POLARIZATION

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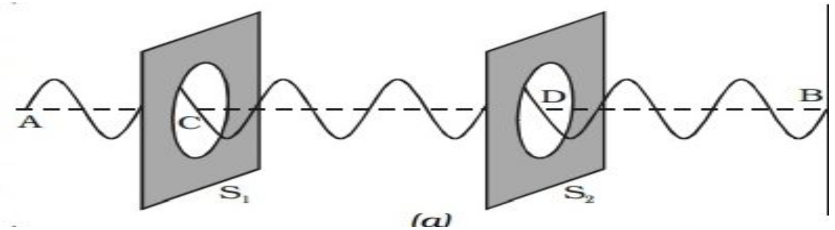
POLARIZATION

The phenomenon of Interference and diffraction tells that light is a form of wave motion . But these phenomena do not reveal the character of its wave motion i.e whether it is longitudinal or transverse.

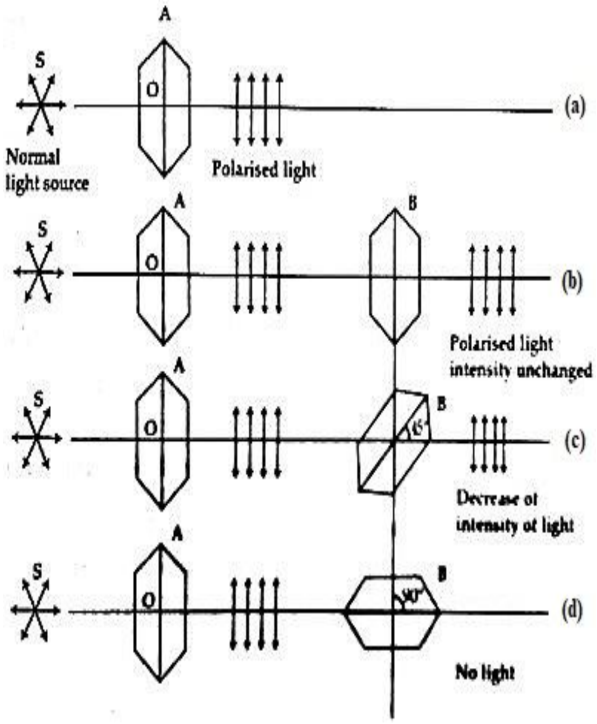
Polarization of Transverse waves: Consider a rope or a spring passing through two parallel slits S_1 and S_2, with one end fixed to a point B as shown in the figure. The other end is move up and down to produce a Transverse waves. When two slits are parallel , the wave emerges out of the 2nd slit. But when the 2nd slit is ⊥lr to 1st slit , the wave doesn't emerge from the 2nd slit.



If the spring is compressed and released longitudinal waves are produced . These waves emerges out of the 2nd slit when the slits are parallel or ⊥lr to each other . This experiment shows that Transverse wave cannot emerge from the 2nd slit when the slits are ⊥lr to each other i.e the Transverse wave between the two slits is effected by the rotation of the slit i.e it is unsymmetrical about direction . The wave which is unsymmetrical about direction is called a <u>polarised wave</u> while the wave which is symmetrical is called <u>unpolarised wave</u> .

Polarization of light waves

- Two tourmaline crystals are placed so that their optic axis are parallel to each other. A beam of light is incident normally on the crystal A .
- When the axis of two crystals A and B are parallel the intensity of the emerging light is maximum.
- Keeping one crystal fixed, and other is rotated . The intensity gradually decreases.
- When the two optic axes are ⊥lr the intensity of emerging light is zero.
- This experiment shows that light waves are Transverse waves.



Plane Of Polarization :

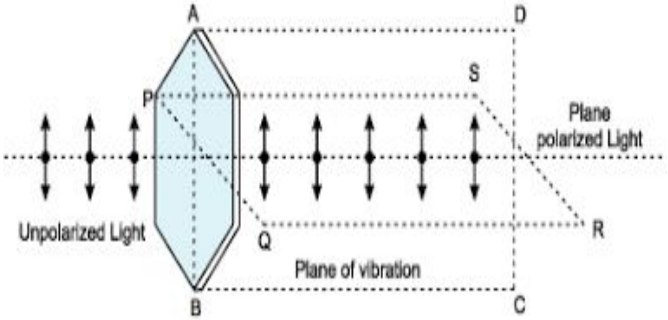
The Plane of Polarization is that plane

in which no vibration occur.

