PHY 353 - Electromagnetic Waves

Problem Set II

Due: 5:00pmm 30 March, 2000

1) Show that for large values, the resolving power $R = \lambda/\delta\lambda$ can also be written as $\omega/\delta\omega$.

2) Newton's Rings are observed on a film with quasi-monochromatic light that has a wavelength of 500nm. If the 20th bright ring has a radius of 1 cm, what is the radius of curvature of the lens forming one part of the interfering system?

3) A glass camera lens with an index of refraction of n=1.55 is coated with a film (n=1.33) to decrease the reflection of normally incident green light (λ = 500nm). How thick should the coating be?

4) What is the peak reflectance of a stack of a stack of 10 microscope slides with alternating high (n=2.5) and low (n=1.4) refractive indexes?

5) Show that the power spectrum of a Gaussian pulse $f(t) = A \exp(-at^2 - i\omega_0 t)$ is also a Guassian pulse centered on ω_0.

6) Show that the focal length of a thin lens of refractive index *n* and surfaces with radius of curvature R_1 and R_2 is given by $f = ((n - 1)/R_1 - (n-1)/R_2)^{-1}$.

7) The major space agencies (NASA and ESA) are planning to build orbiting telescopes capable of imaging the large planets that have recently been discovered orbiting some of our neighboring stars. Show that the Airy pattern in the observation plane is related to the telescope diameter and the angular deviation of the incoming light. If they wish to resolve a planet in a 0.1 A.U. orbit, 10 parsecs from the Earth, what is the minimum diameter telescope required? How large would the telescope have to be in order to produce a crude image of the planet? How could you reduce the size of the orbiting instrument without reducing its power to resolve planets?

8) Light from a nearby star is reflected from a planet in close orbit. The motion of the planet causes a Doppler shift in the reflected light of 100 km s^{-1}. We wish to construct a Fourier transform interferometer to independently resolve the reflected light from that emitted directly by the star. If we observe a specific Calcium line in the star's emission spectrum (λ = 6439.07 Å), what is the minimum path length FTI required to separate the reflected spectrum from the direct spectrum?

9) If we instead decide to use a Fabry-Perot interferometer to resolve the reflected light, what reflectivity mirrors would be required? What would the free spectral range of the device be? Assume that the largest cavity that can be placed into orbit is 0.5 m and that the instrument is evacuated.

10) A laser emits a 1 Watt parallel beam of monochromatic light 1 mm in diameter. If the intensity is constant across the beam, what is the maximum amplitude of the magnetic field?

11) Derive the Fresnel approximation to the Kirchoff-Integral formula identifying all the assumptions required.

12) Show that the irradiance emitted over a hemisphere is π times the radiance.