Laboratory room F10313 : Polarization of Light and Brewster angle

Objectives

- To learn about the polarization of light
- To learn about the dichroic crystal (Polarizer)
- To measure the brewster angle of different material

Theoretical Discussion

Diffraction and Interference are the properties for all kind of waves but Polarization is the property for only transverse wave. Light wave is an electro-magnetic wave in which the electric field and magnetic field are oscillated perpendicular to the direction of propagation. Therefore, the light wave is the transverse wave which has a polarization property. In case of light wave, only the oscillation of electric field will be considered for the polarization property.

"Polarization" is the property of light wave in which the oscillation of the electric field occurs in a single plane which is called "Plane of polarization". The light from the sun, the lamp, and the laser are generally "Unpolarized" in which their electric field is oscillated in more than one planes. The linear polarized light can be generated by shining the unpolarised light through a dichroic crystal. The dichroic crystal is the material that can be absorbed the oscillation of electric field in many directions due to the alignment of its crystal and allow on single plane of oscillation to be transmitted. This plane of the material call "Transmission axis". This crystal is called "Polarizer" which is used to change the unpolarized light to the polarized light.

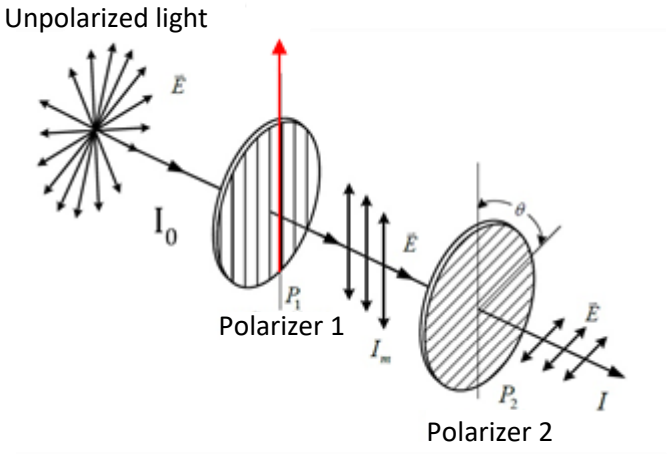


Figure 1 The setup to generate the polarized light by using polarizer

Figure 1 presents the setup to generate the polarized light by using polarizer. When the unpolarized light is shone through a polarizer 1, the polarized light will be generated in which the plane of polarization will be the same plane as the transmission axis of polarizer 1. The intensity of polarized light after transmitted through the polarizer 1 (I_m) is the half of the intensity of the unpolarized light (I_0).

$$I_m = 0.5I_0$$

When shining the polarized light through the polarizer 2, the polarized property of transmitted light is remained but the plane of polarization will be the same as transmission axis of polarizer 2. If the transmission axis of polarizer 2 is located with an angle (θ) compare with the transmission axis of polarizer 1, the intensity of the light transmitted through polarizer 2 (I) can be calculated from **Malus's law** as presented below.

$$I = I_m cos^2\theta$$

A light is said to be a plane polarized light, if all the oscillations are confined to a single plane. Consider an unpolarized light incidents on a transparent surface. If the angle of incidence is equal to a particular angle of incidence θ_B, the reflected light produced will be completely plane polarized. This particular angle is called the Brewster's angle or the polarizing angle B.

Sir David Brewster, in 1892, found that the maximum polarization of the reflected ray occurs when the reflected ray is perpendicular to the refracted ray. This is called the Brewster's law. The Brewster angle (θ_B) is an incident angle where the combination of this angle with the reflected angle (θ_r) is equal to 90°.

$$\theta_B + \theta_r = 90^\circ$$

When considering the Brewster angle condition with the Snell's law : $n_1 \sin\theta_{incident} = n_2 \sin\theta_r$, the Brewster condition can be express below:

$$\tan\theta_B = \frac{n_2}{n_1}$$

Where n_1 is the refractive index of environment (air)

n_2 is the refractive index of transparent material in which the light is reflected.

