Polarization of light by reflection : Brewster's law

In 1808, a French engineer E.L. Malus discovered polarization of light by reflection. He observed that when natural light i.e. unpolarized light is incident on a smooth surface at a certain angle then the reflected light is completely plane polarized. The degree of polarization of reflected light depends upon angle of incidence and material of smooth surface upon which unpolarized light is incident.

When unpolarized light wave is incident on a separating plane of two dielectric media then a part of incident light is reflected and remaining part is transmitted (refracted). Reflected and refracted light both are partially polarized as shown in fig-1. Refracted light is always partially polarized but degree of polarization of reflected light depends upon angle of incidence for two given dielectric media. In shown fig-1. the incident light AO and normal NON' define the plane of incidence. The electric field vector $\vec{E}$ of the incident light AO is resolved into two components. One component perpendicular to the plane of incidence is represented by dots and it is known as s-component and second component parallel to the plane of incidence is represented by arrows and it is known as p-component. In the case of completely

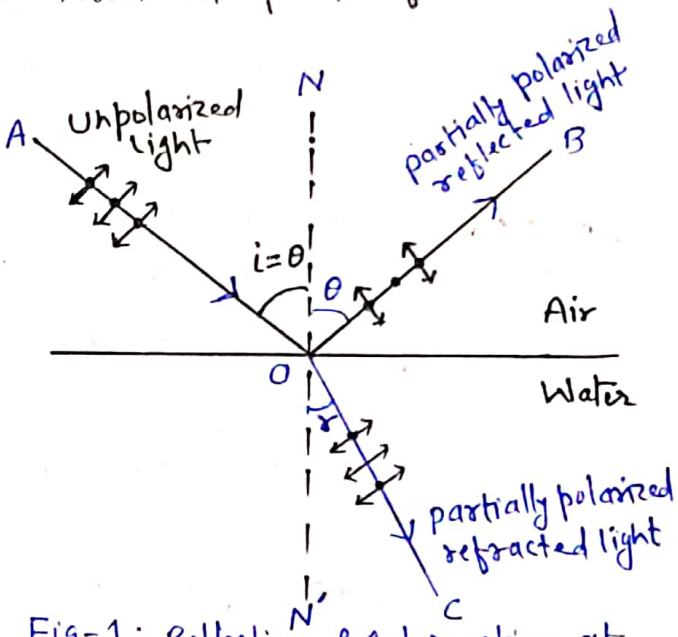

Fig-1 : Reflection & Refraction at separating plane of two media

unpolarized light, the two components s and p are of equal magnitudes. At particular angle of incidence $i = \theta_B$ or i_p, the reflection coefficient for p-component becomes zero. i.e, the reflected beam does not contain any p-component. The reflected beam contains only s-component i.e, the reflected light beam is completely plane polarized as shown in fig-2.

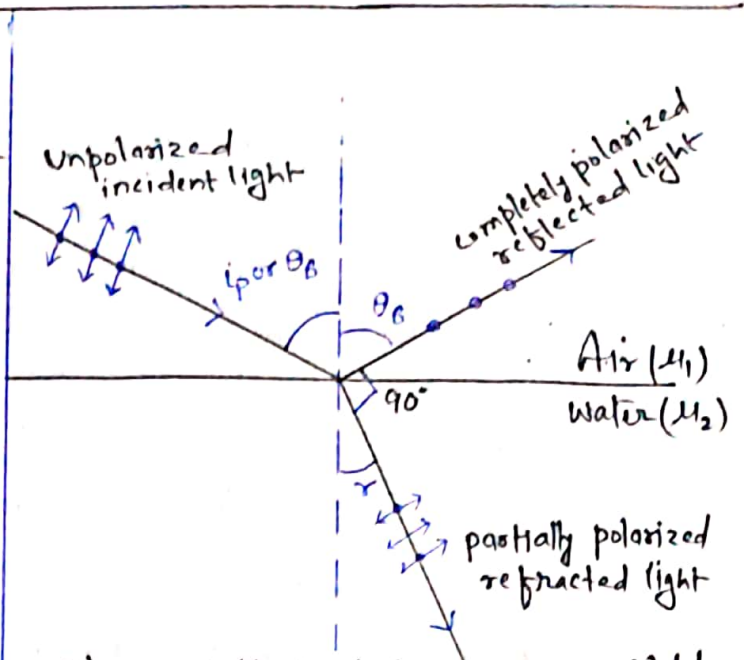

Fig-2: Reflected light is completely polarized - Brewster's law.

The angle of incidence θ_B or i_p at which the reflected light beam becomes completely plane polarized, is known as Brewster angle or polarizing angle. This particular method for polarizing light is not advantageous because intensity of reflected light beam is very small.

Sir David Brewster performed a series of experiments on polarization of light by reflection. He found that polarizing angle depends upon the refractive indices of the two media. In 1892, Brewster showed that the reflected light becomes completely polarized when reflected light is perpendicular to the refracted light as shown in fig-2.

From fig-2, $\theta_B + r = 90^\circ \Rightarrow r = 90^\circ - \theta_B$ and $i = \theta_B$

From Snell's law, $\frac{\sin i}{\sin r} = {}_1\mu_2 = \frac{\mu_2}{\mu_1}$

$$\Rightarrow \frac{\sin\theta_B}{\sin(90^\circ - \theta_B)} = {}_1\mu_2 \Rightarrow \frac{\sin\theta_B}{\cos\theta_B} = {}_1\mu_2 \Rightarrow \boxed{\tan\theta_B = {}_1\mu_2}$$

Therefore, tangent of Brewster angle (polarizing angle) is equal to refractive index of the second medium with respect to the first medium. It is known as Brewster's law.

Application of Brewster's law:- ① Brewster's law can be used to determine refractive index of the medium.

② Brewster's law can be used to determine polarizing angle for total polarization of reflected light if refractive index of the medium be known.