

AP217
Problem Set 1

PROBLEMS

1. Derive the reflection/refraction formulas for p -polarized light (Jackson §7.3), i.e., find $\frac{E'_0}{E_0}$ and $\frac{E''_0}{E_0}$.
2. Let σ^+ light (a yellow laser beam, for example) be incident on a piece of glass with incidence angle 45° . Characterize the polarization of the reflected light.
3. a. The dielectric tensor for a linear (non-magnetic) medium is

$$\underline{\underline{\epsilon}} = \begin{bmatrix} \epsilon_0 & \Delta\epsilon & 0 \\ \Delta\epsilon & \epsilon_0 & 0 \\ 0 & 0 & \epsilon' \end{bmatrix}$$

with respect to (x, y, z) cartesian (laboratory) axes; ϵ_0 , ϵ' , and $\Delta\epsilon$ are real valued. Find the polarization of a plane wave, propagating in the medium along the z axis, as a function of propagation depth z into the medium when the initial (at $z = 0$) polarization is linear along x . (Hint: diagonalize the matrix and find eigenvalues and an orthonormal basis of eigenvectors).

- b. Same question as part (a), however now the dielectric tensor is

$$\underline{\underline{\epsilon}} = \begin{bmatrix} \epsilon_0 & i\Delta\epsilon & 0 \\ -i\Delta\epsilon & \epsilon_0 & 0 \\ 0 & 0 & \epsilon' \end{bmatrix}$$

Note that in both cases the dielectric tensor is Hermitian (and hence, the eigenvalues are real valued), but the behavior of the polarization of the propagating wave is very different in the two cases. (Reminder: a 3x3 Hermitian matrix has entries $\{a_{ij}\}_{i,j=1,2,3}$ such that $a_{ij} = a_{ji}^*$). Crystalline quartz is a material that is well-described by the dielectric tensor in (b) for propagation of optical waves. Quartz comes in two forms, called left and right handed, corresponding to different signs of $\Delta\epsilon$ – can you explain why the names “left” and “right” are reasonable from an optics standpoint?