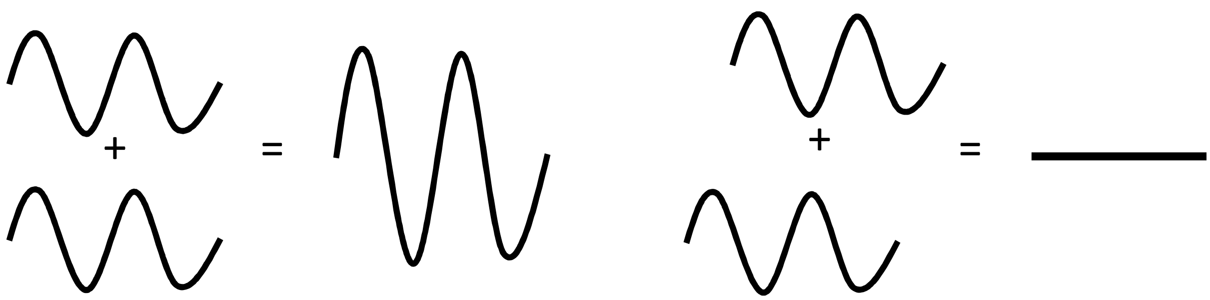
PHY 152/252

Interference and Diffraction of Light – Laboratory 9

Objective: The objective is to use the characteristics of light such as interference and diffraction and determine the slit width “w” for a single slit and the slit separation “d” for a double slit.

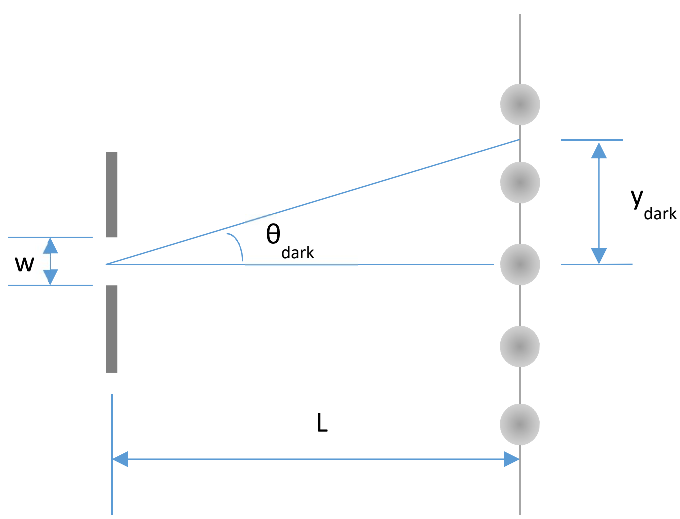
Theory: In 1801 Thomas Young successfully demonstrated the wave nature of light when he conducted an experiment of white light diffraction by passing a light through a pair of slits. Based on the theory of optics, this consequence of the superposition of light lead to the conclusion that any form of two waves superimposed on each other was simply the algebraic sum of the two.

In this lab, we will produce a series of bright and dark spots using a laser that passes through double and single slits where constructive and destructive interference takes place.



Constructive Interference Destructive Interference

Single Slit Experiment: The expression for single slit diffraction provides with the location of the destructive interference or the dark spots. In diagram,



Where w is the width of the slit, λ the wavelength of the light, and y_{dark} the distance from the central intensity maximum (bright spot) to the next intensity minimum (dark spot).

The location of the destructive interference (or the dark spots) is

$$\sin\theta_{dark} = \frac{m\lambda}{w} \qquad where\ m = \pm 1,\ \pm 3,\ \ldots$$

Mathematically, the *sinϑ* is

$$\sin\theta_{dark} = \frac{y_{dark}}{L}$$

(L is large compared to y_{dark}, so ϑ is small enough to approximate to this)

Therefore,

$$\frac{y_{dark}}{L} = \frac{m\lambda}{w} \qquad where\ m = \pm 1,\ \pm 3,\ \ldots$$

Solving for "*w*",

$$w = \frac{m\lambda L}{y_{dark}}$$

Double Slit Experiment: Double slit diffraction pattern can be made when a plane wave of light is incident on a pair of slits separated by a distance "a". The width of the slits (i.e. openings), *w*, has to be smaller than "*a*" so that we can observe diffraction patterns. After the diffracted light waves from the slits spread out and strike the screen to create the destructive and constructive interference patterns. If the difference in path length, *d*, is equal to an integer number of wavelengths, the constructive patterns occur. However, when the difference in path length is a ½ integer number of wavelengths, the destructive patterns take place.

