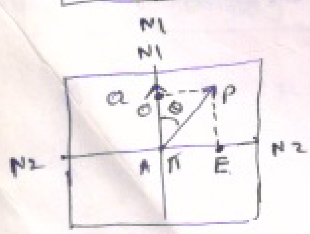
How ?.

(a)

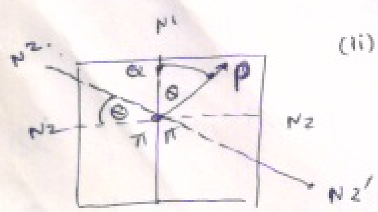


N1N1 → principal section of ~~analyser~~ polariser
N1N1 ⊥ N2N2 crossed position.

AQ → Vibration of P. polarised light passing through principal section of polariser.



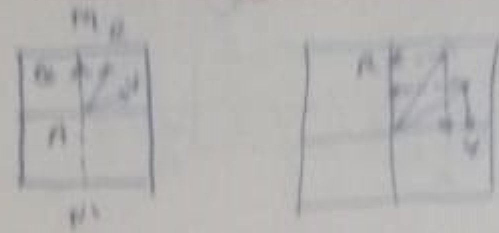
Now introduce Quartz (b).
AQ is rotated to AP through θ.
AP → emergent through Quartz.
AE = AP sin θ transmitted
AQ = AP cos θ blocked (⊥) to N1N1.



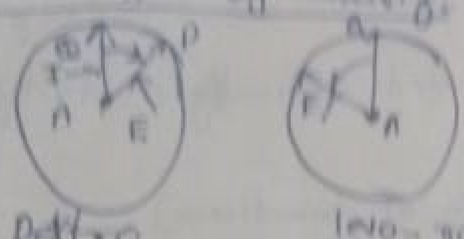
(ii) For complete darkness rotate N2N2 analyser. Note angle θ. It is the rotation produced by Quartz plate.

$\boxed{\text{calcite is optically inactive}}$

Rotatory dispersion:



Two types of crystals:



Dextro — Right handed.

laevo-rotatory — Left-handed

Laws of Rotation: By Biot (i) $\theta \propto$ thickness.

(ii) $\theta = \theta_1 - \theta_2 + \theta_3 - \theta_4 \cdots\cdots$

(iii) $\theta \propto \frac{1}{\lambda^2}$.

Fresnel's Explanation of Rotatory polarisation:

Rectilinear S H Vibration, Same frequency.

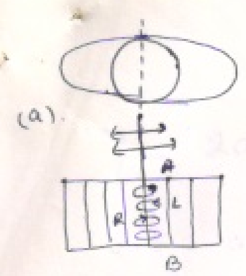
$$\left.\begin{aligned} x_1 &= a\cos\omega t \quad \text{ACW} \\ y_1 &= a\sin\omega t \end{aligned}\right] \quad \& \quad \begin{aligned} x_2 &= -a\cos\omega t \\ y_2 &= a\sin\omega t \end{aligned} \quad \left[\begin{array}{c}\text{CW} \\ \text{Motion}\end{array}\right].$$

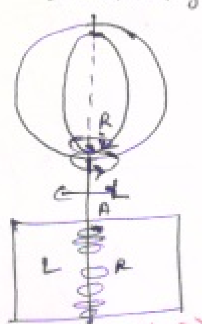
$$Y = 2a\sin\omega t \qquad x = x_1 + x_2 = 0.$$

Linearly polarised light.

Ist assumption:

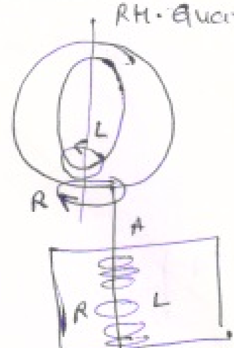
Calcite. LH. Quartz RH. Quartz.





