Experiment 8:   Single & Double Slit Diffraction   Phys 431

Fraunhofer diffraction, also called far-field diffraction, occurs when the source and the screen are large distances from the diffracting mask. In Fresnel diffraction, the source and/or screen are so close to the mask that the light incident on the mask and screen cannot be considered plane waves. In this lab, you will explore Fraunhofer diffraction by sending a laser beam through single, double, and multiple slits, as shown schematically below. Please see the appendix for a brief summary of the principles.

You are required to photograph all of the diffraction patterns for your write-up. You will also need to make marks on the paper screen to record the distances between minima. FYI, the wavelength of the He-Ne laser is 6328 Å. Also, please note that each mask has nominal values for slit width, separation, etc. marked right on the card. These should be compared to the results of your measurements.
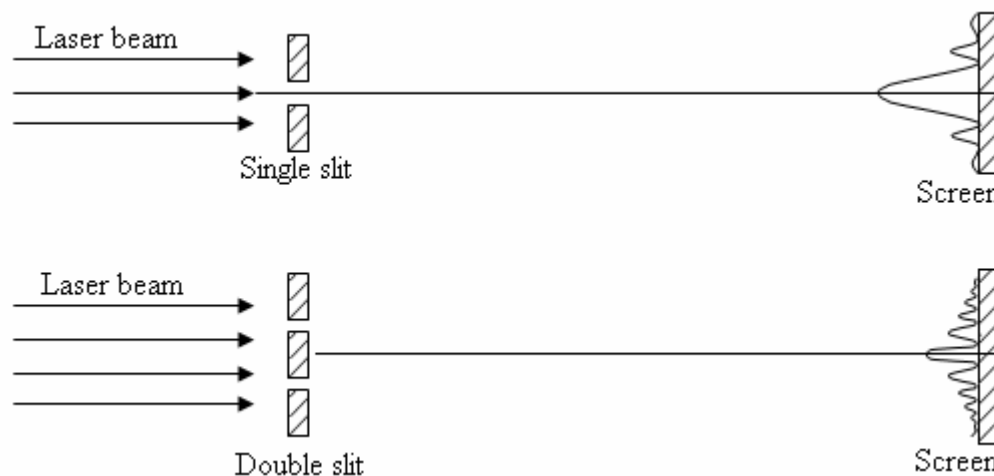
Procedure:

A. Record the patterns for four different width single slits (nominally 0.02mm, 0.04mm, 0.08mm and 0.16mm).**Q1** Based on Huygen's principle, can you qualitatively explain why the central maximum gets wider as the width becomes more narrow? From the positions of the minima and the distance to the screen, compute the slit widths. Of course, you should then compare the measured values to the nominal values marked on the masks.

B. Record the patterns for four different pairs of double slits (slit width 0.04 and spacing 0.25mm and 0.5mm, and slit width 0.08mm and slit spacing 0.25mm and 0.5mm). **Q2** Can you find any empirical relations between various parts of this more complex pattern and relate that to the slit spacing and slit separation?

C. Record the patterns resulting from four-slit and five-slit masks. From your measurements, compute the separation of the slits. **Q3** Can you deduce the number of slits from the diffraction pattern?

D. Find the card labeled "circular apertures" and choose either the square or hexagonal pattern. Both of these patterns are made up of smaller holes, as can be verified using

a magnifying glass. Now shine the laser on it and record the resulting diffraction pattern. **Q4** Can you explain the qualitative appearance of the diffraction pattern?

