Physics 42 Lab 5: Double Slit Interference

Introduction

In today's lab we will determine the wavelength of a laser by analyzing its double slit diffraction pattern. We will shine a laser of wavelength $\lambda$ through a double slit with a given slit separation, $d$, which will produce an interference pattern on a screen a distance $x$ from the slits. We will measure the distances, $y$, from the center of the central maximum to each bright fringe of order $m$, as shown below. From this information we can use equation (1) to determine the angle and then equation (2) to calculate the wavelength of light.

$$\tan \theta = \frac{y}{x} \quad (1)$$
$$d \sin \theta = m\lambda, \quad m = 0, 1, 2, 3... \quad (2)$$

Equipment: Light benches, laser, power supply, optical bench stands (2), Double Slit Set wheel, wheel holder, long measuring tape, pen lights, magnifiers, clear rulers.

Experimental Procedure

Set up the equipment as shown by your instructor so you project the interference pattern on the wall at least 2 meters away from the double slit. Tape a piece of paper snuggly to the wall. Adjust the laser and apparatus to produce the best interference pattern possible. Carefully sketch the bright fringes with a pencil for as many as you can see, labeling the fringe order on both sides of the central bright maximum. Remove the paper and allow another student in the group to sketch the pattern. Repeat for 3 other slit width and slit separation sizes for a total of 4 interference patterns. Remove the paper and carefully measure the distances from the central bright fringe to the center of every fringe. Do not assume symmetry about the central fringe – measure the distance $y$ to each fringe. Label everything on your interference pattern page. Enter the values into the provided excel spreadsheet. Since this is a formal lab, each lab partner must collect their data and have their own interference pattern page and data page.

Be sure to note any sources of experimental error in the apparatus or measurement WHILE you are doing the experiment. Find the wavelength of light on your laser.
Analysis

Find the angle and the wavelength of light for each fringe for each of the four double slits. Calculate the wavelength using the small angle approximation too. Average all the values to find a final value for the wavelength of light. Generate an uncertainty using statistics (average deviation) on your data. Express your final result in standard form (average value +/- uncertainty). Does the true value fall within your uncertainty? What is the discrepancy? The percent error?

Lab Report

Introduction & Theory: Briefly explain the purpose of the lab. Show your experimental set up and a diagram from which you can derive the equations you use to find the wavelength in terms of your measured experimental values. Make sure that the variables in your diagram match the variables in your equations! In your derivation be sure to explain what assumptions and approximations you make and what they mean.

Procedure: Briefly explain your procedure. What were your sources of error?

Data: Include your data table and interference pattern page. Make sure your data/data sheets are labeled.

Calculations: Show sample calculations

Analysis & Conclusion: Express your final results (one using the angle and one using the small angle approximation) in standard form (average value +/- uncertainty). Does the true value fall within your uncertainty? What is the discrepancy and the percent error? What was the agreement between finding the wavelength using the small angle approximation and not using it? How do they compare as the angle increases?

How does the interference pattern change with changing slit separation and slit width? For example, if the slit width stays the same, but the slit separation changes, what happens to the interference fringes? Do they get brighter but otherwise do not change? Do the fringes get brighter and closer together? Brighter and farther apart? Do they get out of focus? Do they fade out and disappear? Etc. What if the slit separation stays the same, but the slit width changes? EXPLAIN.

Abstract: Lastly, write an abstract summarizing your experiment and results. It should be on the front page alone with your name, lab number, lab section, title, etc.

Lab reports will be graded based on writing, spelling, grammar, etc.