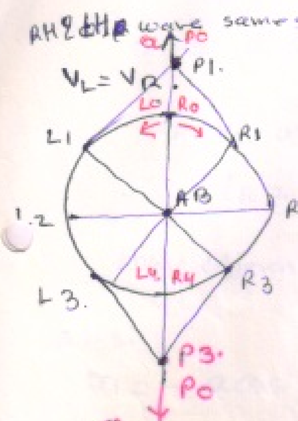
$V_L > V_R$

different velocity

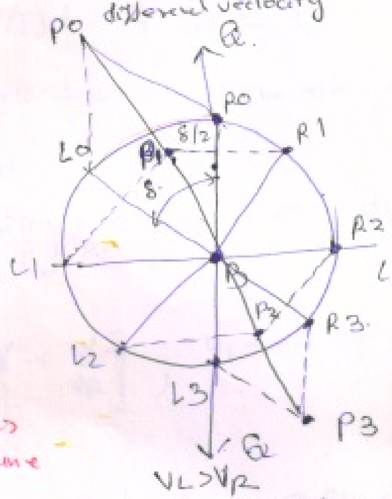


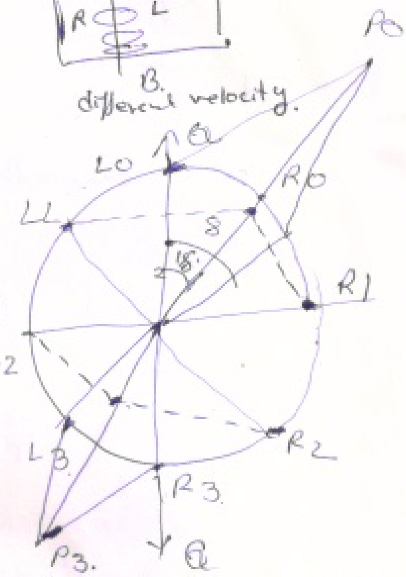
different velocity.

RH & LH wave same speed.



Resultant BP_0 coincides along AQ. Vibration plane of incident wave.





L component reaches at B first. and it has rotated through an angle δ before R component reaches at B.

δ is the phase difference between R & L component.

Let us call it $t=0$, and both component rotate in opposite direction R_0 & L_0. Resultant lies along BP_0

Calculation of angle of rotation:

$$\Delta t = t_L - t_R = \left[\frac{d}{V_L} - \frac{d}{V_R}\right]$$

$$\Delta = c\,\Delta t = d\left[\frac{c}{V_L} - \frac{c}{V_R}\right] = d\left[\mu_L - \mu_R\right].$$

$$\delta = \frac{2\pi}{\lambda} d\left[\mu_L - \mu_R\right].$$

$$\theta = \frac{1}{2}\delta = \frac{\pi}{\lambda} d\left[\mu_L - \mu_R\right].$$

$$\theta = -\frac{1}{2}\delta = -\left(\frac{\pi}{\lambda}\right) d\left[\mu_L - \mu_R\right].$$

Analytic treatment of Fresnel's Theory of Rotation. 3

$$Y = 2a \sin\left(\frac{2\pi}{T}\right)t \quad \text{——} \quad (1)$$

$x_1 = -a\cos\left(\frac{2\pi}{T}\right)t$ & $y_1 = a\sin\left(\frac{2\pi}{T}\right)t$.] R.H. Polarised

$x_2 = a\cos(2\pi/T)t$ & $y_2 = a\sin\left(\frac{2\pi}{T}\right)t$ [L.H. Polarised].

V_R, V_L are velocities, d be the thickness of crystal.

$$t_R = d/V_R.$$

phase difference $\left(\frac{2\pi}{T}\right)t_R$ or $\frac{2\pi}{T}\times\left(\frac{d}{V_R}\right)$.

RHS.

$$x_1 = -a\cos\frac{2\pi}{T}\left[t - \frac{d}{V_R}\right], \quad y_1 = a\sin\frac{2\pi}{T}\left[t - \frac{d}{V_R}\right]$$

LH

$$x_2 = a\cos\frac{2\pi}{T}\left[t - \frac{d}{V_L}\right] \quad y_2 = a\sin\frac{2\pi}{T}\left[t - \frac{d}{V_L}\right]$$