Appendix: Single & Double Slit Diffraction

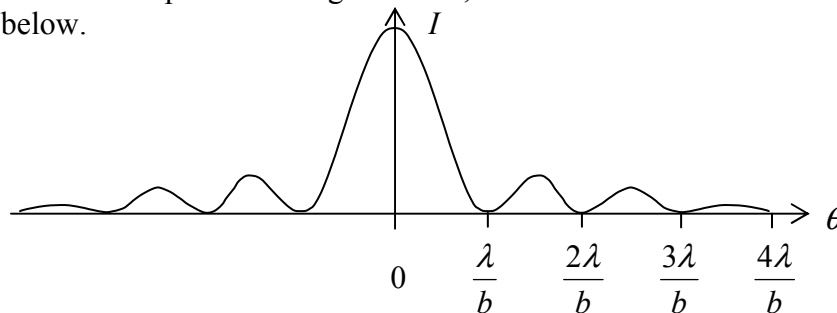## 1. Diffraction from a single slit

Screen

Plane Wave   Slit

Using Huygen's principle, we can imagine the slit to be filled with a line of point sources. Consider two point sources separated by b/2, one right at the edge and one at the center:
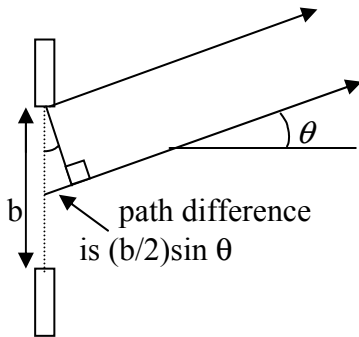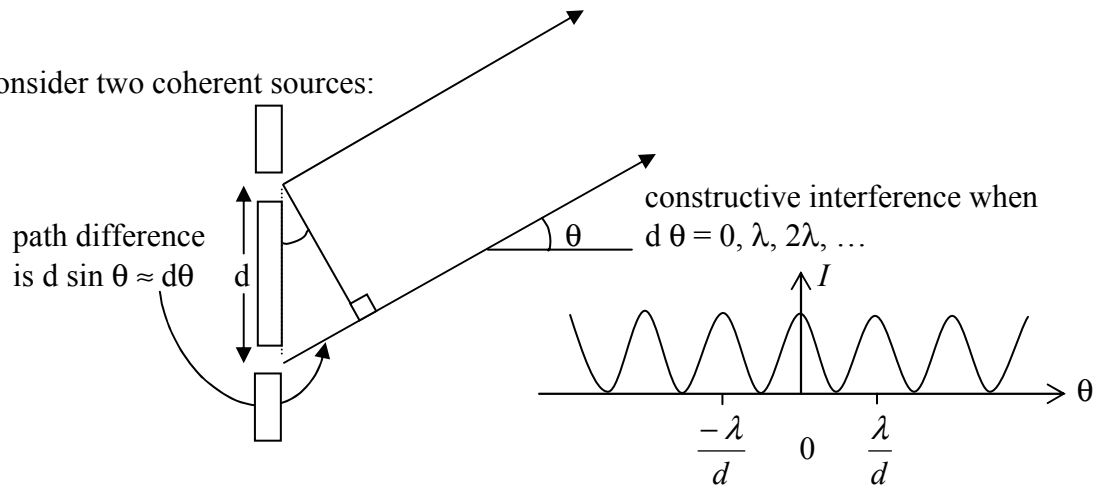
destructive interference when
$(b/2)\sin\theta = \lambda/2, \lambda, 3\lambda/2, \ldots$

b   path difference
is $(b/2)\sin\theta$

Now, each point sources can be paired with one b/2 away. If one pair is out-of-phase, they all will be out-of-phase. Note that a minimum does not appear at sin θ=0. This arises from the undiffracted beam, i.e. the point sources away from the edges, which produce rays that arrive in-phase. Taking $\sin\theta \approx \theta$, we see that the minima occur at the angles shown below.

I

0 $\dfrac{\lambda}{b}$ $\dfrac{2\lambda}{b}$ $\dfrac{3\lambda}{b}$ $\dfrac{4\lambda}{b}$ θ

2. **Diffraction from a double slit**

Consider two coherent sources:

path difference
is $d \sin \theta \approx d\theta$ d

constructive interference when
$d\,\theta = 0, \lambda, 2\lambda, \ldots$

I

$\dfrac{-\lambda}{d}$ 0 $\dfrac{\lambda}{d}$ θ

Now, lets consider that each slit has some non-zero width, b, which would results in the single-slit pattern if the slit were isolated. The resulting pattern is

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