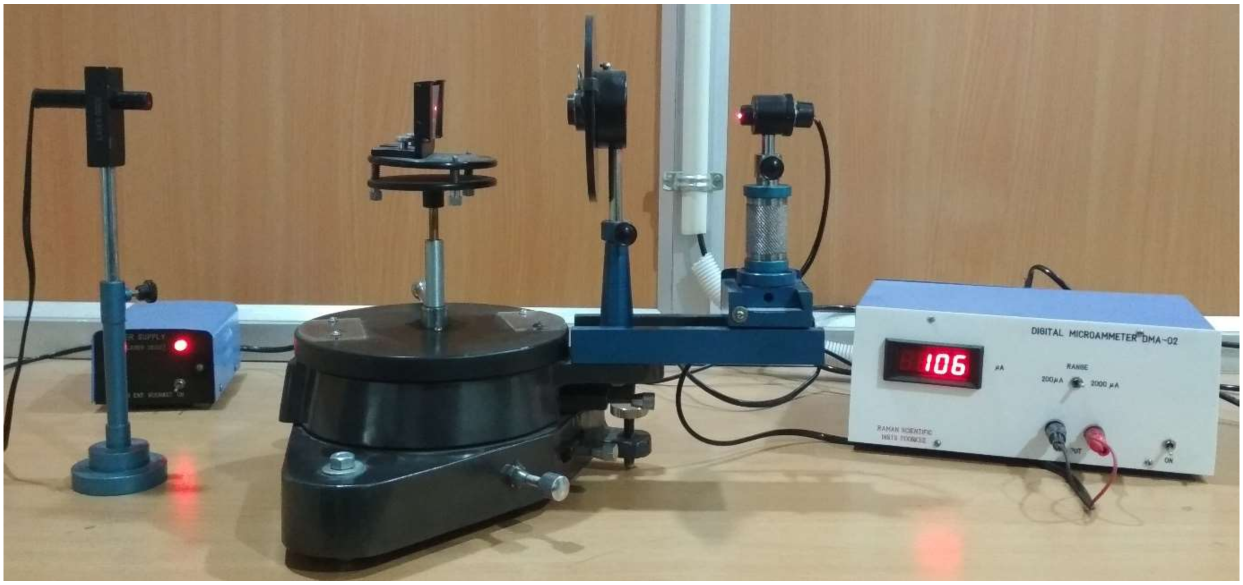
Experiment No. 12

Brewster's Angle



Aim :
To determine the of Brewster's angle for glass using a polarized monochromatic light source.

Apparatus Required:

He laser, dial fitted polarizer, photo detector, micro ammeter, rotational mount, glass plate, constant power supply .

Formula Used : Brewsters angle for a given pair of medium is

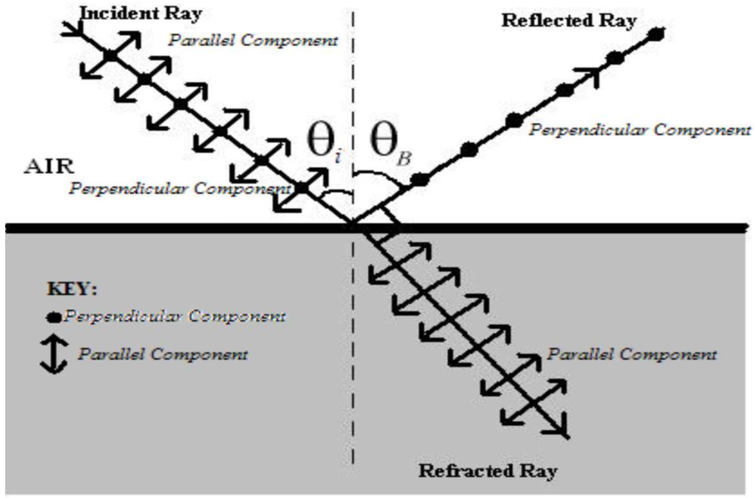
$$\theta_B = \theta_i = tan^{-1}(\frac{n_2}{n_1})$$

Where n_1 and n_2 are refractive index of medium 1 and 2 respectively

Principle:

When light moves between two media of differing refractive index (n), some of the light is reflected from the surface of the denser material. This reflected ray's intensity changes with change in the incident angle (θ_i) at the interface of two mediums. At one specific angle of incidence of light only perpendicular vibrations of electric field vectors are reflected whereas parallel vibrations are restricted or polarized. This loss in light intensity is due to polarization by reflection and the angle of incidence for which reflected ray is polarized is called the Brewster's angle θ_B (also known as the Polarization angle). This phenomenon of polarization by reflection is illustrated in the figure below.

