

Experiment 29

Interference and Diffraction

Advanced Reading:

(Serway) Chapter 37, sections 37-1 & 37-2. Chapter 38, sections 38-1 & 38-2.

Equipment:

- 1 Laser
- 1 double slit slide
- 1 single slit slide
- 1 aluminum slit holder
- 1 meter stick
- 1 Vernier caliper

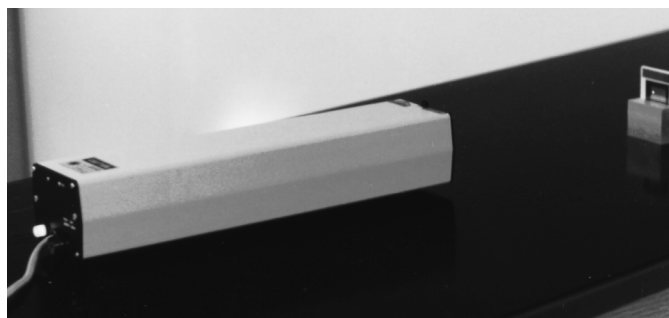


figure 29-1

Objective:

The object of this experiment is to study the diffraction and the interference patterns of single and double slits and from them to determine the wavelength of the laser light.

Theory:

Diffraction

Light passing through a narrow slit (slit width approximately equal to the wavelength of light), will produce a diffraction pattern if projected on a distant screen. This diffraction pattern consists of a series of light and dark bands.

Figure 29-2 shows a plot of the light intensity in the diffraction pattern on the right and the slit, greatly enlarged, on the left. The central bright band of the diffraction pattern subtends an angle of 2ϕ where $\phi = \lambda/d$, with λ being the wavelength of light and d being the slit width. The angle ϕ can be determined by measuring the distance from the slit to the screen and the width

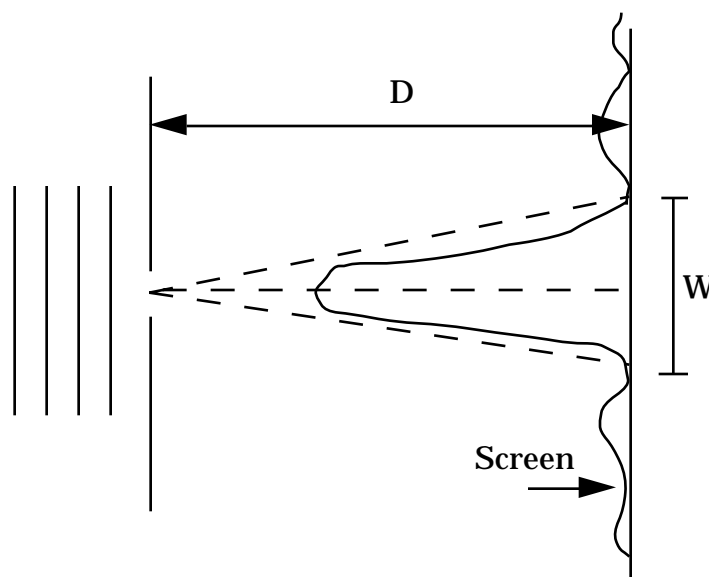


figure 29-2

of the central maximum, W . One can see from figure 29-2 that $2\tan\phi = W/D$.

Interference-Young's double slit

When coherent light (such as laser light) passes through two narrow slits that are very close together, an interference pattern will result. This pattern of light and dark parallel bands are called fringes and results from the addition and cancellation of light waves from the two slits, known as constructive and destructive interference respectively.

The two slits are treated as if they are two points of coherent light. Constructive interference occurs when the path length difference is equal to a integral number of whole wavelengths. Destructive interference occurs when the path length is an odd number of half wavelengths. From figure 29-3, we see that constructive interference occurs for $\delta = m\lambda$, but $\delta = d\sin\theta$, and for small angles, $\sin\theta \approx \tan\theta = y/D$. From this we find that:

$$\frac{dy}{D} = m\lambda \text{ or } \lambda = \frac{dy}{mD}$$

where $m=0, \pm 1, \pm 2, \dots$, with $m=0$ being the central maximum.

Procedure:

Part 1: Single slit diffraction

1. Put the smallest single slit (the slit width is printed on the slide) in the path of the laser beam and project the diffraction pattern on the screen. The screen should be about 1 meter from the slit. Measure the width of the central maximum with the Vernier calipers. Measure the distance from the slit to the screen.
2. Repeat for the other three slits.
3. Calculate the wavelength of the laser light for each of the slits and calculate an average value.

Part 2: Double slit interference

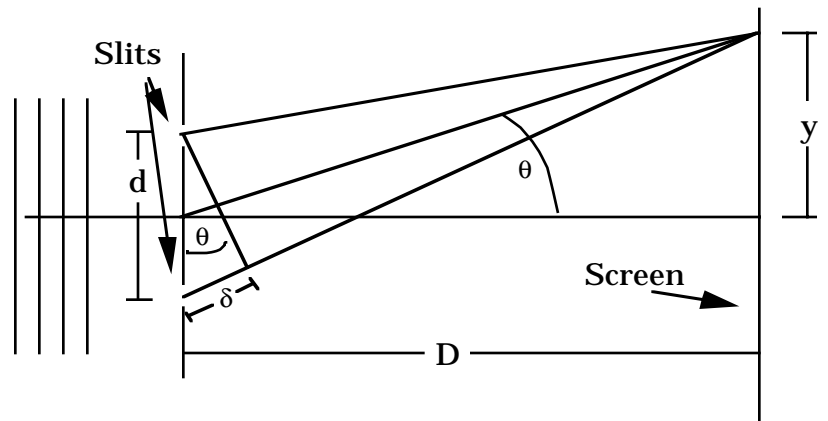


figure 29-3

4. Place the slide with the closest double slits in front of the laser beam and project the interference pattern on a screen approximately 1 meter away. The pattern should look similar to the one in part 1, only this one will have a series of smaller light and dark places. The lines to be measured are the narrow lines.

5. On the screen (a piece of paper) mark the position of the first 8 bright fringes to the right and to the left of the central maximum. Measure the separation between the right hand and the left hand fringes so that the distance between them is $2y$ (see figure 29-3)

6. Calculate an average y/m value for the above data. Use this average value to find the wavelength of the laser light using the equation:

$$\lambda = \frac{d}{D} \left(\frac{y}{m} \right)_{av}$$

7. Calculate the experimental error between the accepted value for the laser ($\lambda = 6238\text{\AA}$, $\text{\AA} = 10^{-10}$ meters)

and the experimental value for parts 1 and 2.

Questions/Conclusions:

1. What are the sources of uncertainty in this experiment?
2. Explain or compare diffraction and interference.