

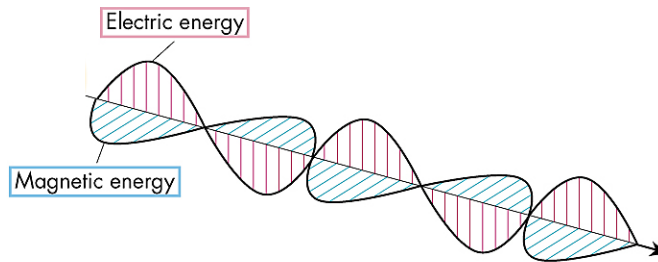
# Polarized Light

Some mechanisms that produce polarized light are:

- Dichroism
- Reflection
- Scattering
- Transmission

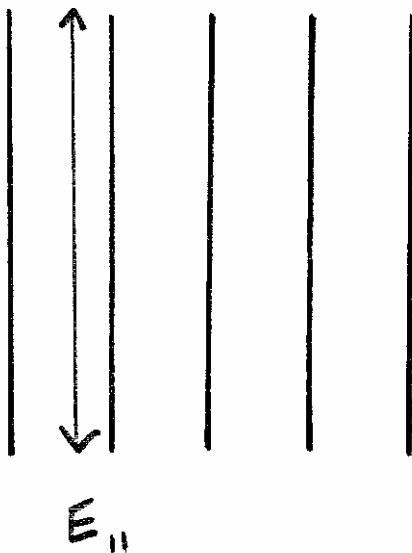
*Optical Activity* - any mechanism that modifies polarized light

*Linear Polarization (LP)* - refers to light that has been polarized so that only oscillations occur only in a single plane.



## The Wire Grid Polarizer

Used in 1888 by Hertz to test the properties of radio waves:



Components  $||$  to the wire grid cause electrons in the wires to oscillate, causing the wires to heat up. Any dipole radiation produced is scattered throughout 360 degrees.

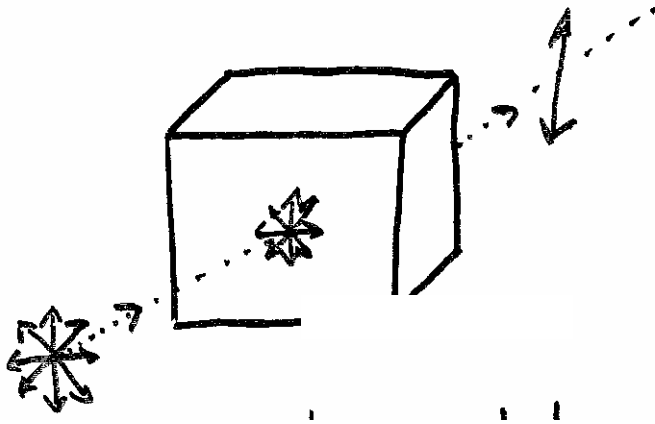
The  $\perp$  components can't drive electrons very far and are therefore not absorbed.

At optical frequencies, dichroic crystals accomplish the same thing as a wire grid polarizer.

Dichroism - Polarization by selective absorption.

Dichroic polarizers selectively absorb light with  $E$  field vibrations along a unique direction characteristic of the dichroic material.

