Single and Double Slit Experiments

I. EQUIPMENT LIST

- Optics Bench
- (3) Optics Bench Clamps
- He-Ne Laser
- Single-slit Slide
- Adjustable Slit
- Double-slit Slide
- Screen or whiteboard

II. BACKGROUND INFORMATION

One of the attributes of a wave is its ability to flare out behind barriers or openings/slits. Huygens' principle can be useful in explaining this behavior. Each point on the wave front acts as a secondary point source so some of the wave will propagate in directions NOT perpendicular to the edge. This phenomenon occurs for a "single slit" opening in an opaque material, as well as for "double slit" openings, resulting in the wave "flaring" around the edges of the openings, and producing interference effects.

<u>Double-slit interference/diffraction with slit separation ***d***</u>

The condition for interference maxima for a double slit is given by

$$d \sin\theta = m \boldsymbol{\lambda} \qquad (1)$$

The intensity pattern for a double slit is given by the following equation

$$I(\theta) = I_m \cos^2\beta \, (\sin\alpha/\alpha)^2 \quad \text{where } \beta = (\pi d/\lambda)\sin\theta \text{ and } \alpha = (\pi a/\lambda)\sin\theta \qquad (2)$$

<u>Single-slit diffraction with slit width ***a***</u>

The condition for diffraction minima for a single slit is given by

$$a \sin\theta = m \boldsymbol{\lambda} \qquad (3)$$

The single slit intensity pattern is given by the following equation where a is the slit width.

$$I(\theta) = I_m (\sin\alpha/\alpha)^2 \quad \text{where } \alpha = (\pi a/\lambda)\sin\theta \qquad (4)$$

<u>General slits</u>

The equation for the intensity function for N slits is given by

$$I(\theta) = I_m ((\sin\alpha)/\alpha)^2 ((\sin N\beta)/\sin\beta)^2 \qquad (5)$$

III. EXPERIMENTAL PROCEDURE

<u>1. Double Slit</u>

Using a laser, obtain a double slit interference pattern and project it on a relatively distant screen or wall or whitebeard. You should notice a general variation in intensity across this interference pattern. This is the "diffraction envelope" and is related to the width of a single slit, a, whereas the pattern within each envelope is related to the slit separation, d.

a) Carefully measure the distance from the slits to the projecting surface and make sure it does not change during your measurements.

b) Measure the distance between bright spots. Take at least four measurements. Create a data table and enter your measurements.

c) Measure the distance between dark spots. Take at least four measurements.

d) Count the number of bright interference fringes in the central diffraction maximum and compare to the calculated value.

e) Compute the separation between the slits, *d*, and the slit width, *a*.

f) Compare with the values printed on the slide before changing the setup.

Note: do this before putting away the setup.

g) Repeat for another double-slit on the slide.

2. Single Slit measurements

A. Fixed width single slit

Using the laser and a single-slit slide, obtain a diffraction pattern and project it on a relatively distant screen or wall or whitebeard. Observe the general behavior of the diffraction pattern from a single slit width.

a) Carefully measure and record the distance from the slits to the projecting surface.

b) Measure the distance between four bright spots and record this in a data table.

c) Measure the distance between four dark spots and record this information in your data table.

d) Use the average value to compute the predicted slit width from the diffraction pattern

e) Compare quantitatively the calculated value of the slit width with the value printed on the slide

Note: do this calculation before changing the setup.

f) Repeat for another slit width on the slide.

B. Adjustable-width single slit

Using the adjustable single slit, produce a single slit pattern on the wall

a) Measure the FWCM (full width of the central maximum)

b) Measure the distance between 4 dark spots and between 4 bright spots

c) Calculate the slit width and compare it with the measured width (if possible)

Note: do this before putting away the equipment.

V. CALCULATIONS

a) For the single and double-slit data compute the separation between the slits (*d*) and the slit width (*a*) and compare to the values printed on the slide. Show your results in a table.

b) Calculate the angle to the first two diffraction minima (Eq.1)

b) Use MATLAB or EXCEL to compute and plot the intensity patterns I/I_m as represented by Eq. 2 and 4 for one of each of the setups.

Compare with your experimental patterns.

Vary the parameters a and d and briefly describe your results.

VI. QUESTIONS

Consider a continuous spectrum such as that obtained using white light: is it possible for the first-order maximum for a given wavelength to overlap the second-order maximum for a different wavelength? Justify by showing your calculations.