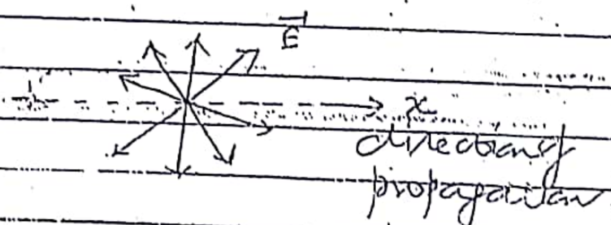
Ayush Jaglan

(UNIT-IV)

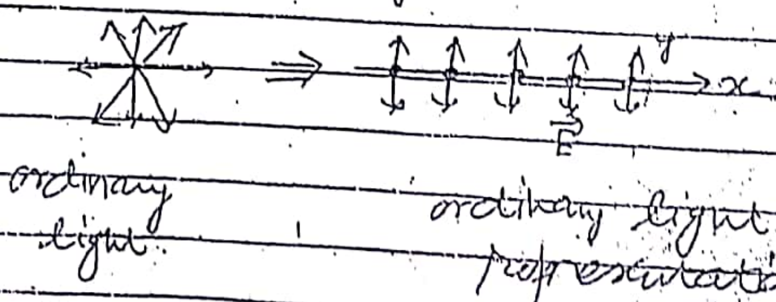
Polarisation of light →

According to Maxwell, Light is an electromagnetic wave. Electromagnetic wave consists of electric field vector and magnetic field vector which vibrate ⊥ to each other and both are also ⊥ to direction of propagation of light. But optical effects of light are due to electric field vibrations (E) only.

In an ordinary light beam, electric vector keeps on changing its direction in random manner.

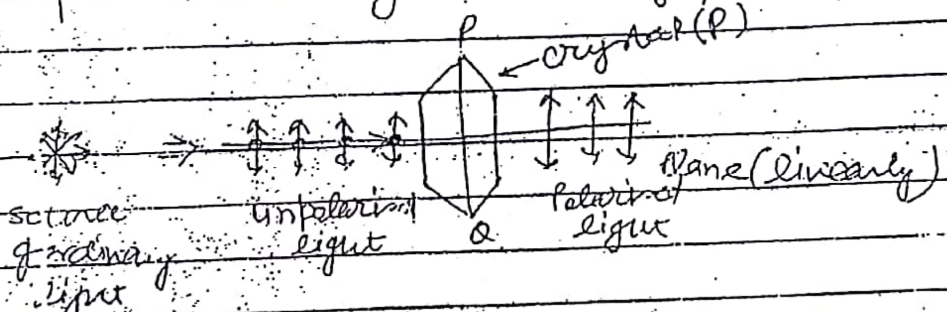


All these vibrations can be resolved into any two planes mutually ⊥ to each other. So a ray of ordinary light may be regarded as consisted of two sets of vibrations. One electric vector in plane of paper and other ⊥ to plane of paper. (Represented by ↕ and • respectively).



The phenomenon of restricting the vibrations of light waves in a particular direction in a plane ⊥ to direction of propagation is called polarisation of light.

If we take a crystal say tourmaline with its face cut ∥ to its crystallographic axis and ordinary light is incident on its one face then light vibrations of transmitted light are confined to one direction ∥ to PQ (crystallographic axis). The transmitted light is called Plane polarised light (linearly polarised light)



To verify whether this emergent light is plane polarised or not, take a second crystal A cut similarly and hold it in path of emergent beam so that its axis is ∥ to axis of crystal P. If we see through second crystal then light will be seen. Now when we rotate crystal A about the ray direction as axis, then emergent beam intensity through A will decrease. The intensity of emergent light through A will be zero when two crystal axis are ⊥ to each other which means light emitted from P is polarised.

Crystal P is called Polariser and A is called analyser.

Methods of Polarisation: →

Light can be polarised by any of the following methods:

(I) Polarisation by reflection.
(II) Polarisation by scattering.
(III) Polarisation by double refraction.

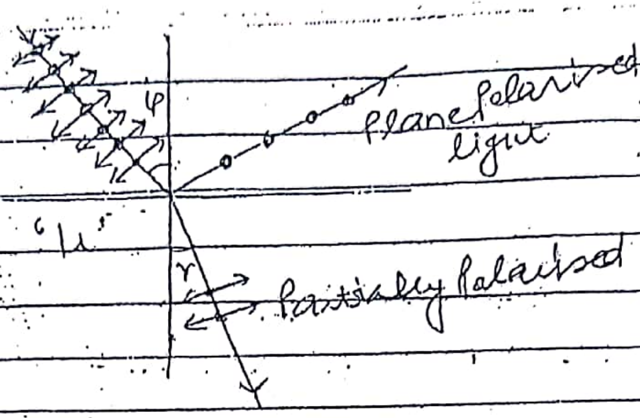
Polarisation by Reflection: →

It is the simplest method to produce plane polarised light. He showed that when a beam of ordinary light is reflected from the surface of a transparent medium like glass or water, the reflected light is partially polarised and degree of polarisation depends upon angle of incidence. At a certain angle i_p of incidence, reflected light is almost plane polarised. The angle of incidence i_p is called angle of polarisation.

For glass angle of polarisation is $57.5°$.