Tourmaline -  $Al_2O_2$ ,  $B_2O_3$ ,  $SiO_2$



The horizontal component is attenuated

Transmitted light appears green

Attenuated component is black

Dichroic - black + green

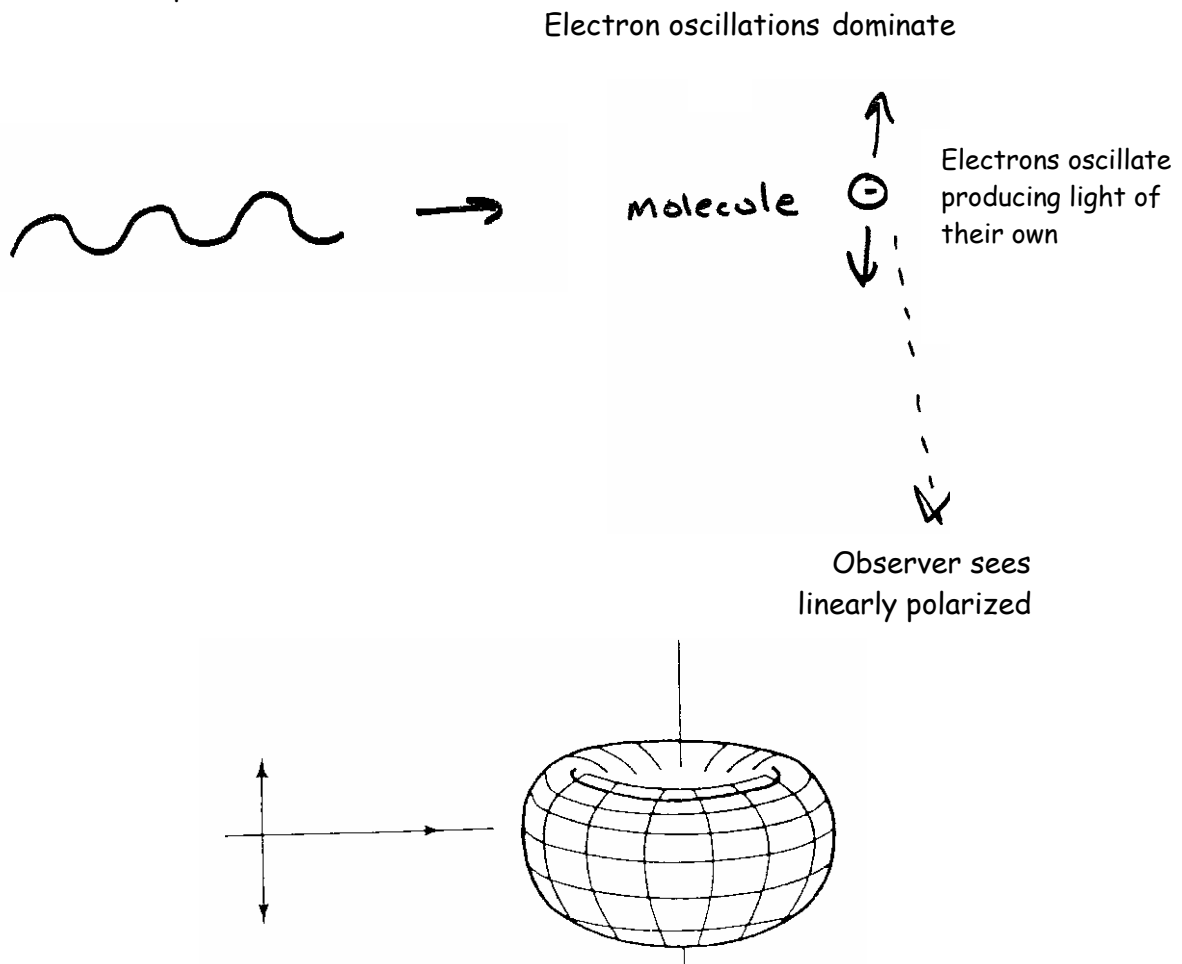
## Polaroid Filters

Quinine sulfo-iodide crystals in sheets are commonly used as selective absorbers.

- A sheet of PA (polyvinyl alcohol) is stretched and impregnated with alcohol.
- The iodine attaches itself to the long hydrocarbon molecules, allowing electrons to move along the hydrocarbon filaments as if they were wires.
- A Polaroid sheet works like a wire grid polarizer for optical frequencies.

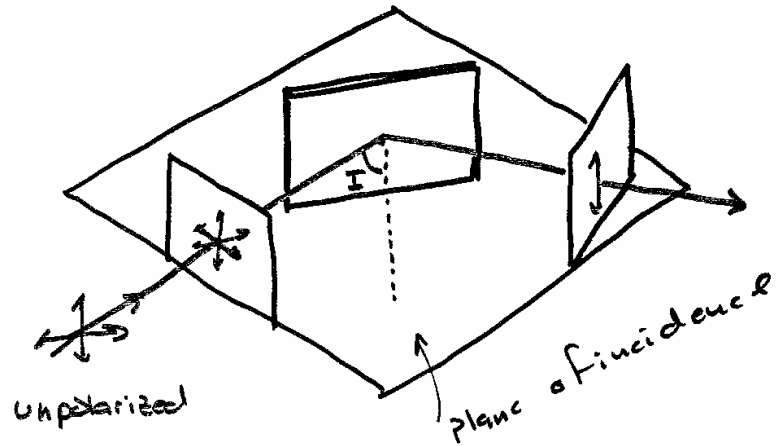
## Polarization by Scattering

Consider a bundle of unpolarized light that passes through a region of small particles in suspension.



