Astronomical Telescopes and Instruments 2010: Exercises on Foundations of Optics (Due on 10 September 2014 at 13:45)

C.U.Keller

September 3, 2014

1 Interaction between Electromagnetic Wave and Matter

Show that the interaction between an electromagnetic wave and matter (assume electrons moving at speed v) is a factor of v/c smaller for the magnetic field component of the electromagnetic wave as compared to the electric field component.

2 Energy Densities of an Electromagnetic Wave

Show that the energy densities of the electric and magnetic field components of an electromagnetic wave are equal.

3 Harmonic Spherical Waves

Show that the wave equations for a dielectric ($\sigma = 0$)

$$\nabla^2 \vec{E} - \frac{\mu\epsilon}{c^2} \frac{\partial^2 \vec{E}}{\partial t^2} = 0 \tag{1}$$

derived from the Maxwell equations also have a solution that corresponds to purely spherical waves of the form

$$\psi(r,t) = \frac{A}{r} e^{i(kr-\omega t)}, \tag{2}$$

where A is a constant and r the radial distance from the center/source of the wave.

4 Reflectivity

Use the Fresnel equations for normal incidence (incoming beam of light is perpendicular to interface) to calculate the intensity of the reflected light for

1. window glass with an index of refraction of 1.55,
2. diamond with an index of refraction of 2.42, and
3. aluminum with a complex index of refraction of $0.8 + i6.0$.