Introduction to Physics of Nanoparticles and Nano structures

Part I: Physics of Nanoparticles **Questions on Module 2**

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1. Consider the phenomena of reflection and refraction of plane waves incident on planar interface between two dielectrics.
   (a) Derive *Fresnel's* law of reflection and refraction for S-polarized and P-polarized plane waves for general angle of incidence.
   (b) What is Brewster's angle? Show that if the angle of incidence exceeds Brewster's angle, then an incident plane wave becomes polarized on reflection.
   (c) Describe the condition for total internal reflection and Goos-Hänchen effect.

2. Consider reflection and refraction of a plane wave of wavelength λ (in vacuo) incident normally on a dielectric slab of thickness d and homogeneous and isotropic refractive index $N_1 = n_1 + ik_1$, placed in a non-absorbing medium of homogeneous and isotropic refractive index $N_2 = n_2$.
   (a) Show that the *Reflectance* R_{slab} for the slab is given by

$$R_{slab} = R\,\frac{1 + e^{-2u} - 2e^{-u}\cos 2\psi}{1 + R^2 e^{-2u} - 2Re^{-u}\cos[2(\psi+\phi)]},$$

   where $u = 4\pi k_1 d/\lambda$, $\psi = 2\pi n_1 d/\lambda$, $\phi = \tan^{-1}[2k_1 n_2/(n_1^2 + k_1^2 - n_2^2)]$, and

$$R = \frac{(n_2 - n_1)^2 + k_1^2}{(n_2 + n_1)^2 + k_1^2}, \quad \text{(Recflectance at normal incidence for the slab material).}$$

   (b) Show that the *Transmittance* T_{slab} for the slab is given by

$$T_{slab} = \frac{1 + R^2 - 2R\cos 2\phi}{e^u + R^2 e^{-u} - 2R\cos[2(\psi+\phi)]},$$

   where u, ψ, ϕ and R are as defined earlier.
   (c) Find the approximate separation between two successive maxima in the ripple structure appearing in the *Optical density* ($\equiv \log_{10}({T_{slab}}^{-1})$ as a function of λ^{-1}, if $d = 10\mu m$, $n_1 = 2.5$, at wavelength $\lambda \approx 500nm$.
   (d) If $k_1 \ll 1$ and in addition, $d \ll \lambda$, then find their averages of R_{slab} and T_{slab} over the fine ripple structures, where the averages are defined as

$$R_{slab}^{avg} = \frac{1}{\pi}\int_0^\pi d\psi\, R_{slab}(\psi), \qquad \text{and} \quad T_{slab}^{avg} = \frac{1}{\pi}\int_0^\pi d\psi\, T_{slab}(\psi).$$

   Use the standard integral

$$\frac{1}{2\pi}\int_0^{2\pi} \frac{d\theta}{\alpha - \cos\theta} = \frac{1}{\sqrt{\alpha^2 - 1}}, \ |\alpha| > 1.$$

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