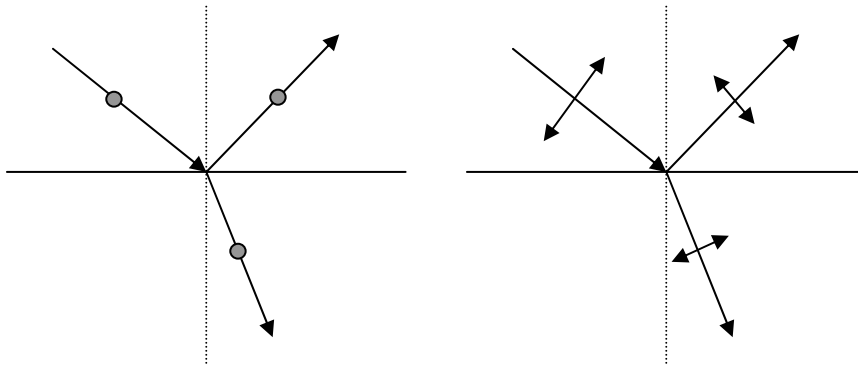
- Rayleigh Scattering: Particles small compared to incident light. ( $O_2$ ,  $N_2$ ) light.
- Mie Scattering: Particles large compared to incident light (water droplets)

## Polarization by Reflection

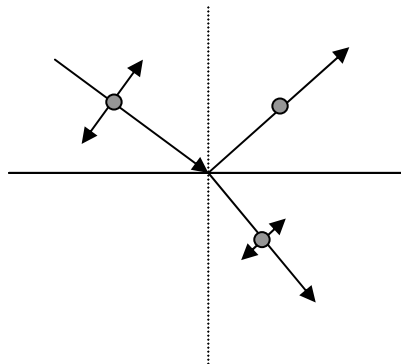


Specularly reflected light is at least partially polarized.

Consider beams of light incident on an optical boundary separating media of indices of refraction  $n_1$  and  $n_2$ .



Maximum polarization occurs when the reflected and refracted light subtend an angle of  $90^\circ$ .

