DEPARTMENT OF PHYSICS AND NANOTECHNOLOGY
SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

18PYB101J -Electromagnetic Theory, Quantum Mechanics, Waves and Optics

Module-IV (Waves and Optics) Lecture-14

Brewster's angle

Brewster's angle

Sir David Brewster performed a series of experiments on the polarization of light by reflection at a number of surfaces. He found that the polarizing angle depends upon the refractive index of the medium. In 1892, Brewster proved that **the tangent of the angle at which polarization is obtained by reflection is numerically equal to the refractive index of the medium.** If θ_B is the angle and m is the refractive index of the medium, then

$$\mu = \tan\theta_B \qquad \ldots (20.3)$$

This is known as Brewster's law.

If natural light is incident on a smooth surface at the polarizing angle, it is reflected along *BC* and refracted along *BD*, as shown in Fig.20.14 (*b*). Brewster found that the maximum polarization of reflected ray occurs when it is at right angles to the refracted ray. It means that $\theta_B + r = 90^\circ$.

$$\therefore \quad r = 90^\circ - \theta_B \qquad \ldots (20.4)$$

According to Snell's law,

$$\frac{\sin\theta_B}{\sin r} = \frac{\mu_2}{\mu_1} \qquad \ldots (20.5)$$

where μ_2 is the absolute refractive index of reflecting surface and μ_1 is the refractive index of the surrounding medium. It follows from equ.(20.4) and equ.(20.5) that

Brewster's angle

$$\frac{\sin\theta_B}{\sin(90^\circ - \theta_B)} = \frac{\mu_2}{\mu_1}$$

or

$$\frac{\sin\theta_B}{\cos\theta_B} = \frac{\mu_2}{\mu_1}$$

$\therefore$

$$\tan\theta_B = \frac{\mu_2}{\mu_1} \qquad \text{... (20.6)}$$

Equ.(20.6) shows that the polarizing angle depends on the refractive index of the reflecting surface. The polarizing angle q_B is known as **Brewster angle**. Light reflected from any angle other than Brewster angle is partially polarized.

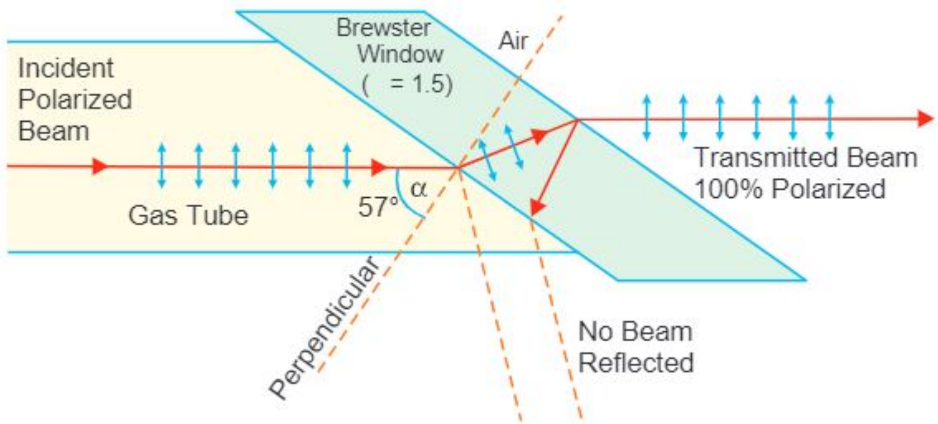
Application of Brewster's law:

(*i*) Brewster's law can be used to determine the refractive indices of opaque materials.

(*ii*) It helps us in calculating the polarizing angle necessary for total polarization of reflected light for any material if its refractive index is known. However, the law is not applicable for metallic surfaces.

Brewster's angle

(*iii*) In gas lasers it is common to arrange two glass windows at the two ends of the laser tube. The windows are arranged at Brewster angle to the axis of the laser tube and hence they are called **Brewster windows**. The light beam traveling between the mirrors of the laser is reflected many times from these mirrors. Since the mirrors are at Brewster angle, all the light that is polarized perpendicular to the beam plane is emitted out of the laser cavity at early stage. In the gas tube remains only radiation polarized in the beam plane. The advantage of this arrangement is that the beam has no reflection losses, since only the transmitted polarized beam is traveling between the mirrors. The radiation out of these lasers is polarized as can be seen in Fig.20.15.



Brewster angle window at the end of gas laser

Fig. 20.15

(*iv*) Another application utilises the Brewster angle for transmitting a light beam into or out of an optical fibre without reflection losses.