Figure1. Polarization by reflection and Brewster's angle (θ_B)



Polarization By Reflection

The fraction of the incident light that is reflected depends on both the angle of incidence and the polarization direction of the incident light. The functions that describe the reflection of light polarized parallel and perpendicular to the plane of incidence are called the Fresnel Equations. According to the Fresnel Law when light moves from a medium of a given refractive index (n_1) into a second medium with refractive index (n_2), both reflection and refraction of the light may occur. This can be explained with the aid of a diagram, as shown in figure 2 below:

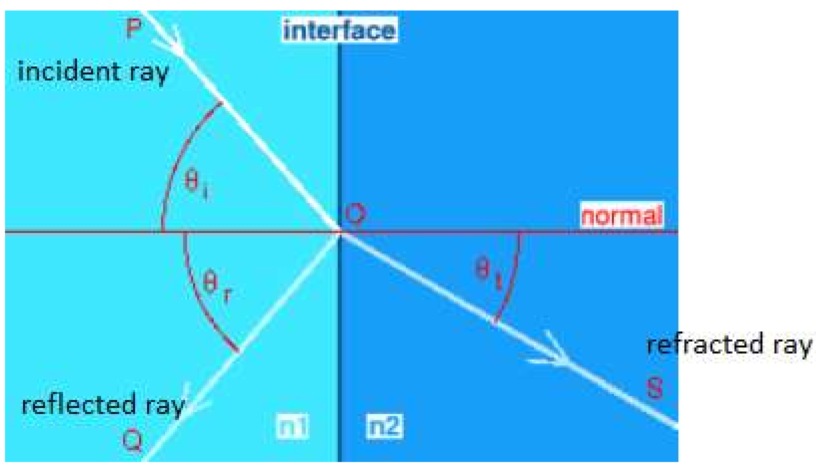


Figure 2.

__Illustration of Fresnel's Law:__

The incident light ray **PO** strikes at point **O** the interface between two media of refractive indexes n_1 and n_2. Part of the ray is reflected as ray **OQ** and part refracted as ray **OS**. The angles that the incident, reflected and refracted rays make to the normal of the interface are given as θ_i, θ_r and θ_t , respectively. The relationship between these angles is given by the law of reflection also called Snell's law:

$$n_1 \sin\theta_i = n_2 \sin\theta_t$$

At Brewster's angle, the reflected and refracted ray are perpendicular to each other (the angle of 90º indicates the reflected light is completely polarized parallel to the interface). Therefore the sum of $\theta_r + \theta_t$= 90º (Refer to figure 2).

Or θ_t = 90º - $\theta_r = 90^o - \theta_i$. Incorporating this fact into Snell's Law and rearranging it, we get:

$$n_1 \sin\theta_i = n_2 \cos\theta_i$$

Which implies that, $\tan\theta_i = n_2 / n_1$

This angle θ_i in fact gives the value for Brewster's angle therefore on final rearrangements we get the final equation to be :

$$\theta_B = \theta_i = \tan^{-1}(\frac{n_2}{n_1})$$

It is important to note that the perpendicular component of polarization is almost always reflected more strongly than the parallel component (see figure 3). Figure 3 also shows that for one angle of incidence, called Brewster's angle, none of the parallel polarization is reflected.

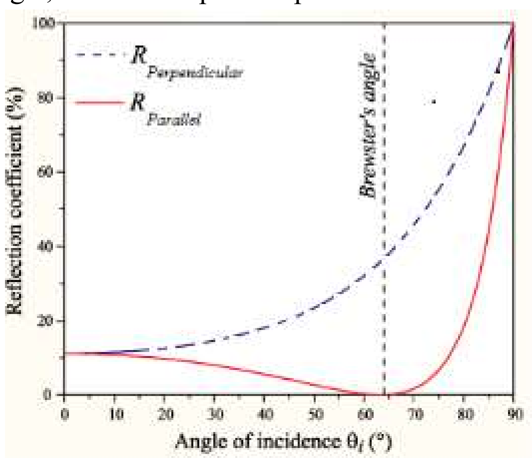


Figure 3. Components of polarization, parallel and perpendicular to the plane of incidence

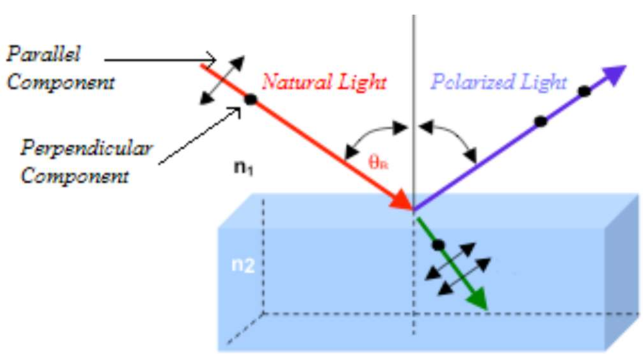


Figure 4. Polarization of natural light

PROCEDURE :

1. Set up the system shown in fig(5). Be sure the glass reflecting material is vertical and centered over the axis of rotation of the rotational stage. Glass reflecting material was setup such that at 90° on the protractor, the incident ray (from a red He Laser source) hit the surface perpendicularly so the reflected beam goes back into the laser aperture. Be sure that the rotational stage reads 0° at this point.

