ATI 2014
Exercises on Interference and Diffraction

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1. (a) Derive the angular intensity pattern $I(\theta)$ for two small pinholes separated by a distance d, where θ is the angle measured from the normal of the midpoint of the line between the two pinholes. Assume that the pinholes are illuminated by a distant point source and that $I(0) = I_0$. Also assume monochromatic light with wavelength λ, and assume that you are in the Fraunhoffer limit (i.e. the distance to the fringes is $>> d$). [3]

   (b) What is the angular separation between adjacent fringe peaks? [2]

   (c) The Sun is 150 million km away and is 1.4 million km in diameter. How close do the pinholes have to be before you'll see Young's fringes with the Sun? Assume a narrowband filter with $\lambda_0 = 0.5\mu m$. [2]

   (d) Sirius is a nearby star, nearly 25 apparent magnitudes fainter than the Sun. *Estimate* the maximum separation of the pinholes using only this fact. [2]

2. (a) The typical time for a dipole electronic transition in an atom is 10^{-8} seconds. What is the coherence length? [1]

   (b) The typical coherence time for a gas laser is 10^{-4} seconds. How big an interferometer can I build and still see fringes? [1]

3. Write down the angular far-field diffraction pattern $I(\theta)$ for a circular aperture radius a and wavelength λ. [6]

   Verify that the peak intensity I_1 of the first ring in the Airy pattern for far-field diffraction at a circular aperture is such that $I_1/I(0) = 0.0175$.

   A useful approximation for the first Bessel function:

$$J_1(u) = \frac{u}{2}\left[1 - \frac{1}{1!2!}(u/2)^2 + \frac{1}{2!3!}(u/2)^4 - \frac{1}{3!4!}(u/2)^6 + ...\right]$$