Brewster's law: → Acc. to this law tangent of angle of polarisation is numerically equal to ref. index μ of the refractive medium.

$$\boxed{\mu = \tan i_p}$$



from Snell's law

$$\mu = \frac{\sin i_p}{\sin r} \quad \text{---(I)}$$

from Brewster's law,

$$\mu = \tan i_p \quad \text{---(II)}$$

$$\Rightarrow \mu = \frac{\sin i_p}{\cos i_p} \quad \text{---(III)}$$

from (I) and (III)

$$\frac{\sin i_p}{\sin r} = \frac{\sin i_p}{\cos i_p}$$

$$\sin r = \sin(90 - i_p)$$

$$r = 90 - i_p$$

$$\boxed{r + i_p = 90^\circ}$$

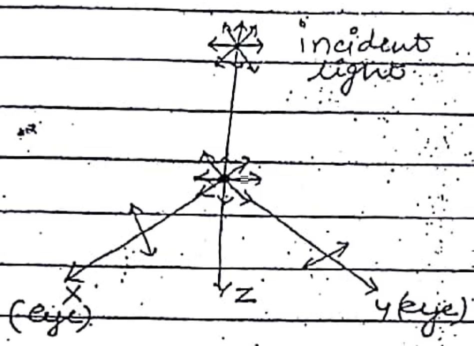
So at polarising incidence refracted and reflected rays are mutually ⊥ to each other.

Polarisation by Scattering:→

When a beam of white light passes through a medium consisting of small particles of about same size as the wavelength of light, the light seen in direction at rt. angles to incident beam.

appears bluish. This phenomenon is called Scattering of light.

Let us suppose that a beam of unpolarised light is incident on a scatterer along Z-axis.



If we look along x-axis then due to transverse nature of light vibrations must be ⊥ to x axis i.e ∥ to Y-axis.
Similarly if we look along Y axis, vibrations must be ∥ to x axis.
So we find that light scattered in a direction ⊥ to incident light is always plane polarised.

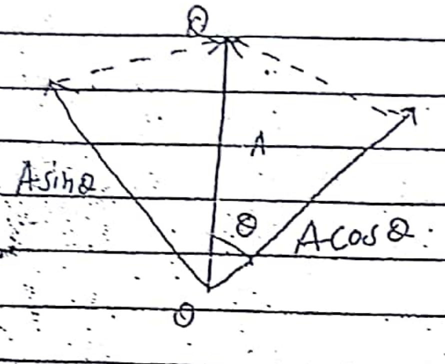
Law of Malus → Acc. to this law intensity of polarised light emitted from the analyser varies as the square of the cosine of the angle between the plane of transmission of analyser and plane of polariser. Let

A = amp. of vibrations transmitted by polariser

θ = angle between plane of polariser & analyser.

Divya Sharma

Resolve A into two components.
A cos θ ∥ to plane of transmission of analyser
A sin θ ⊥ to ,, ,, ,,



Only A cos θ is transmitted through the analyser.
Now Intensity of transmitted light through the analyser

$I \propto (A\cos\theta)^2$

$I \propto A^2\cos^2\theta \Rightarrow I = I_0\cos^2\theta$

$\boxed{I \propto \cos^2\theta}$

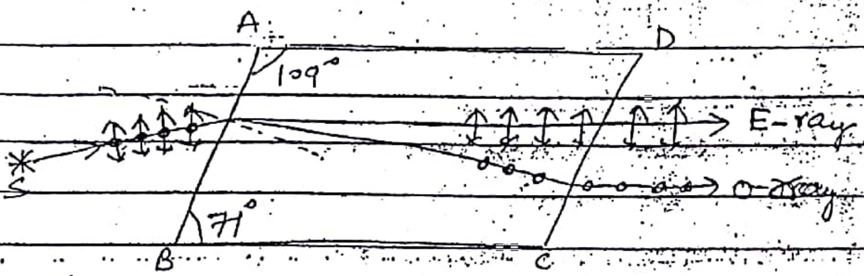
When $\theta = 0$ $\boxed{I = I_0}$

When $\theta = 90°$ = $\boxed{I = 0}$

So when plane of polariser and analyser are parallel, emitted intensity is maximum and no light emerges through analyser when plane of polariser is ⊥ to plane of analyser.

Double Refraction :-

In 1669 Scientist Erasmus Bartholinus observed that when a beam of unpolarised light is made to pass through a calcite or quartz crystal, two refracted beams are obtained. This phenomenon is called double refraction and crystals which exhibits this phenomenon are called doubly refracting crystals.



The phenomenon of double refraction can be observed very easily. If we view a dot marked on a sheet of paper through a calcite crystal, two images of dot are seen.

If we rotate the crystal about the incident ray as axis one image remains stationary, this image is called ordinary image and refracted ray which produces this image is called ordinary ray (o-ray), because these rays obeys the ordinary laws of refraction.

The other image rotates around the first image and is called extra-ordinary image and the refracted ray which produces this image is called E-ray (extra ordinary ray). This ray dont obey ordinary laws of Refraction.

Both O and E rays obtained by double refraction are plane polarised.
The vibrations of O rays are normal to plane of paper whereas those of E ray are in plane of paper.

The refractive index for ordinary ray is called ordinary ref. index (μ_o) and is constant.

$$\mu_o = \frac{c}{v_o} = \text{constant}$$

[∵ for O-ray $\mu_o = \frac{\sin i}{\sin r}$ = c]

Its value for a calcite crystal for Na light is 1.658.

The refractive index for extra ordinary ray is known as extra ordinary ref. index (μ_e). Its value is not constant but varies with direction of incident ray.
Now

$$\mu_e = \frac{c}{v_e} \neq \text{constant}$$

[∵ E-ray do not follow Snell's law ∴ $\mu_e = \frac{\sin i}{\sin r} \neq$ con]

Therefore velocity of extra ordinary ray is different in different direction and velocity of O ray in crystal is same in all directions.

