OPTICAL PROPERTIES OF DIAMOND

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References: Griffiths, David J. (2007), Introduction to Electrodynamics, 3rd Edition; Pearson Education - Problem 9.17.

We've seen how to derive the properties of reflected and transmitted waves in the case where the wave is polarized perpendicular to the plane of incidence. The derivation in the case of parallel polarization is very similar and is given in Griffiths 9.3.3. Here we'll have a look at some of these properties at an interface between air and diamond.

The Fresnel equations for parallel polarization, giving the reflected and transmitted amplitudes in terms of the incident amplitude, turn out to be

$$E_R = \frac{\alpha-\beta}{\alpha+\beta}E_I \quad (1)$$

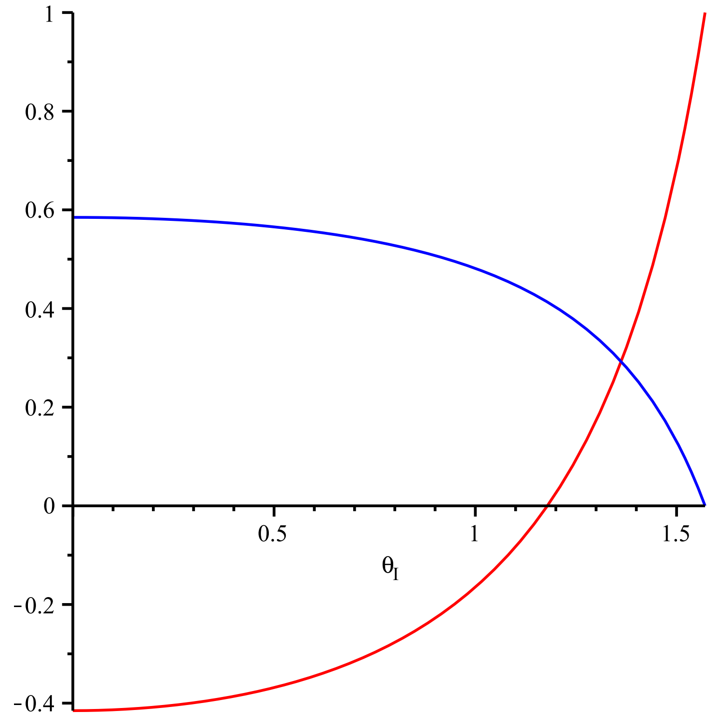
$$E_T = \frac{2}{\alpha+\beta}E_I \quad (2)$$

where the angle of incidence is θ_I, the angle of transmission is θ_T and

$$\alpha \equiv \frac{\cos\theta_T}{\cos\theta_I} \quad (3)$$

$$\beta \equiv \frac{\mu_1 n_2}{\mu_2 n_1} \quad (4)$$

Taking $\mu_1=\mu_2=\mu_0$ and using diamond's index of refraction $n_2=2.42$, we can draw plots of E_R/E_I and E_T/E_I (red for reflected and blue for transmitted):



At normal incidence $\theta_I = \theta_T = 0$ and

$$\frac{E_R}{E_I} = -0.415 \quad (5)$$

$$\frac{E_T}{E_I} = 0.585 \quad (6)$$

The negative value for the reflected amplitude indicates that the wave is π out of phase with the incident wave.

The reflected and transmitted amplitudes are equal where the curves cross, which occurs at an angle obtained from solving $E_R = E_T$:

$$\theta_{R=T} = 1.362 \text{ rad} = 78.06^\circ \quad (7)$$

We can see that if $\alpha = \beta$, $E_R = 0$ and there is no reflected wave. This occurs at *Brewster's angle* θ_B, given by

$$\sin^2\theta_B = \frac{1-\beta^2}{(n_1/n_2)^2 - \beta^2} \quad (8)$$

For the air-diamond interface, we get

$$\theta_B = 1.179 \text{ rad} = 67.55^\circ \quad (9)$$