Physics 422 - Spring 2016 - Assignment #8, Due April 29th

1. Total internal reflection occurs when the angle of incidence, θ_i, in a medium with index of refraction n_1, is greater than the critical angle, $\theta_C = \sin^{-1} n_2/n_1$, when the medium on the other side of the interface has index of refraction n_2.

When light undergoes total internal reflection, the reflection coefficients for the components of the electric field parallel and perpendicular to the plane of incidence are

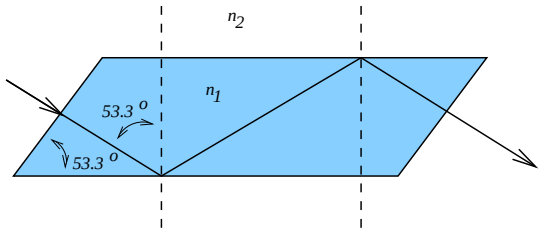
$$r_{\parallel} = -\frac{n_2^2 \cos\theta_i - i n_1 \sqrt{n_1^2 \sin^2\theta_i - n_2^2}}{n_2^2 \cos\theta_i + i n_1 \sqrt{n_1^2 \sin^2\theta_i - n_2^2}}$$

$$r_{\perp} = \frac{n_1 \cos\theta_i - i\sqrt{n_1^2 \sin^2\theta_i - n_2^2}}{n_1 \cos\theta_i + i\sqrt{n_1^2 \sin^2\theta_i - n_2^2}}$$

where $i = \sqrt{-1}$.

(a) Show that when light undergoes total internal reflection, the ratio of the reflected to incident intensity is 1.

(b) A Fresnel rhomb is constructed from glass with an index of refraction $n_1 = 1.5$ and is cut so that the angle of total internal reflection is 53.3° as shown:



Light initially polarized at 45° has equal components of its electric field parallel and perpendicular to the plane of incidence. Show that these two polarization components will emerge from the Fresnel rhomb with a phase difference of $3\pi/2$.

(c) What is the nature of the polarized light that emerges from the Fresnel rhomb?

2. *(Hecht, 8.54)* Two incoherent light beams represented by $(1, 1, 0, 0)$ and $(3, 0, 0, 3)$ are superimposed.
(a) Describe in detail the polarization states of each of these.
(b) Determine the resulting Stokes parameters of the combined beam and describe its polarization state.
(c) What is its degree of polarization?
(d) What is the resulting light produced by overlapping the incoherent beams $(1, 1, 0, 0)$ and $(1, -1, 0, 0)$? Explain.

3. *(Hecht, 9.6)* Two 1.0-MHz radio antennas emitting in-phase are separated by 600 m along a north-south line. A radio receiver placed 2.0 km east is equidistant from both transmitting antennas and picks up a fairly strong signal. How far north should that receiver be moved if it is again to detect a signal nearly as strong?

4. *(Hecht, 9.35 - almost)* A Michelson Interferometer is illuminated with monochromatic light. One of its mirrors is then moved 0.0225 mm and it is observed that 100 fringe-pairs, bright and dark, pass by in the process. Determine the wavelength of the incident beam.