Introduction to Physics of Nanoparticles and Nano structures

Part I: Physics of Nanoparticles **Questions on Module 4**

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1. Consider a monochromatic plane em-wave of the form $\vec{E}(z,t) = \vec{E}_o e^{i(qz-\omega t)}$, where

$$\vec{E}_o = E_{||}\hat{e}_{||} + E_\perp \hat{e}_\perp, \qquad E_{||} = a_{||}\exp[-i\delta_{||}], \qquad \text{and} \qquad E_\perp = a_\perp \exp[-i\delta_\perp],$$

with $\hat{e}_{||}$ and $\hat{e}_\perp$ denoting orthogonal unit vectors on the wavefront, and $a_{||}$, $a_\perp$, $\delta_{||}$ and $\delta_\perp$ having real values.

(a) Define the Stokes parameter I, Q, U, V for the em-wave.

(b) Show that

$$I = a_{||}^2 + a_\perp^2, \qquad Q = a_{||}^2 - a_\perp^2, \qquad U = 2a_{||}a_\perp \cos\delta, \qquad V = 2a_{||}a_\perp \sin\delta,$$

with $\delta = \delta_{||} - \delta_\perp$.

(c) Show that $I^2 = Q^2 + U^2 + V^2$.

(d) If the basis vectors $\hat{e}_{||}$ and $\hat{e}_\perp$ are rotated clockwise through an angle ϕ about an axis normal to the wavefront, then show that the new set of Stoke's parameter relative to the rotated vectors $\hat{e}'_{||}$ and $\hat{e}'_\perp$ are given by

$$I' = I, \qquad Q' = Q\cos 2\phi + U \sin 2\phi, \qquad U' = -Q\sin 2\phi + U\cos 2\phi, \qquad V' = V.$$

(e) If $a_\perp = a$, $a_{||} = 2a$, and $\delta = \pi/6$, what is the degree of the linear polarization and that of the circular polarization?

2. For a quasi-monochromatic wave prove the inequality $I^2 \geq Q^2 + U^2 + V^2$.

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