— × — × — × — × —

Negative and Positive crystals →

(I) Negative crystals → are those in which refractive index for E ray is less than that for O-ray. i.e

$$\mu_E < \mu_O$$

in all directions in the crystal except along optic axis where $\mu_E = \mu_O$.
e.g Calcite and tourmaline.

(II) Positive crystals → are those in which refractive index for O ray is less than that for E-ray. i.e

$$\mu_O < \mu_E$$

in all directions except along optic axis when $\mu_E = \mu_O$.
e.g Quartz and ice.

Quarter wave plate and Half wave plate →

(I) Quarter wave plate →

It is a uniaxial doubly refracting crystal plate, cut with its optic axis parallel to refracting faces and having a thickness so as to produce a phase diff. of $\pi/2$ or a path difference of $\lambda/4$ between O and E rays.

If 't' is thickness of such a plate, then the distance travelled in plate is equivalent to $\mu_o t$ and $\mu_e t$ in air for O & E waves respectively.

path difference between O & E waves on emergence is $\mu_o t - \mu_e t$

If plate is to act as quarter wave plate then, this path difference should be equal to $\lambda/4$.

$$\Rightarrow \mu_o t - \mu_e t = \frac{\lambda}{4}$$

$$\Rightarrow \boxed{t = \frac{\lambda}{4(\mu_o - \mu_e)}}$$ for -ve crystal

For +ve crystal this relation becomes

$$\boxed{t = \frac{\lambda}{4(\mu_e - \mu_o)}}$$

When a plane polarised light is passed through a quarter wave plate, transmitted light in general is elliptical polarised light. However In a special case quarter wave plate can produce circularly polarised also.

Half wave plate:→

It is a uniaxial doubly refracting crystal plate cut with its optic axis ∥ to refracting faces & having a thickness so as to produce phase difference of π or path diff of $\lambda/2$ between O and E rays.

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(6)

If 't' is thickness of such a plate then distance travelled by light in plate is equivalent to $\mu_o t$ and $\mu_e t$ in air for O and E rays respectively.

So path difference between O and E waves on emerging through plate is, $\mu_o t - \mu_e t$

If the plate has to act as half wave plate, then this path difference should be equal to $\lambda/2$.

$$\Rightarrow \quad \mu_o t - \mu_e t = \frac{\lambda}{2}$$

$$\Rightarrow \quad \boxed{t = \frac{\lambda}{2(\mu_o - \mu_e)}} \quad \text{for -ve crystal}$$

Similarly for +ve crystal (where $\mu_e > \mu_o$)

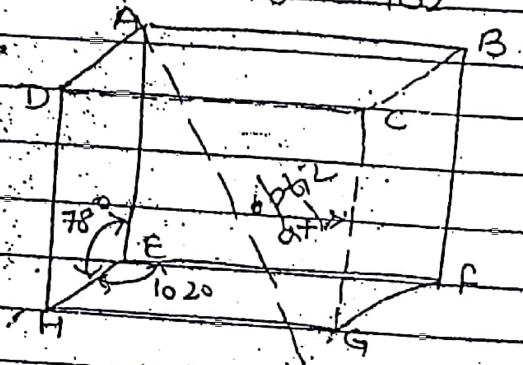
$$\boxed{t = \frac{\lambda}{2(\mu_e - \mu_o)}}$$

Since Quarter wave plate and half wave plates are used to introduce a given phase difference between O & E waves traveling through it so these plates are also called retardation plates.

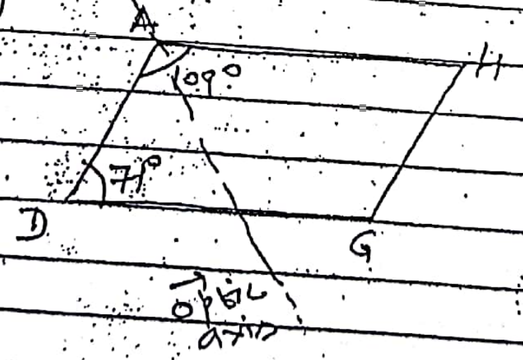
——— x ——— x ——— x ——— x ———

Calcite crystal →

A calcite crystal also known as iceland spar is transparent to visible as well as U.V light. It occurs in nature in different forms all of which break up into simple rhombohedron. Each of six faces of crystal is a parallelogram whose angles are 78° & 102°



A plane containing the optic axis and ⊥ to the two opposite refracting faces of the crystal is called principle section of the crystal. ADGH is principle section of this calcite crystal.
A principle section always cuts the surfaces of calcite crystal in a parallelogram having angle of 71° & 109°.



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Nicol prism :-

In 1828, William Nicol, made a prism called Nicol prism or Nicol. This prism is made up of calcite crystal in such a way that it eliminates one of the two rays i.e. O-ray or E-ray by using total internal reflection. it usually eliminates O-ray and transmits E-ray. Nicol prism can be used for producing and analysing plane polarized light. i.e as a polarizer and as an analyzer.

Construction :- To construct a Nicol prism a calcite rhombohedron having length three times its breadth is taken.

The end faces of this crystal are grounded so as to reduce the angle 71° of calcite to 68°. The crystal is then cut along the plane through the shorter diagonal. Then two cut faces are grounded and polished optically plane and cemented together by using a layer of Canada Balsam. Canada balsam is a transparent substance having value of its refractive index in between the values of ref. index for O and E-rays.

For Na light, ($\lambda = 5893 Å$),

$\mu_o = 1.66$, $\mu_{CB} = 1.55$, $\mu_e = 1.486$

The end faces of the prism are kept open and its sides are coated with lamp black and contained in metal tube.