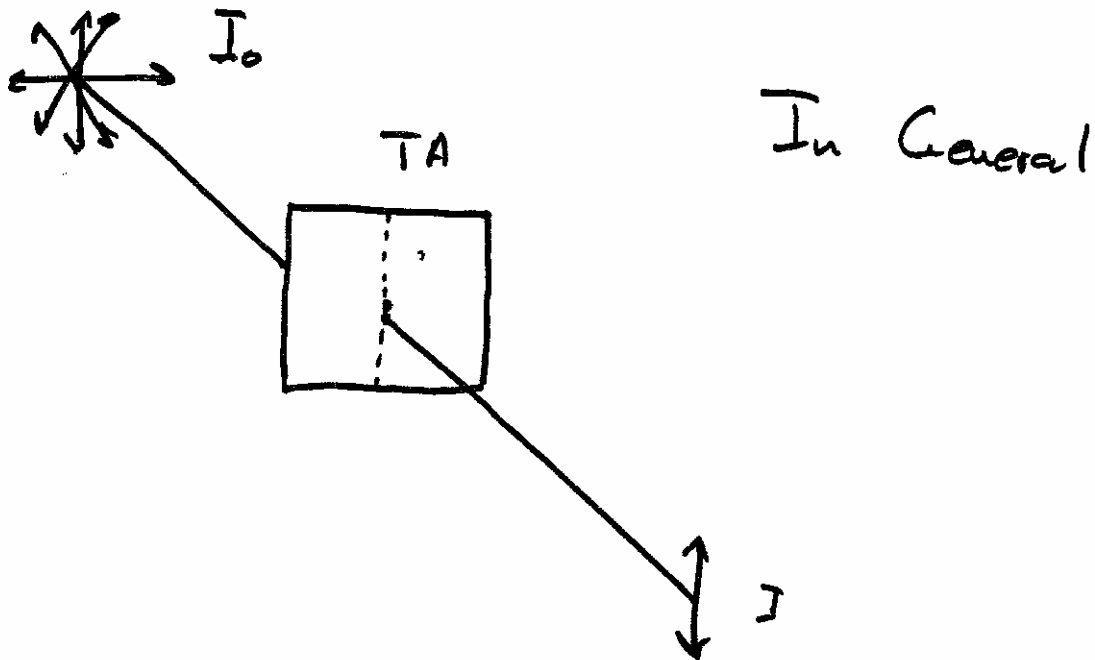


The polarizing angle (Brewster's angle) is:

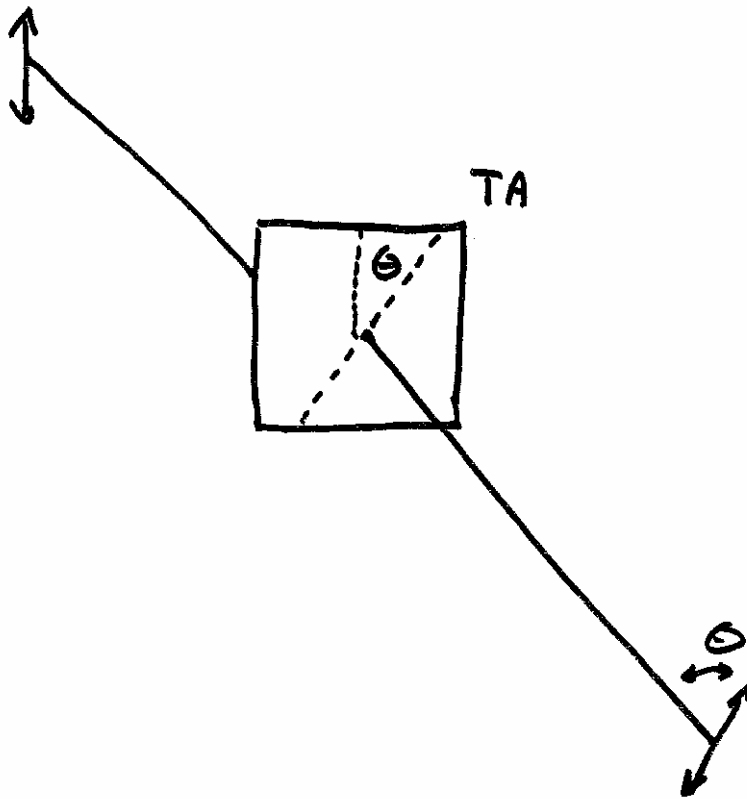
$$\theta_p = \tan^{-1}\left(\frac{n_2}{n_1}\right)$$

- Light reflected at the Brewster angle contains a completely LP component.
- The light transmitted through the surface has this component missing.
- If this process is repeated often enough, the transmitted light becomes LP in the other plane.