The location of the constructive patterns (or bright spots) can be found:

$$d = a\sin\theta_{bright} = n\lambda; \qquad where\ n = 0,\ \pm 1,\ \pm 2, \ldots \quad (1)$$

For small angles ϑ,

$$\sin\theta_{bright} = \frac{y_{bright}}{L} \qquad (2)$$

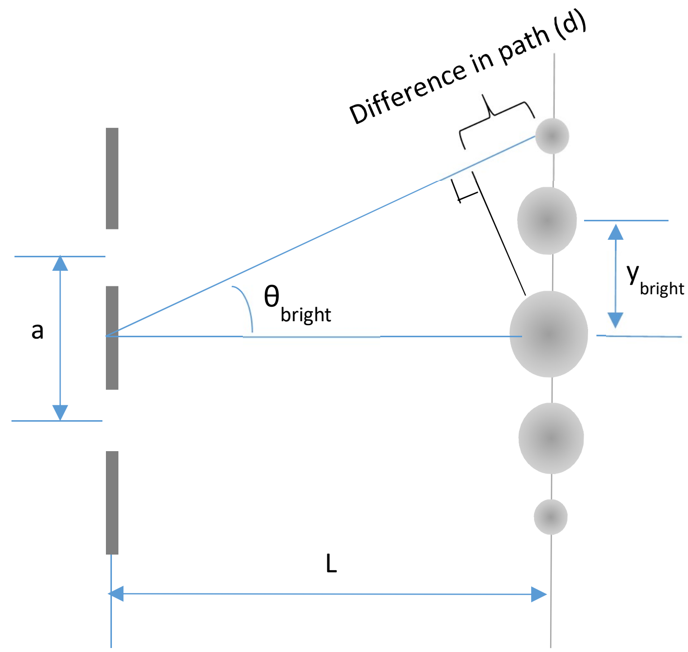
Where y_{bright} is the distance from the central maximum to the next one (bright spot).

From eq. (1) and (2),

$$y_{bright} = \frac{n\lambda L}{a}$$

So, "*a*" can be found to be

$$a = \frac{n\lambda L}{y_{bright}}$$



Procedure:

<u>Part 1 Double Slit Interference</u>

1. The laser must be perpendicular to the double slit apparatus and the slit parallel to the white screen.

2. Use the optic bench to properly adjust the positions of the slit and screen until you get a clear diffraction pattern.

3. Measure and record the locations of the central maximum and at least three modes on either sides of the bright spots corresponding to n=±1, ±2, ±3.

4. After recording them, turn off the laser, and measure and record the distance "L" from the optic bench.

<u>Part 2 Single Slit Interference</u>

5. Do the same setup as the procedure 1 (at this time, we are using a single slit)

6. Use the optic bench to properly adjust the positions of the slit and screen until you get a clear diffraction pattern.

7. Measure and record the locations of the central maximum and at least three modes on either sides of the dark spots corresponding to m=±1, ±2, ±3. <u>Note that you are measuring the locations of the dark spots.</u>

8. After recording them, turn off the laser, and measure and record the distance "L" from the optic bench.

Calculation:

Double slit experiment:

Distance, *L*:________________m

Manufacture's value for "*a*":________________m

Laser wavelength, *λ*:______________m

Mode	y_{bright} (R) (m)	y_{bright} (L) (m)	Avg. y_{bright} (m)	"a" (m)
±1				
±2				
±3				

Avg. experimental values, "*a*":__________________________

Calculate the percent difference for the experimental and manufacture's "*a*":

Single slit experiment:

Distance, *L*:________________m

Manufacture's value for "*a*":________________m

Laser wavelength, *λ*:______________m

Mode	y_{dark} (R) (m)	y_{dark} (L) (m)	Avg. y_{dark} (m)	"w" (m)
±1				
±2				
±3				

Avg. experimental values, "*w*":__________________________

Calculate the percent difference for the experimental and manufacture's "*w*":