$x = x_1 + x_2.$

$$= a\left[\cos\frac{2\pi}{T}\left(t - \frac{d}{V_L}\right) - \cos\frac{2\pi}{T}\left(t - \frac{d}{V_R}\right)\right].$$

$$= 2a\sin\frac{\pi d}{T}\left[\left(\frac{1}{V_L} - \frac{1}{V_R}\right)\sin\left[t - \frac{d}{2}\left(\frac{1}{V_R} + \frac{1}{V_L}\right)\right]\right].$$

$Y = y_1 + y_2.$

$$= a\left[\sin\frac{2\pi}{T}\left(t - \frac{d}{V_L}\right) + \sin\frac{2\pi}{T}\left(t - \frac{d}{V_R}\right)\right].$$

$$= 2a\cos\frac{\pi d}{T}\left(\frac{1}{V_L} - \frac{1}{V_R}\right)\sin\frac{2\pi}{T}\left[t - \frac{d}{2}\left(\frac{1}{V_R} + \frac{1}{V_L}\right)\right]$$

$V_R > V_L$.

crystal is RH

$$R = \sqrt{x^2+y^2}$$

$$= 2a \sin \frac{2\pi}{T}\left[t - \frac{d}{2}\left(\frac{1}{v_R}+\frac{1}{v_L}\right)\right].$$

$$\tan\theta = \frac{x}{y} = \tan\left(\frac{\pi d}{T}\right)\left[\frac{1}{v_L}-\frac{1}{v_R}\right]$$

$$\theta = \frac{\pi d}{T}\left[\frac{1}{v_L}-\frac{1}{v_R}\right] = \pi d \frac{c}{\lambda}\left(\frac{1}{v_L}-\frac{1}{v_R}\right)$$

$$\theta = \pi \frac{d}{\lambda}\left[\mu_L - \mu_R\right] \text{ radians}.$$

<u>LH</u> $v_L - v_R$

$$\theta = -\left(\frac{\pi d}{\lambda}\right)\left[v_R - \mu_L\right].$$

For calcite $\mu_L = \mu_R$, $\theta = 0$.

<u>Proof</u>.

Specific and Molecular Rotation:

$$\text{Specific rotation} = \frac{\text{Rotation produced by 10 cm length of solution}}{\text{Density of sol. in gms per cc.}}$$

$$\alpha = \frac{100\,\theta}{l\,w} \qquad w\text{ - weight}$$

$\alpha \times$ molecular weight of the optically active substance is termed as molecular rotation or molecular rotatory power.

(+) dextro & –ve for levo

$$\alpha = P + QC + RC^2 \qquad R, P, Q \text{ - constant.}$$

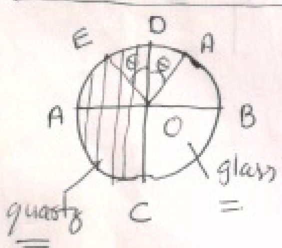
C - concentration:

$$[\alpha]_t^\lambda = 21.72\,[1 + 0.000147\,(t-20)] \quad \text{— for quartz.}$$

for sugar

$$[\alpha]_t^\lambda = 66.5 - 0.0184\,(t-20).$$

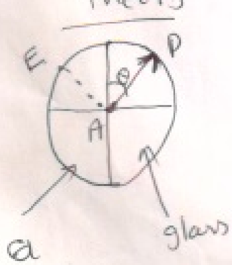
Laurent Half Shade Device:



$\frac{\lambda}{2}$ = plate — To introduce $\delta = \pi$ between O & E, wave.

Why half shade device — ?