2. Darken the room as much as possible.

3. Adjust the laser so the output is horizontally polarized.

4. The protractor is then rotated to angle values less than 90° in an interval of 5°. The reflected ray is directed to a fiber optic light intensity sensor which measures the intensity of the reflected light in terms of current. Record the current in microammeter . This alignment of the incoming laser and the protractor ensures that the angle on the protractor equals the angle of the incident ray, thus gives the value of the incidence angle (See figure 5). The angle range is limited between 20° and 80° because of the expanse of the fiber optic light intensity sensor holder.

5. Between the angles of 50° and 60°, measure the intensity of reflected beam in 2° increment. You will notice that at a certain angle, Brewster's angle, there will be little or no reflected light. Record this angle.

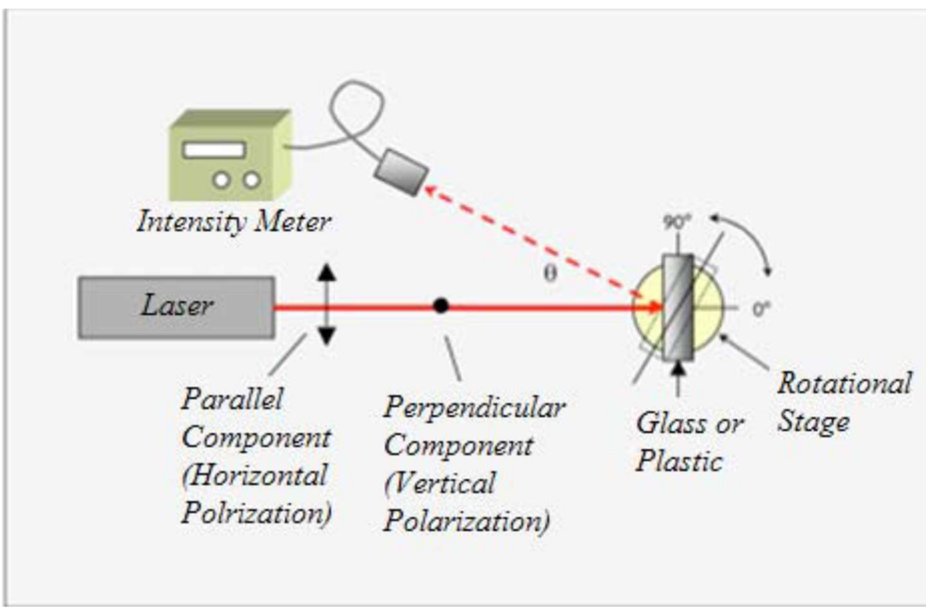


Figure 5. Experimental Set up

<u>Observation Table:</u>

S.No.	Angle 'θ' (°)	Current 'I' ($\mu\, amp$)

1.		
2.		
3.		
4.		
..		
..		
..		

1. Make a graph of reflected power (current I) vs angle **'$\boldsymbol{\theta}$'** Figure (6)**.**

2. Note Brewster's angle from your data calculate the index of refraction (refractive index) for the material of material.

<u>Result:</u>

1. The graph plotted is in good agreement with the predicted values.

2. Brewster's angle for the material is ….

3. The refractive index of material of glass is ….

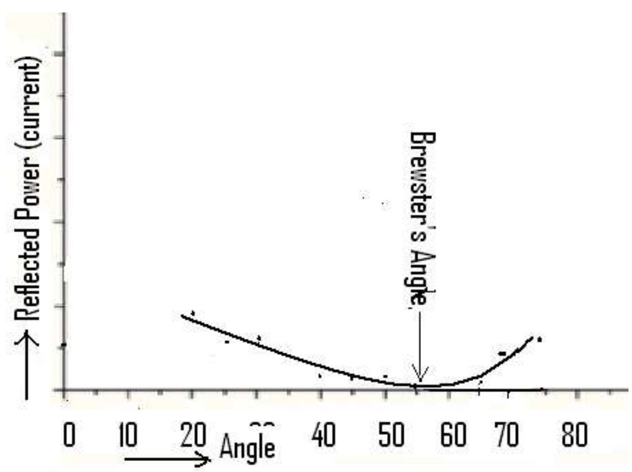


Figure 6

<u>Precaution:</u>

1. The laser beam should not penetrate into eyes as this may damage the eyes permanently.

2. The photo detector should be as away from the slit as possible.

3. The laser should be operated at a constant voltage 220V obtained from a stabilizer. This

avoids the flickering of the laser beam.

3. Laser should be started at least 15 minutes before starting the experiment.

4. Scale of vernier should be rotated slowly.

6. Room should be perfectly dark.