Malus Law



$$I = \frac{1}{2} I_0$$



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

Malus' Law

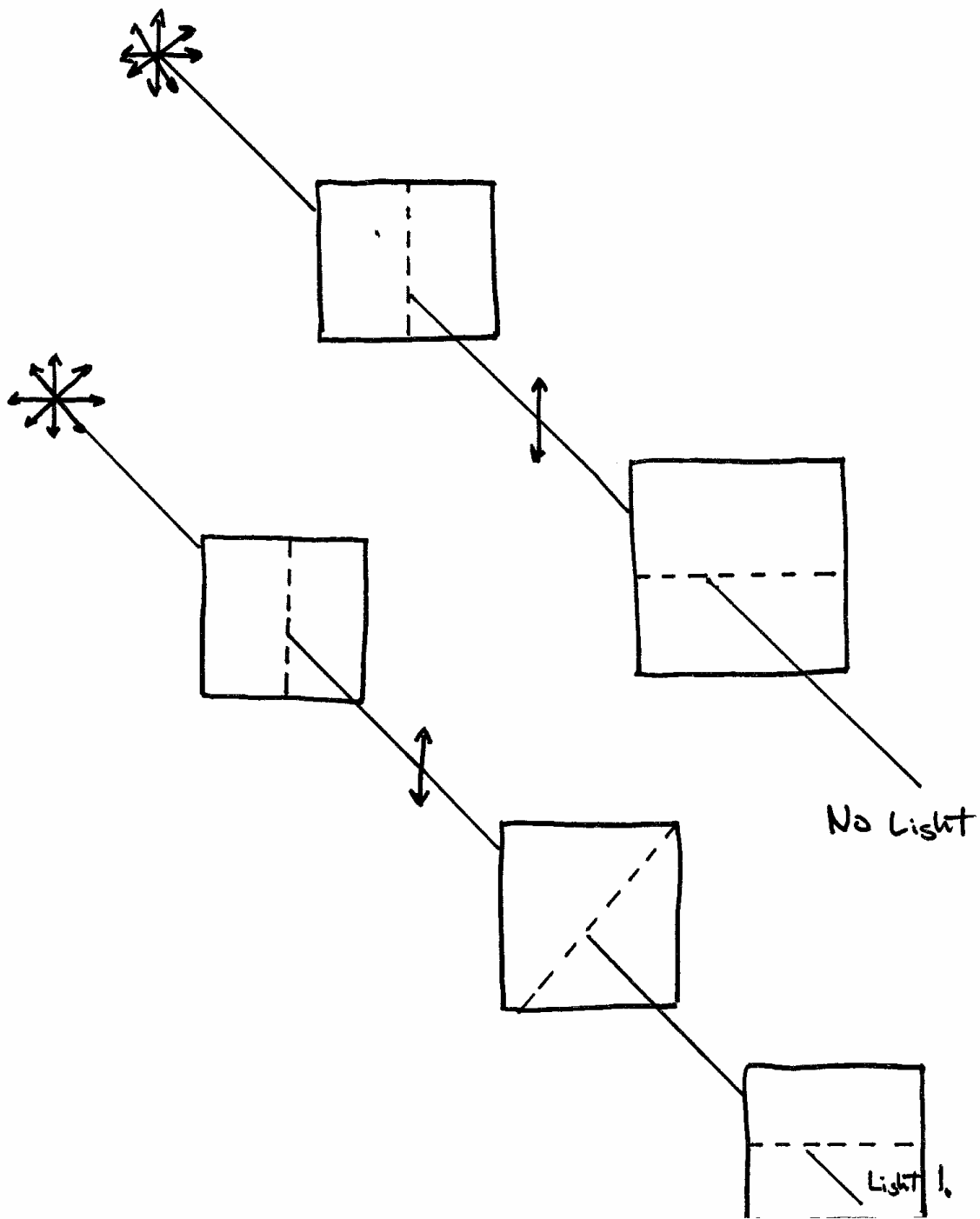
$$\theta = 0$$

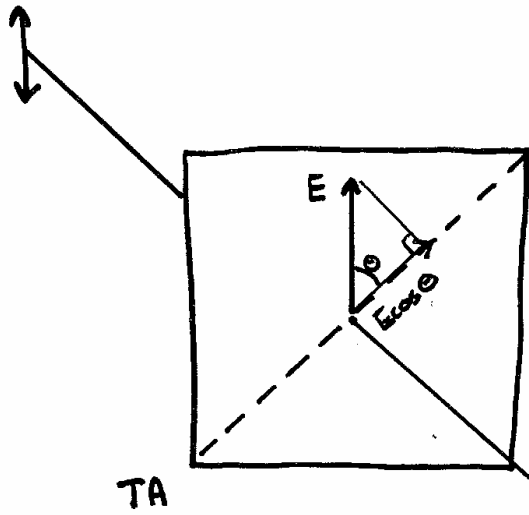
$$I = I_0$$

$$\theta = 90^\circ$$

$$I = 0$$

Example: Crossed Polarizers





In order for any light to get through there must be a component ( $E \cos \theta$ ) that lies along the T.A.