Theory



$AP = P_i = A \sin\omega t$

$x_i = A \sin\theta \sin\omega t$ — O-wave

$y_i = A \sin\omega t \cos\theta$ — E wave

$x_e = A \sin\theta \sin(\omega t + \pi)$

$= -A \sin\theta \sin\omega t.$

$Y_e = A \cos\theta \sin\omega t$

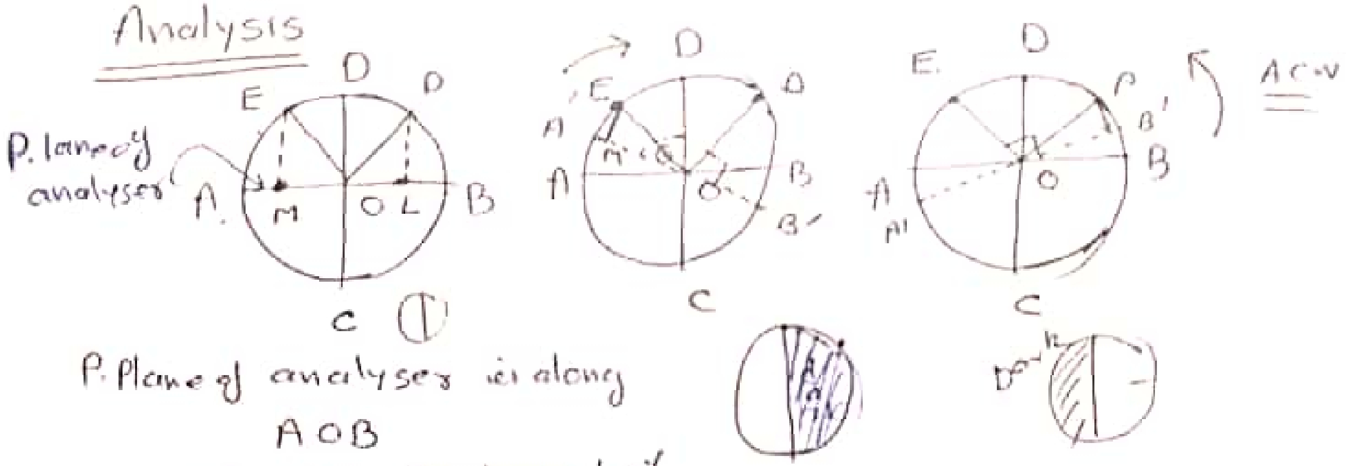
$$R = \sqrt{x_e^2 + y_e^2}$$

$$R = A \sin\omega t$$

$$\tan\phi = \frac{y_e}{x_e} = -\cot\theta$$

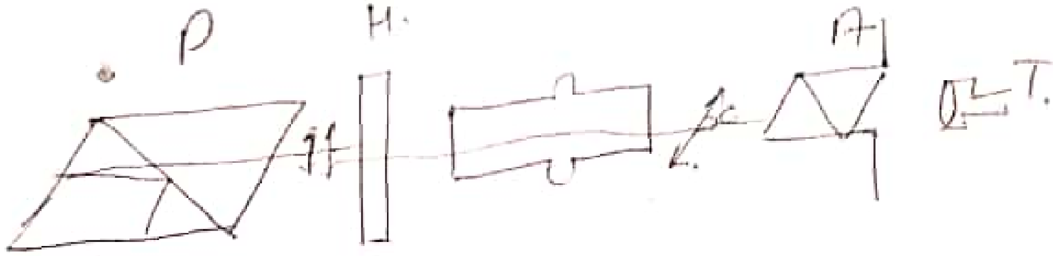
$$\phi = (\pi/2 + \theta)$$

Analysis



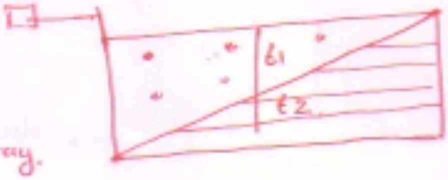
P. Plane of analyser is along AOB

OL = OM component of emergent wave.



Babinet compensator:

Calibration: quartz wedges.



$\Delta_1 = t_1(\mu_e - \mu_o)$. E & O ray.

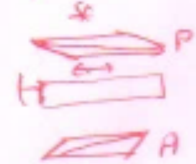
$\Delta_2 = t_2(\mu_o - \mu_e). = -t_2(\mu_e - \mu_o)$.

