PHY385-H1F Introductory Optics

Class 17 – Outline: Sections 8.4 to 8.9

- Linear Polarizers
- Malus's Law
- Polarization by Reflection
- Polarization by Scattering
- Birefringence
- Rochon Prism
- Phase Retarders; Wave Plates

In Class Discussion Quiz

Polarization can be a property of

1. Transverse waves
2. Longitudinal waves
3. Both

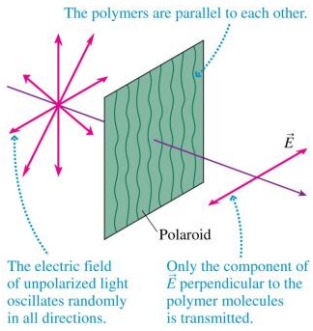
Dichroism

- "Dichroism" is the selective absorption of one of the two orthogonal P-state components of an incident beam.
- *Polarization state determines absorption coefficient.*

Birefringence

- "Birefringence" is when the index of refraction of a material depends on the polarization and propagation directions of an incident beam.
- *Polarization state determines speed.*

A Horizontal Polarizing Filter.



What a Polarizing filter does. (1)

A polarizing filter has two effects on normal, unpolarized light:

1. It reduces the irradiance by ½. That is why polarizing filters can be used as sunglasses.

$$I_{\text{transmitted}} = \frac{1}{2} I_0 \qquad \text{(incident light unpolarized)}$$

2. The light that is transmitted is now polarized in the direction of the polarizing filter.

What a Polarizing filter does. (2)

If the light that strikes the polarizing filter is already polarized, then the amount of light transmitted depends on the angle between the polarization of the incident light, and the polarization axis of the filter.

In any case, the light that is transmitted by a polarizing filter is *always* polarized in the direction of the polarizing filter.

Example: the angle between the incident light polarization (E-field oscillations) and the polarizing filter axis is 90 degrees. Result: No light transmitted.

Example: the angle between the incident light polarization (E-field oscillations) and the polarizing filter axis is 0 degrees (parallel). Result: All light transmitted! (100%)

Malus's Law

Suppose a *polarized* light wave of irradiance I_0 approaches a polarizing filter. θ is the angle between the incident plane of polarization and the polarizer axis. The transmitted irradiance is given by Malus's Law:

$$I_{\text{transmitted}} = I_0 \cos^2\theta \qquad \text{(incident light polarized)}$$

In Class Discussion Quiz

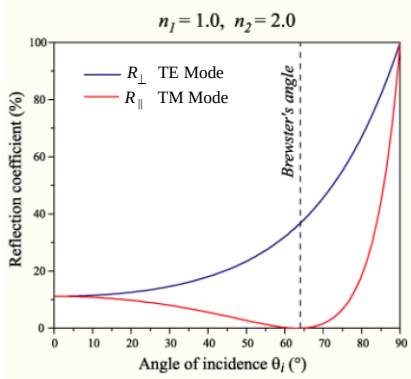
Light will not pass through a polarizing filter if its polarization axis is

1. Parallel to the filter polarization
2. Perpendicular to the filter polarization
3. 45 degrees to the filter polarization

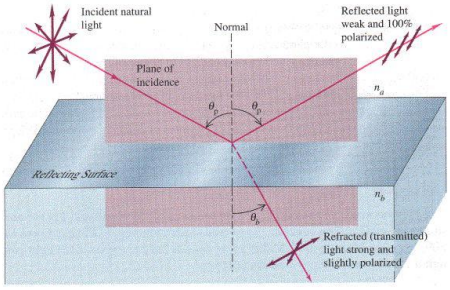
Example

1. Initially unpolarized light traveling in the +*z*-direction passes in turn through three linear polarizers, with transmission axes at 0°, 45°, and 90°, respectively, relative to the *x*-axis. What is the irradiance of the produced light, expressed as a fraction of the original unpolarized light irradiance?
2. What is the irradiance of the produced light if the middle polarizer is removed?

Reflection Coefficient, External Reflection



The incident, reflected and transmitted beams each lie in the "plane-of-incidence".



This figure shows the polarization for the particular angle of incidence called Brewster's Angle, θ_p.

In Class Discussion Quiz

The glare seen from water is mostly

1. Horizontally polarized
2. Vertically polarized
3. Non-polarized

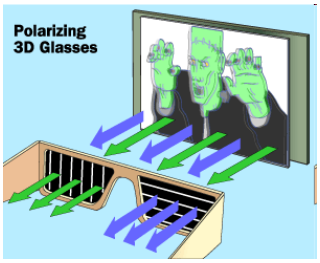
In Class Discussion Quiz

The polarization axes of these Oakley polarized sunglasses are probably

1. Vertical
2. Horizontal
3. At right angles to each other

Polarization by Reflection

3-D Movies

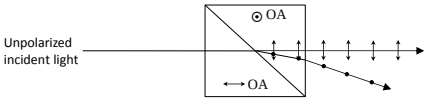


- Binocular vision allows us to tell relative distances to objects within about 6 m.
- 3-D movies are filmed / computer-generated from two side-by-side perspectives.
- In the theatre, two synchronized projectors project two respective views onto the screen, each with a different polarization.
- The glasses allow only one of the images into each eye.

Rochon Prism Example

Initially unpolarized monochromatic light traveling in the +z-direction has a wavelength of 589.3 nm. It passes through a Rochon prism with geometry shown below. Find the angle of deviation between the two emerging beams.

Note that this prism is made of calcite ($CaCO_3$) for which $n_{\parallel} = 1.4864$ and $n_{\perp} = 1.6584$.



Rochon Prism made of Calcite