# Lab 5: Interference and Diffraction
# Phys223 - Thursday (Ellis Roe)

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February 21, 2012

# Purpose

In this lab, we investigate interference and diffraction in both double and single slit experiments. We also look at diffraction on CDs and DVDs to observe the track spacing in the data storage. One of the main relationships noted in this lab is how the quantities of slit separation and slit width affect the resulting interference pattern. We expect that increasing the slit width increases the number of "groupings" of interference extrema. Increasing the slit separation will decrease the distance between each interference extrema in a group.

# Procedure

First, we did a simulated double slit experiment where we used two identical sinusoidal waves printed on transparent material to represent light rays from our simulated source. We pinned them 10cm apart which represented the slit separation. Next we drew a line perpendicular to the waves 50 cm away from where they were pinned. This line represents the screen where we can capture the intensity of the interfering light waves. Lining up the two waves along the screen, we were able to determine locations of maximum and minimum inteference (destructive and constructive) and compare them to the predicted values.

Next, we performed an actual double slit experiment using a 633 nm laser and slit disk with various slit dimensions. We shine the laser through several types of double slits and can observe the result on the screen. Here we see the relationship between slit separation/width and fringe spacing/grouping.

Afterwards, we direct the laser beam on a CD to observe the diffraction pattern on the screen. Using the known wavelength of the laser and the distance between the CD and screen, we can determine the track spacing on the CD. We then repeat the experiment with a DVD, and see that the diffraction pattern is much too large to measure, as it reaches the ceiling.

Finally, we investigate the diffraction from a single slit apparatus. Using a similar setup as the double slit, we shine a laser through single slits of various dimensions. Using measurements of the minimum on the diffraction pattern, we compare our results with the expected values from theory.

Further, we determine the thickness of human hair by measuring the diffraction pattern created when shining a coherent beam (our laser) at a single human hair. Using similar calculations as the single slit experiment, we can find the width of this hair.

# Data

## Simulated Double Slit

For some unknown reason (verified by Ellis), our constructive and destructive interference locations were not symmetric about the center point on the screen. This may have been an error in the setup of the two pinned waves, improperly drawn lines (not completely perpendicular), or a combination of the two. In any case, here is a table showing our results:

| y | Interference Type | $\lambda$ |
|---|---|---|
| 11 $\pm$ 0.25 cm | Constructive | 2.1 cm |
| 4.5 $\pm$ 0.25 cm | Destructive | 0.6 cm |
| 0 cm | Constructive | - |
| -6.75 $\pm$ 0.25 cm | Destructive | 2.6 cm |
| -12 $\pm$ 0.25 cm | Constructive | 2.3 cm |

In the above table, we calculated $\lambda$ using the following formulas derived from equations outlined in the lab text:

$$\lambda_{\text{max}} = \frac{d}{m} \sin\left(\tan^{-1}\left(\frac{y_{\text{bright}}}{L}\right)\right)$$

$$\lambda_{\text{min}} = \frac{d}{m + \frac{1}{2}} \sin\left(\tan^{-1}\left(\frac{y_{\text{dark}}}{L}\right)\right)$$

## Double Slit

For the double slit experiments, we tried three different dimensions of slit widths and slit separations. For each combination, we wrote a description of the interference pattern.

| Width | Separation | Description |
|---|---|---|
| 0.04 mm | 0.25 mm | Spacing between maxima were small but visible. |
| 0.04 mm | 0.5 mm | Same general pattern as with 0.25 mm separation, but space between individual maxima was imossible to measure |
| 0.08 mm | 0.25 mm | Same spacing between maxima as with 0.04 mm width slits, but there were many more groupings of maxima in this pattern. |

# Analysis

In the simulated double slit experiment we saw a larger scale, visual representation of the interference occuring. It was quite obvious how two waves hitting the screen in the same position could have varying amounts of interference, and that maxima and minima were easy to spot.

Actually performing the double slit experiment with the laser was instructive as we were able to see the impact that changing the two slit parameters (slit width and slit separation) had on the resulting interference pattern. Also experimenting with a CD was neat, as they were always a mystery.

Finally, the single slit experiment showed pure diffraction and how the intensities change at different locations on the screen. Also the slit size had a very large impact on the separation of the intensity maxima and minima.

# Conclusion

This lab gave the double slit experiment a tangible explanation and clearly showed how and why light interference happens. Not only did we see diffraction/intereference patterns through slits, but we also saw a little bit about how digital storage works (CDs and DVDs).