PHY252 Lab practical exam, 50 minutes, during the week of April 25, 2011
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 #11 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 monochromatic 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, known as *diffraction*, results in the light beam spreading 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

A related 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 at a point where the light amplitude is equal to the sum of the source amplitudes, and destructive interference at a point where the light amplitude is partially or completely cancelled.

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. Note: in the light from a pair of slits a bright interference maximum can appear dark if it is located at the diffraction minimum of the slits. In the small angle approximation, interference maxima are ~ equally spaced.

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 (with an **B** or **C** label), and a double slit (with an **A**, **B**, **C,** or **D** label). You must be careful to place each slide at the **DISTANCE SPECIFIED** 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, and the slit width and slit spacing of the double slit, and their uncertainties. Also, you must answer the five questions given on the next page.

Relationships needed

On a screen a distance D from a source, a location x_n from the beam axis corresponds to an angle,

$$\boxed{\theta_n = \tan^{-1}\left[x_n / D\right]}. \quad \text{Eq. (1)}$$

A laser beam of wavelength, λ, illuminating a slit of width, w, creates a diffraction pattern with a dark *minimum*, order n, at an angle, θ_n, related by $\boxed{w\sin\theta_n = n\lambda}$. Eq. (2)

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 $\boxed{d\sin\theta_m = m\lambda}$. Eq. (3)

Questions

1) Were the two measurements of the single slit width from the single slit diffraction pattern, consistent with each other?

2) Which order m of in the two-slit interference pattern will give the least uncertainty in the slit spacing, d?
a) $m = 1$ b) $m = 2$ c) $m = 3$ d) largest m available e) smallest m available

3) For a two-slit interference pattern, if the width of each slit is made 20% smaller, what is the change in the angle of the first interference maximum?
a) 40% decrease b) 20% increase c) 40% increase d) 20% decrease e) no change

4) For an illuminated pair of slits, if the spacing between the slits is made 20% smaller, what is the change in the angle of the first diffraction minimum?
a) 40% decrease b) 20% increase c) 40% increase d) 20% decrease e) no change

5) It is not possible to block the light of a star (a pinpoint of light) holding at arms length a wire with the same width as your single slit. What physical property of light prevents this?