$\Delta = \Delta_1 + \Delta_2$

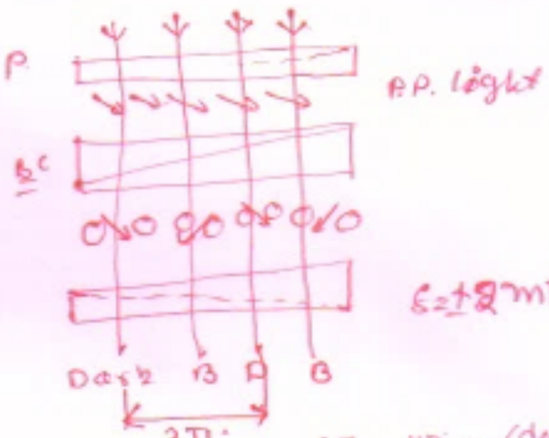
$= (t_1 - t_2)(\mu_e - \mu_o)$.

$\delta = \frac{2\pi}{\lambda}(\Delta) = \frac{2\pi}{\lambda}\left[(t_1 - t_2)(\mu_e - \mu_o)\right]$, $\delta = 0, \pi/4, \pi/2, \pi, \frac{3\pi}{2} \dots 2\pi \dots$

Setting



set P & A in X- position.



calibration factor = (2C).

Initial phase difference:

$x = A \sin(\omega t + \alpha)$

$y = B \sin(\omega t + \beta)$.

2π 4π — (dark band) — P.P light

phase difference $(\alpha - \beta)$.

-4π -2π 0 2

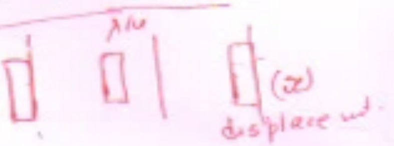
$\delta = \pm(2n+1)\pi$ $= \pm\pi, \pm 3\pi, \pm 5\pi$ (P.P light)

$\delta = \frac{2\pi}{\lambda}[t_1 - t_2][\mu_o - \mu_e]$

Total phase difference

$\alpha - \beta + \delta = 0$. for central band.

How it can be ~~[illegible]~~ done:



$\alpha - \beta = -\delta$

$2C = 2\pi$

$1 = \frac{2\pi}{2C}$

$x = \frac{\pi}{C}(x)$

$\alpha - \beta = \frac{\pi}{C}(x). = \left[\frac{\pi x}{C}\right]$

Position and ration of axis

So IR

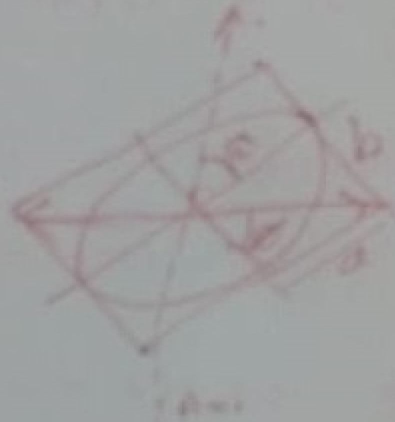
Rotate micrometer to introduce $\delta = (\frac{\pi}{2})$, $\frac{\pi}{2} = [\frac{1}{4}$ of calibration factor$]$

for central band

$[2m\pi \pm \frac{\pi}{2}]$

Introduce $\frac{\lambda}{4}$ plate $= (\pi/2)$

$\cancel{2m\pi \pm \frac{\pi}{2} + \frac{\pi}{2}}$



$\tan\phi = (\frac{a}{b})$

10 A solution of camphor in alcohol in a tube of 25 cm in length containing 50 cm^3 of solution is found to rotate the plane of vibration of light 10^o. What is the mass of camphor in unit volume of solution? The specific rotation of camphor is 66^o per decimeter for unit concentration. Calculate the quantity of camphor in the tube contains solution.

11 A length of 15 cm of 5% solution causes an optical rotation of 20^o. How much length of a 10% solution of the same substance will cause a rotation of 35^o.

12 A 20 cm column of cane sugar solution of concentration of 100gm/litre produces rotation of 10.6^0. Find the purity of cane sugar. Given: Specific rotation of pure sugar is 66 dm^{-1} g^{-1} cm.

13 (a) The refractive indices for quartz (wave length396.8nm), for left-and right-circularly polarize light, are n_L=1.55821 and n_R=1.55810, respectively? What is the specific rotation of quartz for this wave length? (b) What thickness of quartz is required to give an optical rotation of 10^o for light of 396.8nm?