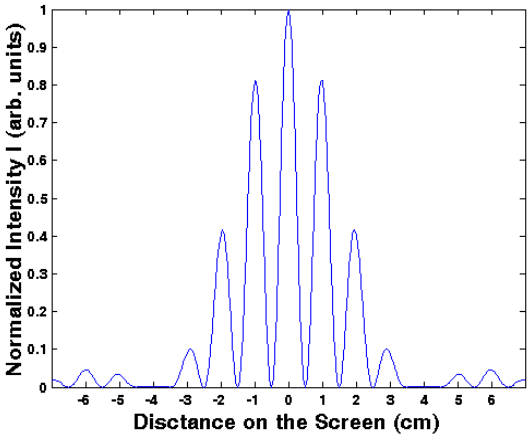
PHY 431 Homework Set #8

Due November 17 at the start of class

1) ***The double slit (20%)***

A plane wave of light from a laser has a wavelength of 6000 A°. The light is incident on a double slit. After passing through the double slit the light falls on a screen 100 cm beyond the double slit. The intensity distribution of the interference pattern on the screen is shown. What is the width of each slit and what is the separation of the two slits?



2) ***Fresnel/Fraunhofer Approximation (30%)***

[Hecht 10.11] Two long slits 0.10 mm wide, separated by 0.20 mm, in an opaque screen are illuminated by light with a wavelength of 500 nm. If the plane of observation is 2.5 m away, will the pattern correspond to Fraunhofer or Fresnel diffraction? How many Young's fringes will be seen within the central bright band?

3) ***Fraunhofer Diffraction (30%)***

a. Consider the Fraunhofer diffraction pattern due to two unequal slits. Let *a* and *b* be the unequal slit widths and *c* the distance between their centers. Derive and expression for the intensity of the pattern for any diffraction angle θ, assuming the arrangement to be illuminated by perpendicular light of wavelength λ.
b. Use your formula from (A) to obtain expression for the pattern in the following special cases and make a sketch of those patterns:
    i. *a=b,*
    ii. *a=0.*

4) ***Spatial and Spectral Resolution (20%)***

Two stars have an angular separation of 1×10^{-6} radian. They both emit light of wavelengths 5770 and 5790 A°.

A. How large a diameter of the lens in the telescope is needed to separate the image of the two stars?
B. How large a diffraction grating is needed to separate the two wavelengths present?

5) Liquid crystal half-wave plate (0.5 bonus point)

A half-wave plate has a phase retardation of π. Assume that the plane is oriented so that the azimuth angle (i.e., the angle between the x-axis and the slow axis of the plate) $\Psi=0$.

a. Find the polarization state of the transmitted beam, assuming that the incident beam is linearly polarized in the y direction.
b. Show that a half-wave plate will convert right-hand circularly polarized light into left-hand circularly polarized light, and vice-versa.
c. E7 is a nematic liquid crystal with $n_0=1.52$ and $n_e=1.75$ at $\lambda=577$ nm. Find the half-wave-plate thickness at this wavelength.

Note on nematic liquid crystal

See, for example, http://whatis.techtarget.com/definition/0,,sid9_gci843121,00.html

A nematic liquid crystal is a transparent or translucent liquid that causes the polarization (that is, the focusing in a plane) of light waves to change as the waves pass through the liquid. The extent of the change in polarization depends on the intensity of an applied electric field. Nematic comes from a Greek prefix *nemato* meaning threadlike and is used here because the molecules in the liquid align themselves into a threadlike shape. Nematic liquid crystals are used in twisted nematic displays, the most common form of liquid crystal display.

A typical nematic liquid crystal produces a 90-degree shift in the polarization of the light passing through when there is no electric field present. When a voltage is applied, an electric field is produced in the liquid, affecting the orientation of the molecules. This causes the polarization shift to be reduced. The effect is slight at low voltages, and increases as the voltage (and the resulting field strength) increases. When the applied voltage reaches a certain level, the polarization shift disappears entirely.

Because their light transmission properties can be deliberately varied as a function of applied external voltage, nematic liquids are used in alphanumeric liquid-crystal displays (LCDs), such as those found in digital wristwatches and many consumer electronic devices.