Modern Optics: Homework 9

Due: 16 September 2015

1 Fresnel ratios: parallel polarization

a) Show that the Fresnel reflection ratio for perpendicular polarization can be written as

$$r^{\perp} = \frac{\sqrt{1-x} - \sqrt{a-x}}{\sqrt{1-x} + \sqrt{a-x}}$$

where $x = \sin^2\theta_i$ and $a = n_t^2/n_i^2$.

b) Use this to show that, if $a > 1$ then

$$\frac{dr^{\perp}}{dx} < 0$$

while if $a < 1$ then

$$\frac{dr^{\perp}}{dx} > 0.$$

c) Use the previous results to describe whether $r^{\perp}$ increases or decreases as θ_i increases. Use these results to determine the maximum and minimum values that $r^{\perp}$ can assume.

d) Repeat this entire analysis for $t^{\perp}$.

e) Use the results to plot $r^{\perp}$ and $t^{\perp}$ vs. θ_i

2 Bennett, *Principles of Physical Optics*, 3.10, page 86.

3 Bennett, *Principles of Physical Optics*, 3.39, page 116. Do these plots accurately, using software such as MAPLE or by creating tables of values using EXCEL and then plotting the resulting data using EXCEL.

4 Bennett, *Principles of Physical Optics*, 3.41, page 116.

5 Fresnel amplitude ratios

Light that is incident on a boundary between two materials. Consider the cases where light is incident in the material with a lower index of refraction. The aim of this exercise is to see how the ratio of the indices of refraction affects the reflection and transmission properties. This will involve plotting $r^{\perp}$ and $t^{\perp}$ for $0 \leqslant \theta_i \leqslant \pi/2$. This must be done accurately, using software such as MAPLE or by creating tables of values using EXCEL and then plotting the resulting data using EXCEL. In one case light in water ($n = 1.33$) is incident on glass ($n = 1.50$). In another case light in air ($n = 1.00$) is incident on diamond ($n = 2.42$).

a) Plot $r^{\perp}$ for water/glass and air/diamond using the same set of axes. In which case does is reflection more selective (i.e. is only strong over a smaller range of angles)?

b) Plot $t^{\perp}$ for water/glass and air/diamond using the same set of axes. In which case does is transmission more selective (i.e. is only strong over a smaller range of angles)?

c) Is reflection stronger when the ratio of the indices of refraction is larger or smaller. Check this by considering the cases $n_t/n_i \to 1$ and $n_t/n_i \to \infty$.

d) Is transmission stronger when the ratio of the indices of refraction is larger or smaller. Check this by considering the cases $n_t/n_i \to 1$ and $n_t/n_i \to \infty$.