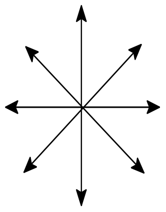
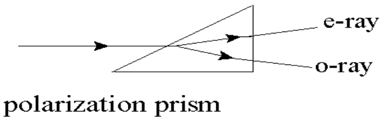
SUPPLEMENT 3A - POLARIZATION

A review of some basic concepts (pp. 39-40, 42-43 in the textbook)

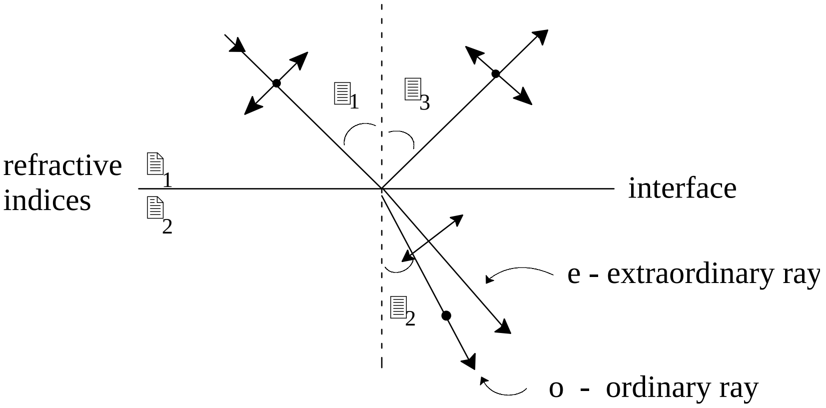


In specialized situations, the polarization of radiation is critical. All radiation is some combination of two perpendicular linear polarization components. For unpolarized radiation, the plane of polarization is totally random. For linear polarized radiation, only one of the two components is present.

Interactions of radiation with atoms or molecules such as absorption can differ for different states of polarization. Some materials exhibit different absorptivities to different polarization components. For certain optically active transparent materials (quartz, calcite), the refractive index and hence the angle of refraction depends on the state of polarization. The reflectivity at the interface of two materials depends on the state of polarization. All these optical phenomena can be use to produce linear polarized radiation as summarized in the table below.

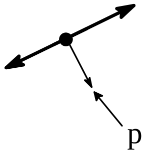
basis of linear polarization	name of phenomenon	material or component
by absorption	linear dichroism	Polaroid sheet
by refraction see figure 1	double refraction or linear birefringence	
by reflection see figure 1 & 2		interface of two materials with different refractive indices

We consider a light beam passing through an interface formed from two transparent materials of different refractive index. We need to consider how the angle of refraction can be affected if the second medium is optically active and how the reflectivity varies with the angle of incidence.



the **plane of incidence** is the plane containing the incident ray and the normal to the interface. The σ component is normal to the plane of

Fig. 1. Reflection and refraction. For anisotropic crystals, optical properties such as the refractive index and the angle of refraction vary with state of polarization.



⊥ or ■ or s component - vibration in and out of page
|| or ▭ or p component - vibration in plane of page

First consider the effect of polarization angle of refraction

η_o = refractive index for the ordinary ray

η_e = refractive index for the extraordinary ray (*for optically active material*)
this refractive index varies with the angle of incidence

at one particular angle of incidence $\eta_o = \eta_e$, which defines the **optic axis**

Now consider the effect of polarization on reflection

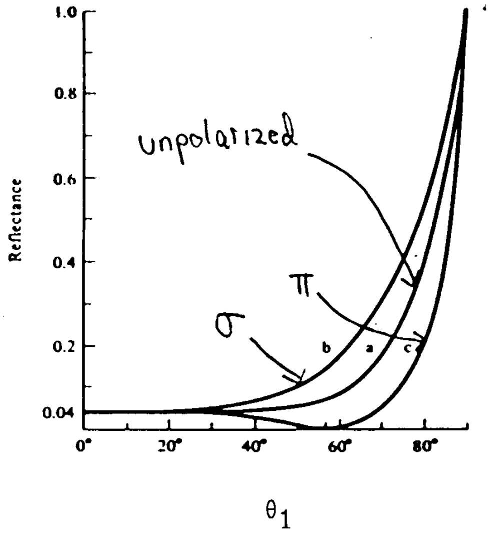


Fig.2. *Dependence of reflectivity on angle of incidence for an air-glass interface*

$$\rho(\lambda) = \rho_\sigma + \rho_\pi$$

both ρ_σ & ρ_π vary with the angle of incidence (see eq. 3-9 in book)

Three points to note:

1. ρ increases with increasing θ_1

2. $\rho_\sigma > \rho_\pi$

3. at one θ_1, called Brewster's angle (θ_p) $\rho_\pi = 0$ reflected ray is totally polarized (σ)

$\theta_p = \tan^{-1}(\eta_2 / \eta_1)$, $\eta_1 > \eta_2$, π component