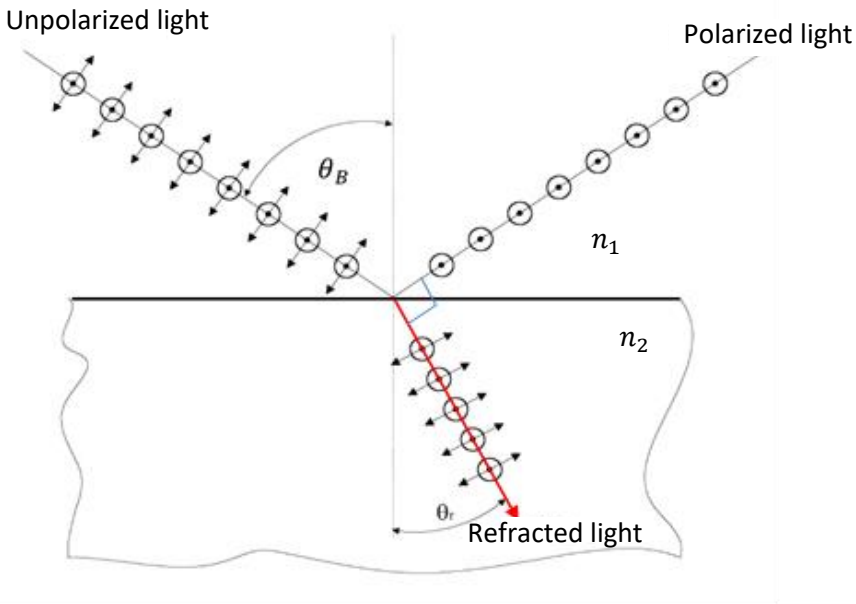


Figure 2 Illustration of the polarization of unpolarized light passing through and reflected off of the material with the incident angle equal to Brewster angle (θ_B).

Worksheet and Quizs : Laboratory 7 (Polarization of light and Brewster angle)

Name_____Student ID _____Group_____

Experiment summary table

Part 1 The intensity of light (I) transmitted through the polarizaer 1 when the transmission axis of polarizer 1 is rotated with different angle (θ_1).

The intensity of light source before transmitted through the polarizer_____

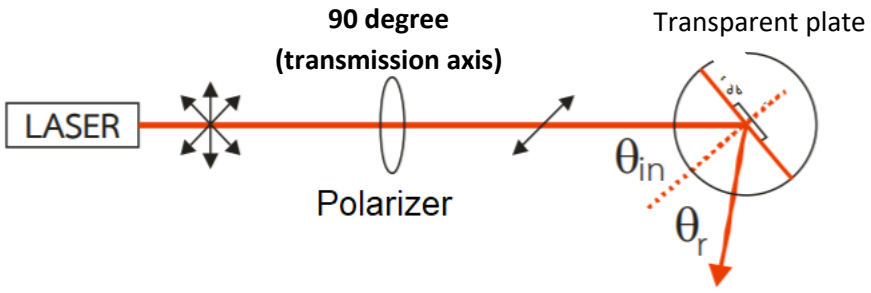
θ_1 Reading error=_____	0°	30°	45°	60°	90°	120°	180°
I ( ) Reading error=_____							

Part 2 The intensity of light transmitted through 2 polarizers (I) when transmission axis of polarizer 1 and polarizer 2 is located with different angle of θ

Intensity of light (I_m) transmitted through 2 polarizers whrn the angle between transmission axis of two polarizers $\theta = 0$ is I_m = _____

$\theta > 0$	Measured Intensity I_{mea}	Calculated Intensity $I_{cal} = I_m \cos^2\theta$	% different $\left\lvert \frac{I_{mea} - I_{cal}}{I_{cal}} \times 100 \right\rvert$

Part 3 Measuring the refractive index of material plate from the Brewster angle



Material	Brewster angle $\boldsymbol{\theta_B}$	Refractive index $n = \tan\theta_B$ (Report with the correct significant number)

Part 3 (for Virtual lab) Measuring the Brewster angle of different material in different environment

Refractive index		Measured Brewster angle $\boldsymbol{\theta_B}$	Calculated Brewster angle $\boldsymbol{\theta_B}$
Medium (n_1)	Material (n_2)		

Post-class Quiz: You have 2 minutes

Please consider the provided photos and/or equation, then answer the questions below:

1. What is the "Intensity" of light that can be read from the Photometer

   Answer _____

2. What is the angle between the transmission axis of polarizer 1 and 2 when the ratio between I_m and I is equal to 0.4.

   Answer _____

3. What is the incident angle of light on the surface when the reflected light is the polarized light and **the refracted angle** of this incident light is 40 degree.

   Answer _____

4. What is the Brewster angle of light on the surface when the reflected light is the polarized light with **the reflected angle** of 47 degree.

   Answer _____

Total score (2)

0 score when all answers are wrong.

1 score when the answers for question 1 and 2 are correct.

2 score when all answers are correct.