Plane Of Vibration :

The plane in which vibrations occur

is known as Plane of Vibration

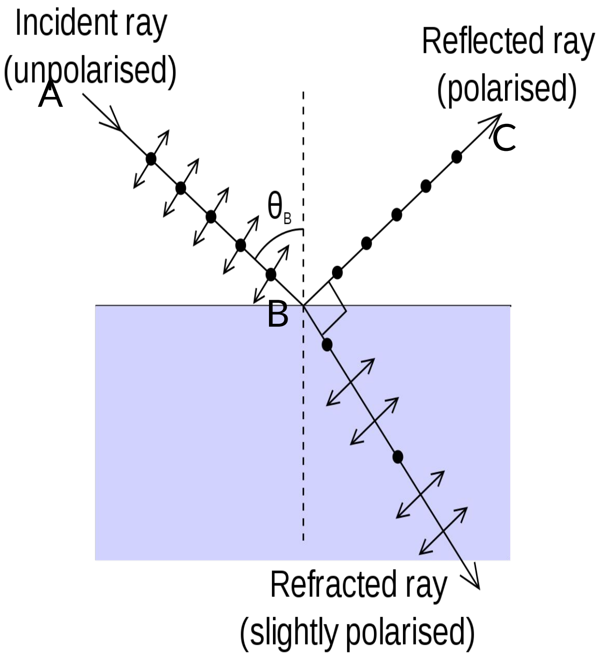


The Plane of Vibration and the Plane of Polarization are ⊥lr to each other.

Polarized Light by Reflection

Polarization of light by reflection from the glass was discovered by MA .

Consider the light incident along the path AB on the glass surface . Light is reflected along BC , place a Tourmaline crystal and rotate it slowly . It will be observed that light is completely extinguished (absent) only at one one particular angle of incidence. When the light is incident on the glass plate of angle 57.5° , then the reflected light is plane polarized .The angle of incidence for which the reflected light is plane polarized is called <u>polarising angle</u>. This angle changes from medium to medium.



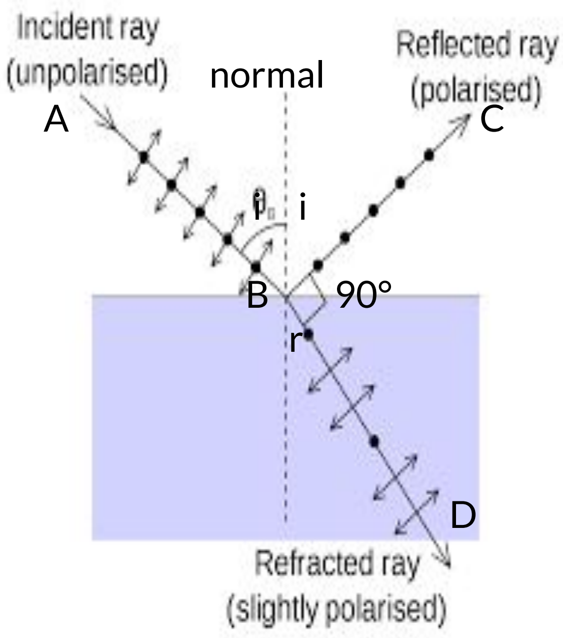
Brewster’s Law:

Brewster's law states that the tangent of the polarizing angle is numerically equal to the refractive index of the medium.

$$\therefore \ \mu = \tan p$$

where **μ** is the refractive index and **p** is the polarising angle.

Suppose an unpolarized light is incident at an angle equal to the polarising angle (i = p) on the glass surface of refractive index **μ .** It is reflected along BC and refracted along BD.



According to SNELL'S Law of Reflection

$$\mu = \sin i \,/\, \sin r \quad \text{----------} \quad (1)$$

where r is the angle of reflection

According to Brewster's law , $\mu = \tan p = \tan i$ ($\because i = p$)

$$\Rightarrow \quad \mu = \sin i \,/\, \cos i \quad \text{-----------} \quad (2)$$

from (1) and (2) $\cos i = \sin r$

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

$$\Rightarrow \quad 90 - i = r$$

$$\Rightarrow \quad i + r = 90 \qquad \therefore \text{angle CBD} = 90$$

This means , at the polarising angle , the reflected ray and refracted ray are ⊥lr to each other

MALUS LAW:

The law of Malus states that when a completely plane polarized light is incident on the analyser, the intensity of polarised light transmitted through the analyser varies as the square of the cosine of the angle between the plane of transmission of the analyser and plane of the polariser.

Let OP = a be the amplitude of vibration and ‘θ’ is the angle between the planes of polariser and analyser . The amplitude of the incident plane polarised light can be resolved into two components. **1)** acosθ along OA **2)** asinθ along OB.

Only acosθ is transmitted through the analyser. Therefore intensity of light transmitted through the analyser.

$I_0 = (a\cos\theta)^2$ since $I = a^2$

$$I_0 = a^2 \cos^2\theta$$

But $I = a^2$ where I is the intensity of incident polarised light

$$\therefore\ I_0 = I\cos^2\theta$$

$$\mathbf{I_0 \propto \cos^2\theta}$$

This is Malus Law.

Case (1) : When $\theta = 0$, i.e two planes are parallel

$$\cos\theta = 1$$

then $I_0 = I$

Case (2) : When $\theta = \Pi / 2$,the two planes are ⊥lr

$$\cos \Pi/2 = 0$$

$$I_0 = 0$$