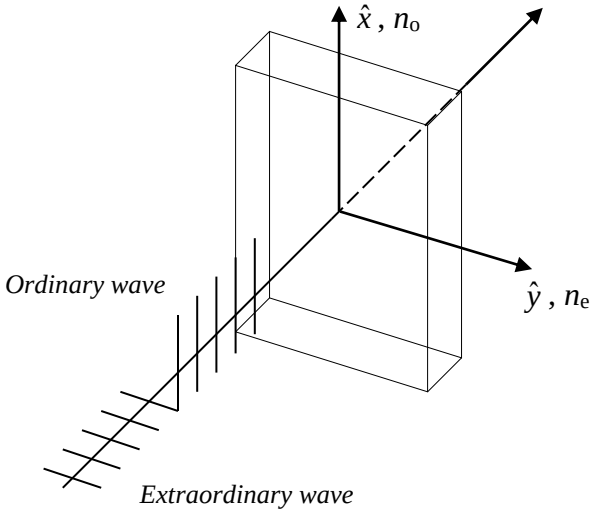
Polarization and Polarization Devices

Problem 1 *Quarter Wave Plate of Quartz*

Quartz is a positive uniaxial crystal with n_e=1.552 and n_o=1.543 (at λ = 633nm). A plate of quartz is cut so that the optic axis is parallel to the face of the plate and oriented parallel to the $\hat{y}$ direction. A plane wave incident normal to the surface of the plate will "see" an index of refraction n_o if its electric field is parallel to the $\hat{x}$ direction ($\hat{x}$-polarized), and n_e if its electric field is parallel to the $\hat{y}$ direction ($\hat{y}$-polarized). These two polarization states are referred to as the ordinary and extraordinary waves, respectively. The *retardation* is the phase shift between an ordinary and extraordinary wave after they pass through the plate.

a) Calculate the retardation per mm at λ_o=633 nm for a quartz crystal oriented as described.

b) At what thicknesses does the plate act as a quarter-wave retarder? A plate with the minimum thickness for a $\pi/2$ phase shift is called a zero-order quarter wave plate. The next thicker plate is a first-order quarter wave plate, etc.



Problem 2 *Cascaded Wave Retarders (wave plates)*

a) Show that two cascaded quarter-wave retarders with parallel fast axes are equivalent to a half-wave retarder.

b) What is the system Jones matrix if the fast axes are orthogonal?

Problem 3 *Transmission through sequential polarizers*

a) Calculate the transmission Jones matrix for a pair of crossed linear polarizers.

b) Now calculate the transmission Jones matrix for the same pair, but with a third polarizer inserted between them and rotated an angle θ with respect to the first polarizer.

c) With right circular polarization incident on the system, what is the polarization state at the output?

d) Does the output polarization state depend on the orientation of the middle polarizer?

e) Sketch the dependence of the output field amplitude as a function of rotation angle θ.

Problem 4 *Brewster plate polarizer*

A polarizer can be made from a series of glass plates tilted at Brewster's angle with respect to the incoming beam.

a) At Brewster's angle, what is the field transmission coefficient for the TE and TM polarized field components when going from air to glass? Use $n = 1.5$ for the glass.

b) What are the field transmission coefficients when going from glass to air?

c) What is the degree of polarization achieved by 4 sequential plates? That is, what fraction of the total output power is TM polarized?