Al-Mustaqbal University

Department of Optics Techniques

Medical and optical physics 1

First stage

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Polarization

Polarization is a physical phenomenon specific to transverse waves, where the wave oscillates in a single direction or plane.

◇ Important Note: Light is a transverse electromagnetic wave, therefore it can be polarized.

Polarized Light

The electric field oscillates in only one direction.

This occurs when unpolarized light passes through a special medium (such as a polarizing filter).

Unpolarized Light

Light emitted from natural sources (the sun).

The electric field oscillates in all directions perpendicular to the direction of propagation.

Types of Polarization

a) Linear Polarization

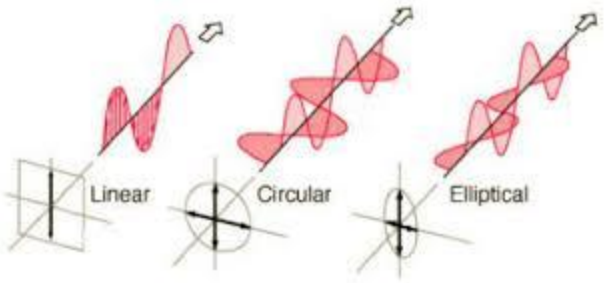
The oscillation is in a single, fixed plane.

b) Circular Polarization

The electric field vector rotates in a circular path as it propagates.

c) Elliptical Polarization

This includes linear and circular polarization as special cases.



Methods of Obtaining Polarized Light

1. Polarization by Polaroid Filters

This filters transmit one wavelength while blocking the rest.

Used in sunglasses.

2. Polarization by Reflection

When light is reflected from a dielectric surface (glass, water).

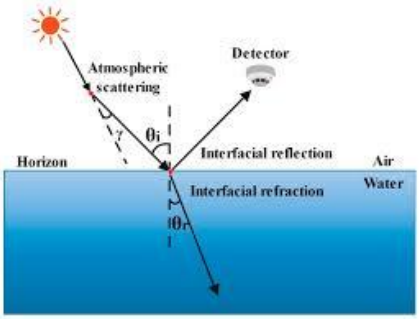
The reflected light is partially or completely polarized.

This occurs at Brewster's angle.

3. Polarization by Birefringence

In crystals such as calcite.

The light is split into two polarized beams.



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First: Why can light be polarized?

1-Light is a transverse electromagnetic wave:

2-The electric field E and the magnetic field B are both perpendicular to the direction of wave propagation.

*Polarization describes only the direction of vibration of the electric field because:

1-its effect is greater.

2-Measuring instruments respond to it.

Second: The Physical Explanation of Polarization

In unpolarized light:

1-The direction of E changes randomly with time.

In polarized light:

E vibrates in a specific and constant direction.

*The analyzer only allows vibrations parallel to its axis.

Third: Polarization by Reflection (Brewster's Angle)

When light is reflected from a dielectric surface: The reflected light becomes linearly polarized.

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Fourth: Polarization by Birefringence

In special crystals such as:

Calcite

Light is divided into:

1-Ordinary beam (O-ray)

2-E-ray

Fifth:Light Intensity and Polarization

Intensity depends on:

1-Analyst Angle

2-Type of Polarization

Malus' Law

When polarized light passes through an analyzer:

$I = I_0 \cos^2 \theta$

I_0 : Incident light intensity

I: Transmitted light intensity

θ: Angle between the polarization direction and the analyzer

Applications of Polarization:

1-Sunglasses

2-LCD screens

3-Photography

4-Light microscopes

Note

*Non-polarized + Analyzer ⇒ Divide by 2

*Two angled analyzers ⇒ Use Malus's Law

*Angle90°⇒ Intensity = Zero

Use:

$I = \frac{I_0}{2}$ For unpolarized light

$I = I_0 \cos^2 \theta$ For Malus' law

EX/

Optical communications Linearly polarized light of intensity I_0 = 80 W/m² passes through an analyzer that makes an angle of 30° with the polarization direction?

Required: Calculate the light intensity after the analyzer.

Solution: Malus' Law:

$I = I_0 \cos^2 \theta$

$I=80\times\cos^2 30^\circ$

$I=80\times(\frac{\sqrt{3}}{2})^2 \Rightarrow I=80\times\frac{3}{4}$

$\frac{3}{4}=0.75$

$80\times0.75=60$

$I=60 W/m^2$

EX/Unpolarized light of intensity I_0 =100 W/m² is incident on a polarizing filter.

Required:Calculate the intensity of the transmitted light.

Solution: When unpolarized light passes through a single analyzer:

I = 100 W/m²

$I =\frac{I_0}{2} = \frac{100}{2}$

I = 50 W/m²

EX/Unpolarized light of intensity I_0 = 200 W/m² passes through two analyzers with an angle between their axes of 45°.

Required: Calculate the intensity of the transmitted light.

Solution:

After the first factor:

$$I = \frac{I_0}{2}$$

$$I = \frac{200}{2} = 100$$

After the second factor:

$$I = I_0 \cos^2 \theta$$

$$I = 100 \cos^2 45$$

$$I = 100x\left(\frac{1}{\sqrt{2}}\right)^2$$

$$I = 100x\frac{1}{2} = 50 w/m^2$$

H.W/Polarized light has an intensity of I_0 = 50 W/m². What is the intensity after a 90° diffuser?

Summary:

1-Polarization is evidence that light is a transverse wave.

2-It does not occur for longitudinal waves.

3-It depends on the direction of the electric field.

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