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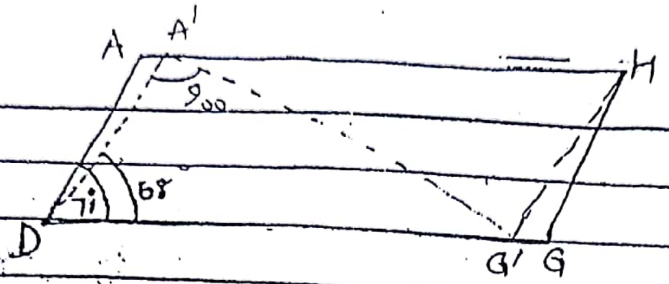
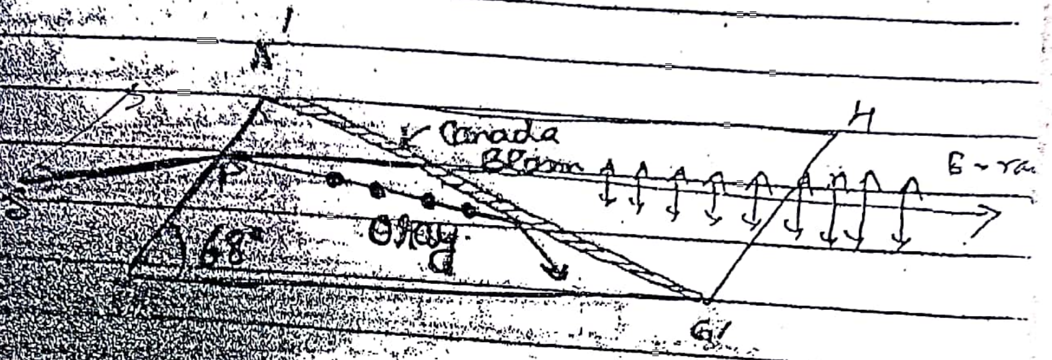




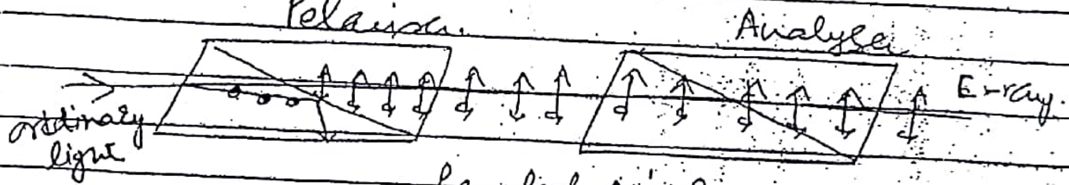
When a ray SP of unpolarised light is incident on one end face of Nicol then the ray is divided into O and E ray. The O ray as it travels from denser medium (calcite having $\mu_o = 1.66$) to a rarer medium (Canada balsam having $\mu_{CB} = 1.55$) will suffer total internal reflection, as the angle of incidence of this ray on layer of Canada balsam is more than critical angle $\theta_c = \sin^{-1}\frac{1.55}{1.69}$

This totally reflected ray is then absorbed by lamp black coating provided on the side of the prism. As the O-ray is eliminated, so we get beam of plane polarised light.

However, if the angle of incidence of O ray on the layer of Canada balsam is less than the critical angle of 69°, it can also be transmitted through the Nicol.

When two prisms (Nicol) are arranged coaxially, then prism P acts as polarizer and Nicol A acts as an analyser.

When two Nicols are similarly oriented i.e principle section of Analyser A is ∥ to that of polariser P, then the E-ray emerging from polariser is freely transmitted by the analyser.



Parallel Nicols

When the analyser is rotated by 90° from above position, then the principle sections of two Nicols become mutually ⊥. In this position, No light is transmitted by the combination & Nicols are said to be crossed.

— X — X — X —

Huygen's theory of double refraction:-

Acc to Huygen's theory,

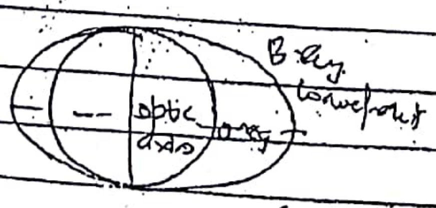
(I) When a wavefront of light strikes a doubly refracting crystal, every point of crystal becomes a source of two type of secondary wavelets, which results in (a) O-type wavefront corresponding to O rays. As O rays have same velocity in all directions, wavefront of O-rays is spherical.

(b) E-type wavefront corresponding to E rays. As E rays have different velocities in different directions, so wavefront of E rays is an ellipsoid of revolution.

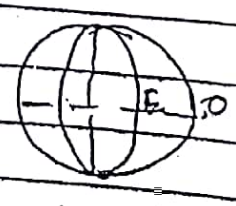
(II) The sphere and ellipsoid touch each other at the points which lie on optic axis of crystal. That's why velocity of E & O rays along optic axis is same.

(III) In -ve crystals E rays travels faster than O rays so the ellipsoid lies outside the sphere.

(IV) In +ve crystals O rays travels faster than E rays so sphere lies outside the ellipsoid.



