PHY252 Lab practical exam, <u>50 minutes</u>, during the week of April 27, 2009
First session times: 8:00, 10:20, 12:40, 3:00, 5:10, 7:20
Second session times: 9:00, 11:20, 1:40, 4:00, 6:10, 8:20

Diffraction and Interference (see Lab #9 in the Lab Manual)

Introduction

Light is an inherently quantum mechanical system. A laser's monochromatic (single wavelength) beam of light and narrow slits allow dramatic quantum effects to be observed.

Diffraction

A light beam impinges on a narrow slit. Immediately beyond the slit the position of the light beam is well defined, however, another aspect of the light, the direction of its components has been made uncertain. This process is known as *diffraction*, and results in the light beam being spread beyond the slit. The light is spread greatly if the slit is very narrow, but a pattern of light and dark regions is observed using a somewhat wider slit. This is a purely quantum mechanical effect that can be seen with particles as well as with light, and is **not** the result of the light "bouncing" off the edges of the slit.

Interference

Another quantum mechanical aspect to light is the addition or cancellation of light coming from two or more sources. This process is known as interference, constructive interference if the light intensity from the multiple sources is greater than the sum of their intensities, and destructive interference if the light intensity from the sources is nearly or completely cancelled. It is the wave-like nature of quantum mechanical systems that causes this effect, and analogous effects can be seen with particles.

Two-slit interference

The light generated by a single source (our laser) can be split into two beams by passing the light through two closely spaced and narrow slits. If the light from each slit is spread by diffraction then interference of the two beams of light can be seen.

Interference grating (also called a diffraction grating)

Also, multiple beams of light can interfere. A diffraction grating is a series of closely spaced and very narrow slits. The multiple beams created by passing the laser light through the grating are greatly spread by diffraction. Beyond the grating the pattern of light seen will be caused by the ***interference*** of the many light beams spread by diffraction.

Procedure

I. You will be given answer sheets on which **ALL** of your measurements of the light patterns, calculations, and answers to the questions are to be written. No scrap paper or aids of any kind other than a calculator are to be used during the practical exam. Required formulas will be provided.

II. You will be asked to record the pattern of light and dark regions created by slides with single slit, double slit, and a diffraction grating. You must carefully place each slide at its **SPECIFIED DISTANCE** from the recording paper. The distances are specific to your slides.

III. Based on the relationships between the wavelength of laser light, λ= 632.8 nm, the width of the slit(s) and the spacing of the slits as described in the lab manual you will be asked to calculate the width of the single slit, the slit width and slit spacing of the double slit, and the spacing of the slits of an interference grating.

Relationships needed

On a screen a distance D from a source, a location x_n from the beam axis corresponds to an angle, $\boxed{\theta_n = \tan^{-1}\left[x_n/D\right]}$.

A laser beam of wavelength, λ, illuminating slit of width, w, creates a diffraction pattern with a dark *minimum*, order n, at an angle, θ_n, related by $\boxed{w\sin\theta_n = n\lambda}$.

A laser beam of wavelength, λ, illuminating slits (double or multiple) of spacing, d, creates an interference pattern with a bright *maximum*, order m, at the angle, θ_m, that are related by $\boxed{d\sin\theta_m = m\lambda}$.

Note: a multi-slit's bright interference maximum located at the slit's diffraction minimum will appear dark.