

Young's Two Slit Interference

Equipment Needed

Flashlight
Jack, Table
Laser, HeNe
Meter stick
Multiple Slit Set
Pasco Optics Bench
Pasco Viewing Screen, Optics Bench
Power Supply, Laser HeNe
Ruler, 15in.

Introduction

In this laboratory we will conduct what is known as Young's Two-Slit Experiment. Historically this experiment was very important, as it was one of the first experiments to clearly demonstrate the wave nature of light. In this experiment a coherent source of light is passed through two closely spaced slits as shown in Figure 1. Each slit acts as an independent source of light, and the light from the two sources interfere producing alternating bright and dark fringes. This effect is easy to understand if light is a wave and thus helped to firmly establish the wave theory of light.

With the advent of quantum mechanics, this experiment has taken on a new life. One of the predictions of quantum mechanics is that if viewed suitably, matter will exhibit wave properties. The first experiment to demonstrate this was carried out by Davisson and Germer in the 1920's. In their experiment, they took a coherent beam of electrons and effectively split it between two slits. They observed an interference pattern in the position of the electrons similar to

the one we will observe for light in our lab. Recently as technology has allowed researchers to effectively trap small numbers of atoms in a line, the Young's Two-Slit Experiment has seen renewed interest. Now researchers can view interference of light emitted from single atoms.

Figure 1 The interference of light from two slits

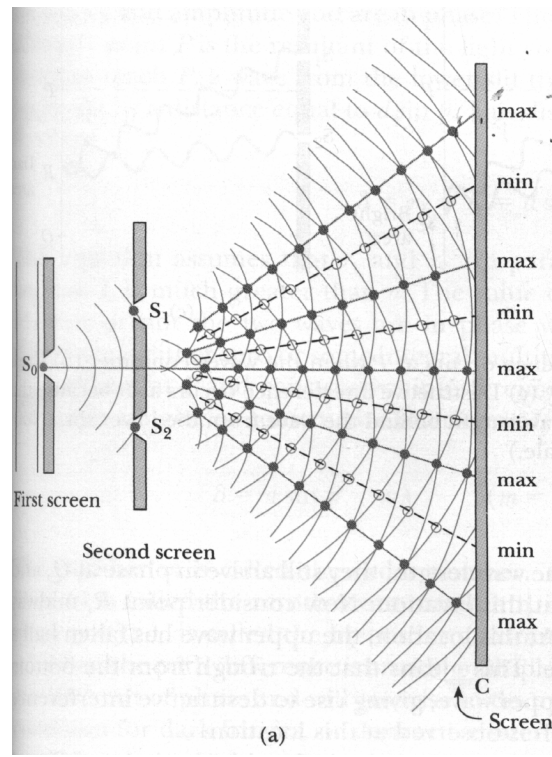


Figure 2

Figure 2 demonstrates the geometry of light after it has passed through the diffraction grating. Figure 3 shows the geometry between the grating and the screen. The pictured angle as shown denotes the second maxima. This is the same shown in Figure 2.

Figure 3

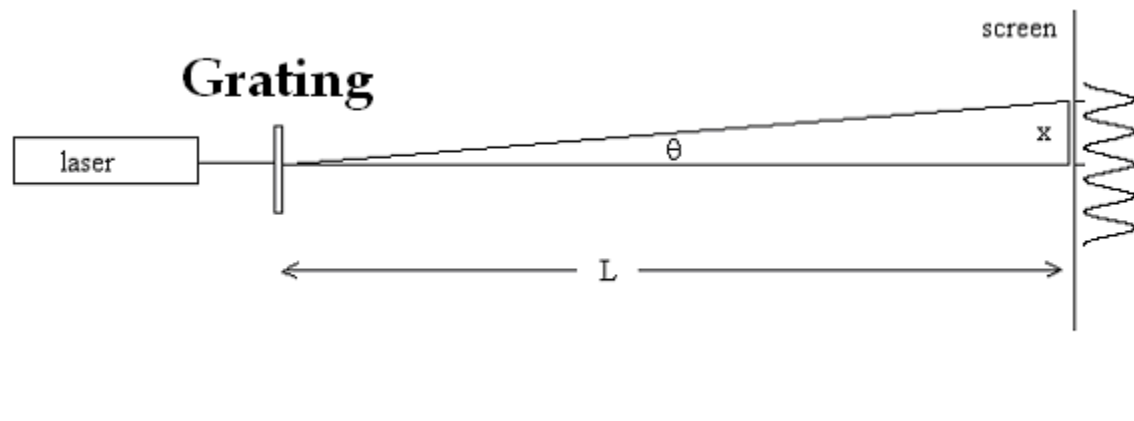


Figure 4 combines Figure 2 and Figure 3.