-ve crystal



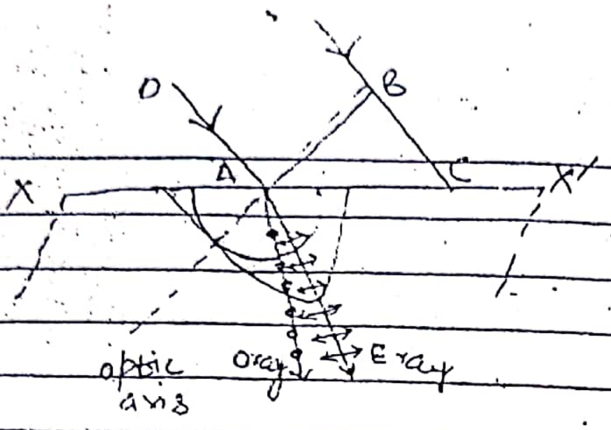
+ve crystal

Now the wavefront may strike the crystal's refracting surface in two ways:-

(I) Oblique incidence
(II) Normal incidence

(I) Oblique incidence →
Following three cases are possible):-
(a) optic axis lying in plane of incidence and lying inclined to refracting surface
(b) optic axis lying in plane of incidence and ⊥ to refracting surface
(c) optic axis lying in the plane of incidence and parallel to refracting surface

(a) → optic axis lying in plane of incidence and inclined to refracting surface →
let a plane wavefront AB strike obliquely on surface XX' of a calcite crystal. The optic axis of crystal lies in plane of incidence and inclined to surface XX'. When edge A of the wavefront strikes the surface the point A on the surface sends out two wavelets inside the crystal, one ordinary and other extra ordinary. Acc to Huygen's theory, ordinary wavefront is spherical and extraordinary wavefront is ellipsoid. As the calcite crystal is -ve, so sphere lies inside the ellipsoid.

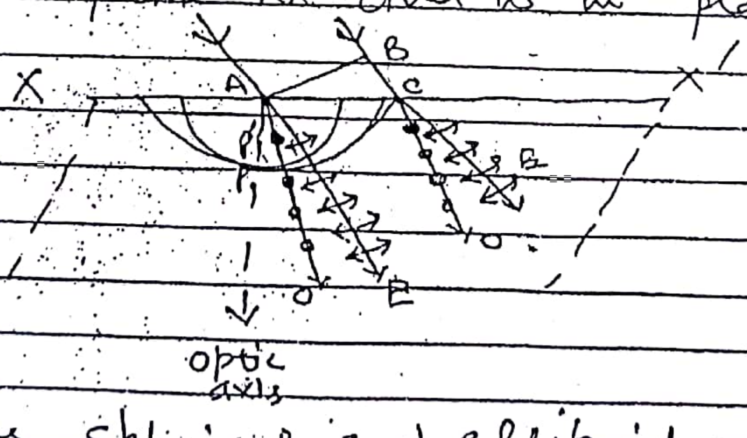


During the time $t = BC/V_a$, in which disturbance from B reaches point C, ordinary spherical wave acquires a radius equal to $t \times V_0 = \frac{BC}{V_a} \times V_0$

$= \frac{BC}{V_a/V_0} = \frac{BC}{\mu_0}$

where V_a = velocity of light in air
V_0 = velocity of ordinary ray
μ_0 = Ref. index of " "

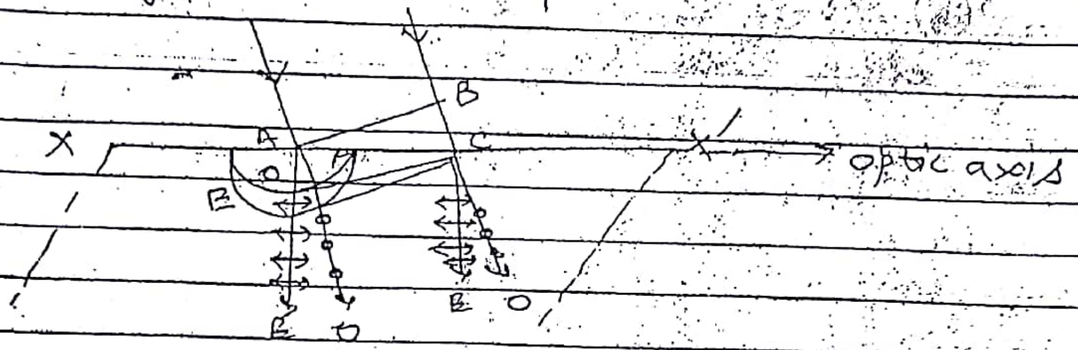
(b) → Optic axis lying in plane of incidence and ⊥ to the refracting surface. → AB is incident wavefront striking crystal XX' obliquely. optic axis is ⊥ to plane XX' and is in plane of incidence



The spherical and ellipsoid wavelets spread from pt. A touch other at pt. P on optic axis. $AP = AP' = BC/\mu_0$

(c) optic axis lying in the plane of incidence and paralled to refracting surface →

Let AB is incident wavefront on refracting surface XX' obliquely. The optic axis is in plane of incidence and parallel to XX'.

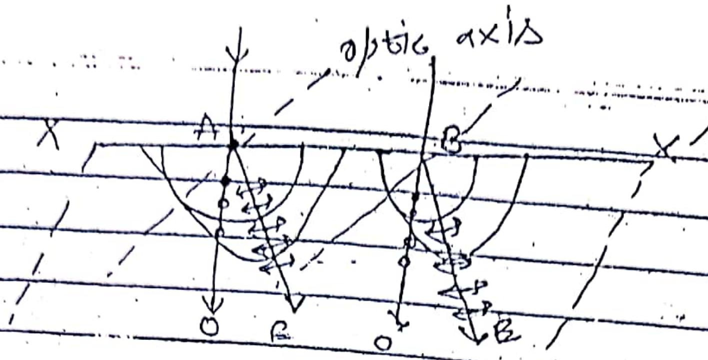


As optic axis is along XX' therefore sphere and ellipsoid touch each other on surface XX'.

(II) Normal incidence → Three cases arises

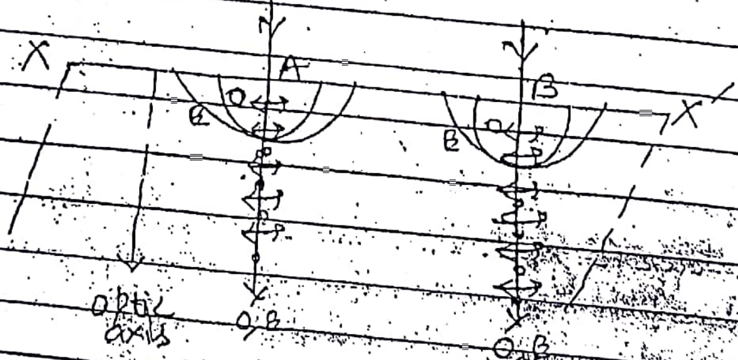
(a) optic axis lying in the plane of incidence and inclined to refracting surface of the crystal →
(b) optic axis lying in plane of incidence and ⊥ to refracting surface
(c) optic axis lying in plane of incidence & ∥ to refracting surface.

(a) → optic axis lying in plane of incidence and inclined to refracting surface
When a plane wavefront AB is incident normally on the refracting surface XX' of wavefront meets all the points on the crystal surface at the same time,

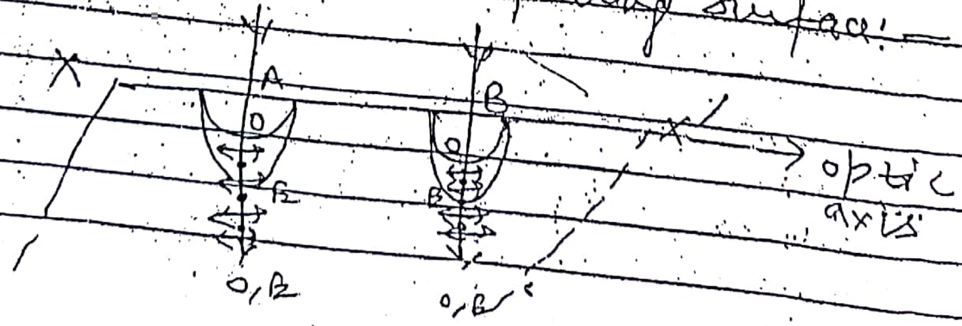


(b) optic axis lying in plane of incidence and ⊥ to the refracting surface:—

Let AB is the incident wavefront normally on refracting surface XX'. optic axis is in plane of incidence and ⊥ to refracting surface XX'. The spherical and ellipsoidal wavefronts coincide and travel in same direction with same velocity. Therefore there is no double refraction in this case.

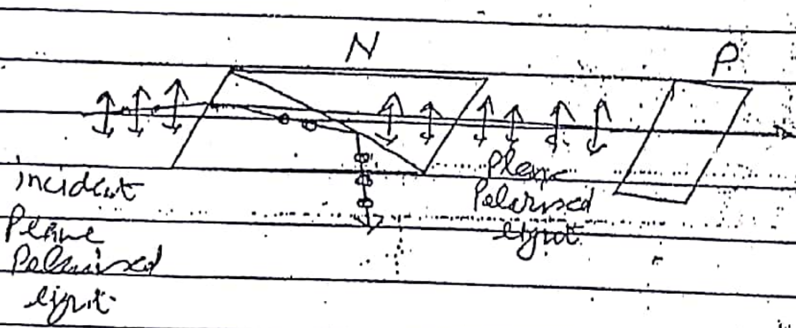


(c) optic axis lying in plane of incidence and parallel to refracting surface:—



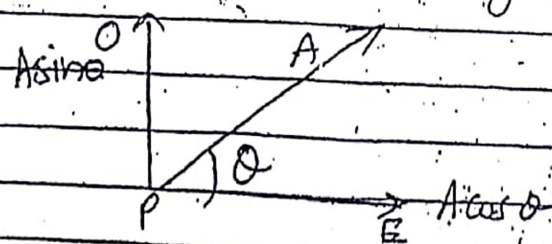
Elliptically & Circularly polarised light :→

Let a beam of monochromatic light be made to incident on a Nicol prism. The light transmitted by Nicol prism is plane polarised. Let this plane polarised light be incident normally on uniaxial doubly refracting crystal P. The vibrations of this plane polarised light should be inclined to optic axis at angle θ.



The plane polarised light incident on the crystal is splitted into O & E rays which travel along same direction with different velocities. After travelling a path 'd' in the crystal a phase diff of 'δ' is introduced between O and E ray.

Theory :→ Let A = Amp. of plane polarised light incident on crystal.



$x = A\cos\theta \sin(\omega t + \delta)$ for E ray

$y = A\sin\theta \sin\omega t$ for O ray let $A\cos\theta = a$, $A\sin\theta = b$

$$\Rightarrow x = a\sin(\omega t + \delta) \quad \text{--- (I)}$$

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

from (II), $\sin\omega t = \frac{y}{b} \Rightarrow \cos\omega t = \sqrt{1-\sin^2\omega t}$

$$\Rightarrow \cos\omega t = \sqrt{1-\frac{y^2}{b^2}}$$

from (I)

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

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

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

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

Squaring both sides

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

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

This eqn represents a general ellipse

Special Cases: (I) When the thickness of the plate is such that the phase difference introduced by it in O & E rays is integral multiple of 2π, i.e. $\delta = 2n\pi$, $n = 0, 1, 2 \ldots$

Then eqn (III) becomes,

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} - \frac{2xy}{ab} = 0 \Rightarrow \left(\frac{x}{a} - \frac{y}{b}\right)^2 = 0$$

$\Rightarrow$ $\boxed{y = \left(\frac{b}{a}\right)x}$ = $\boxed{y = \tan\theta\, x}$ $\left[\frac{b}{a} = \tan\theta = \text{slope}\right.$

which represents a st. line, which is same as that of incident plane polarised light.