Figure 4

To show where the maxima are created we need to know the value of

This value was illustrated in Figure 2. Since this is the difference in distance of the two light beams from the two slits to the screen we will expect a maxima to appear at this point. Note: The maxima occur when the difference in distance equals a multiple of the wave length of the light. We also know that this difference will be equal to one multiple of the wavelength between the two beams so

Equation 1

We know that

Equation 2

If we assume that , then we have

Substituting we get

Equation 3

Rewriting Equation 3 to include multiple maxima we get

Equation 4

Where m is an integer denoting each successive maxima.

Similarly we can derive

Equation 5

which will denote the locations of each successive minima.

Safety

Although these lasers are not particularly dangerous, we should take a few simple precautions to prevent the unlikely event of eye damage.

1. **Never look directly into the laser beam.** Laser light has a high intensity and can also be easily focused. A direct shot of the laser beam on your eye will be focused by your cornea onto a small spot on your retina and can burn or possibly detach the retina.
2. **Never hold a reflecting object by hand in front of the laser beam.** This

- prevents the possibility of accidentally shining the light into your eyes.
3. **Keep your head above the plane of the laser beam.**
 4. Whenever the light strikes an object, there will be a reflection. At times the reflections can be almost as strong as the incident beam. **Know where the reflections are and block them if necessary.**
 5. The laser has a shutter in front of the beam. **When not taking data, place the shutter in front of the laser beam.**

Procedure

Set-up

Figure 5



To begin this lab, set up the optical bench with the HeNe laser mounted on one end as shown in Figure 5. Adjust the optical bench and the laser such that the laser beam points along the axis of the optical bench. Point the optical bench so that the laser is aimed away from the center of the room. Clip a piece of paper on the viewing screen.

Place the mount holding the double slits opposite the laser on the bench. Always

handle optics only by the edges, as this will prevent them from becoming smudged. This is particularly important when working with lasers because the smudges can become burned by the intense laser light and will damage the optics. Carefully position the double slits so that the laser hits the pair labeled $a = 0.08$ mm, $d = 0.25$ mm evenly. When you have proper alignment, remove the double slit and mark the point where the laser hits the paper. This will be your center mark from which to measure the maxima and minima. Replace the double slit and you will get a string of horizontal spots on the sheet. The brightest spot should lie on the mark where the laser struck the paper before and the spots will be symmetric in brightness on either side of the center.

Data Acquisition

Block the laser beam, and measure the distance from the slits to the spot on the screen. Unblock the laser, verify that center spot is aligned correctly, and then mark and label each of the *bright and dark* spots on the sheet of paper.

1. Do you notice something about the pattern of the brightness of the spots? Are all spots equally bright, or does the brightness vary?

Now position the laser so that it hits the small end of the variable double slit. Rotate the variable slit from the small end to the large.

2. How does the interference pattern change as you rotate the slits from smaller to larger slit spacing? Explain why.

Data Analysis

We will examine both the patterns of bright spots and dark spots. First we will use our pattern of bright spots, the slit to screen spacing, and the slit spacing to find the value of the HeNe laser wavelength. Following this, we will conduct an internal consistency check by using the pattern of dark spots, the value of the wavelength we determined and the screen to slit distance to determine the slit spacing.

Determine the position from the center of the center of each of the bright spots. Identify them with an integer counting from the middle. Going either way from your center mark the maxima should be symmetric. Graph the location of the spots versus y . Perform a linear regression to determine the slope of the best-fit line that passes through your data. From your slope, determine the wavelength.

Conduct a similar analysis with the dark spots. (Remember to use Equation 5) Take the first spot to the right of center as $m = 0$. Plot the location of the dark spots versus y . Use the linear regression to find the slope of the best-fit line that passes through the data. How does it compare with the slope you found for the maxima?

Calculate the percent difference of your wavelength findings with the known value of the HeNe laser.

Report Format

Turn in one set per group of your interference pattern, your data analysis, and answers to the numbered questions posed in the lab hand out.