Case (II) When thickness of crystal is such that phase difference introduced by it in O & E rays is $\delta = (2n+1)\pi/2$, $n = 0, 1, ----$

So eqn (III) becomes

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1 \quad \text{—— (IV)}$$

If $a \neq b$ i.e. $\frac{b}{a} = \tan\theta$ (slope) $\neq 1$

or $\theta \neq 45^\circ$

eqn (IV) represents ellipse so emergent light in this case is called elliptically polarised.

If $a = b \Rightarrow \frac{b}{a} = \tan\theta = 1 \Rightarrow \theta = 45^\circ$

eqn (IV) becomes

$$\boxed{x^2 + y^2 = a^2}$$

which is eqn of circle. So emergent light in this case is circularly polarised.

Detection of Plane, circularly & elliptically polarised light: →

(I) Plane polarised light → When a beam of plane polarised light is made to pass through a Nicol prism, which is capable of

$\Rightarrow$ $\boxed{y = \left(\frac{b}{a}\right)x}$ = $\boxed{y = \tan\theta\, x}$ $\left[\frac{b}{a} = \tan\theta = \text{slope}\right]$

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or $\theta \neq 45°$

eqn (IV) represents ellipse so emergent light in this case is called elliptically polarised.

If $a = b \Rightarrow \frac{b}{a} = \tan\theta = 1 \Rightarrow \theta = 45°$

eqn (IV) becomes

$$\boxed{x^2 + y^2 = a^2}$$

which is eqn of circle. So emergent light in this case is circularly polarised.

Detection of Plane, circularly & elliptically polarised light $\rightarrow$

(I) Plane polarised light $\rightarrow$ When a beam of plane polarised light is made to pass through a Nicol prism, which is capable of

(13)

Detection of plane, circularly and Elliptically polarised light

(i) Plane polarised light →

The light beam under investigation is allowed to fall on a Nicol prism capable of rotation about the incident beam as axis. If the beam is completely extinguished twice in each complete rotation, it is plane polarised light. It is so because when direction of vibration is parallel to principle section of Nicol, the beam will pass through it and if the direction of vibration of incident beam is perpendicular to principle section of Nicol, the beam will be cut off.

(ii) Circularly polarised light →

When a beam of circularly polarised light is seen through a Nicol prism, which is rotated about the direction of incident light as axis, no variation in intensity of emergent light is observed. This is because for every position of Nicol, circular vibrations of incident light inside Nicol split up into two rectangular components of equal amplitude having vibrations parallel and ⊥ to principle section of Nicol. But if the light is unpolarised, even then no variation in intensity is seen.

Therefore to differentiate between unpolarised and circularly polarised light, allow the light to fall normally on a quarter wave plate and then examine it through Nicol prism. If intensity varies between maximum and zero, it is circularly polarised light.

ii) Elliptically polarised light:—

When a beam of elliptically polarised light is examined through a rotating Nicol prism, its intensity varies in magnitude but is never zero. It is because an elliptic vibration consist of a combination of two unequal vibrations in two directions ⊥ to each other along major and minor axis of ellipse. When principle plane of Nicol is parallel to vibration along major axis, transmitted light has max. intensity and when the principle plane is parallel to vibration along minor axis, transmitted light has minimum intensity.

Polarimeters:—

These are the instruments used to measure angle of rotation of plane polarised light passed through optical active substances. A polarimeter can be used to determine the specific rotation of sugar solution or if specific rotation is known, it can be used to determine conc. of solution also.

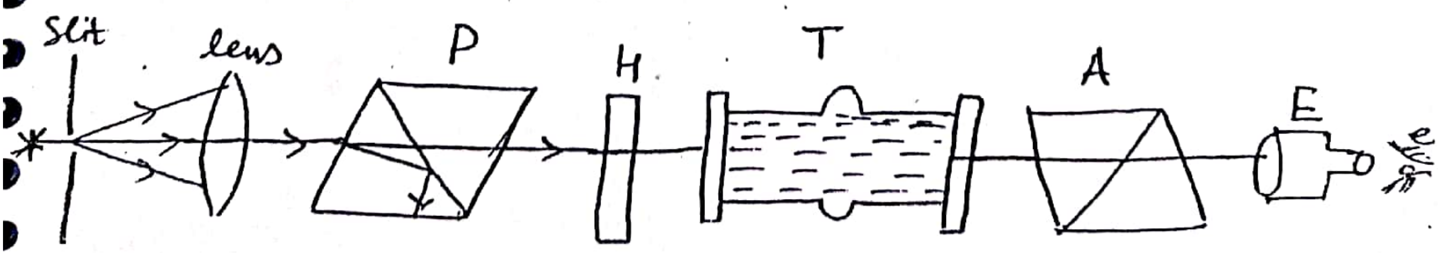
Two forms of polarimeters are:-

(i) Laurent's half shade polarimeter

(ii) Biquartz polarimeter

(i) Laurent half shade polarimeter:—

Construction:— It consists of two Nicol prisms P and A mounted in a brass tubes placed some distance apart and capable of rotation about a common axis. H is a half shade device, which divides the field of polarised light emerging out of Nicol P into two parts generally of unequal brightness. T is a glass tube with round ends and contains optically active solution. This tube is placed in between two Nicols. S is a source of monochromatic light via Sodium lamp. The analysing Nicol A can be rotated about the axis of tube and its rotation can be measured on a circular scale 'C'. The emergent light is viewed with help of telescope E.



(15)

Working:→ For instance let us suppose that half shade device H is not present. The position of analyser A is adjusted so that the field of view is completely dark when tube T is empty. In this position analyser is crossed with respect to polariser. The reading of A is taken on a circular scale C. The tube T is then filled with required solution and placed in position. This solution rotates the plane of polarisation of light coming from P through some angle θ, such that now light is transmitted by A. Thus the field view is again illuminated. Now analyser A is rotated until field of view becomes dark and its reading is noted on circular scale C. This will happen, when A has been rotated through an angle θ in the direction optical rotation produced. Difference of reading of two positions of A noted on scale gives rotation of plane of polarisation.

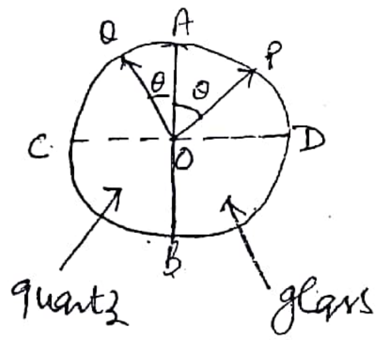
It is found that when analyser A is rotated the total darkness of field of view is attained gradual and hence it is difficult to find the exact position correctly for which complete darkness is achieved. To avoid this difficulty, Laurent invented a device called Half shade device.

Half shade device:→ It consists of semi circular plate AE of glass cemented to a semi circular plate ACB of quartz. The thickness of glass plate is such that it introduces a phase difference of π between O and E vibrations. So quartz then acts as half wave plate. The thickness of glass plate is

(15)

such that it can absorb the same amount of light as is done by quartz plate.

To understand its working, let us suppose that light after passing through polariser P is incident normally on ½ shade plate and has vibration along OP. On passing through glass half vibration will remain along OP, but on passing through quartz half, these will be split up into E and O component. The vibrations of O component are along OD and those of E component are along OA.



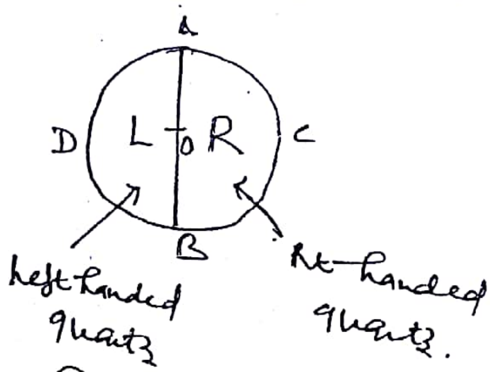
On passing through quartz plate, a phase difference of π is introduced between two vibrations. The O vibrations will advance in phase by π and will occur along OC instead of OD [due to π diff]. If analysing Nicol is fixed with its principle plane parallel to OP, plane polarised light through glass half will pass, hence it will appear brighter than quartz half from which light is partially obstructed. If principle plane of analysing Nicol is parallel to OQ, quartz half will appear brighter than glass half. However when principle plane of analysing Nicol is parallel to AOB, two halves will appear equally bright. When principle plane of analyser is at rt angle to AOB, then two half will be equally dark.

The eye can easily detect a slight change when two-half are equally dark. So [illegible]

(iii) Biquartz polarimeter: →

Construction: — Same as Half Shade polarimeter, except the half shade device is replaced by Biquartz plate.

Working: → A biquartz plate consist of two semicircular pieces ACB and ADB of right handed and left handed quartz cut with their optic axis ~~parallel~~ perpendicular to refracting surfaces (faces). They are cemented together to form a complete circular plate.



The thickness of each half plate is about 3.75 mm which is such that each rotates the plane of polarisation of yellow light through 90°, one anticlockwise and other clockwise. This biquartz plate is placed just behind polarising Nicol.

When light from a monochromatic source is plane polarized by polariser P and is passed through each half of biquartz plate, it is rotated through same angle in each half but in opposite sense. On turning the analyser its position can be adjusted, when two half of biquartz are equally dark.

When monochromatic light is replaced by white light rendered plane polarised by polariser, passes through biquartz, its different colour will be rotated through different angles in each half, but in opposite senses. For yellow light, this rotation is about 90°.

Therefore, if vibrations in incident light are along AOB, then after passing through the biquartz, vibrations of yellow light are along a direction ⊥ to AB. The vibrations of red, green and violet colour are along different directions. This phenomenon of splitting the vibrations of different colour in diff directions is called rotatory dispersion. Thus if plane of analysing Nicol is parallel to AOB, yellow colour will be extinguished in both halves of field and other colour will be present in same proportion in each half. Then two halves of field will be equally illuminated with a greyish violet tint called tint of passage. So position of tint of passage in a biquartz polarimeter is used in place of position of equal brightness of two halves in half shade polarimeter.

Comparison between Half shade & Biquartz polarimeter

① Colour blind persons cannot work with biquartz polarimeter. Moreover colour sensitivity of eye varies from person to person, so different persons with normal vision will get different results.

② If substance whose optical activity is to be measured is coloured it is difficult to adjust analyser accurately for position for which tint in both halves is same.