

Lab 6 : Interference and Diffraction

I. Purpose:

To observe how diffraction and interference both play a role in the intensity pattern observed when plane waves are incident upon multiple slits.

II. Theory:

The distinction between diffraction and interference is somewhat difficult to state clearly. Usually the term interference is reserved for cases in which the amplitude of a wavefront is obtained by considering the action of a few beams. Diffraction occurs when one has to sum over an infinite number of sources on a wavefront as in the case of the single slit. (See Jenkins and White, pg. 342) In multiple slit patterns both diffraction and interference play a role. The following equation gives an expression for the normalized intensity for a multiple slit pattern:

$$I = \frac{I_0}{N^2} \frac{\sin^2(\mathbf{b})}{\mathbf{b}^2} \frac{\sin^2(N\mathbf{g})}{\sin^2(\mathbf{g})}, \quad \text{Eq(1):}$$

where $\mathbf{b} = \frac{2p}{l} \frac{a}{2} \sin(\mathbf{q})$, a is the slitwidth, $\mathbf{g} = \frac{2p}{l} \frac{b}{2} \sin(\mathbf{q})$, b is the slit spacing, and N is the number of slits.

The first factor is simply a repeat of the intensity pattern for single slit diffraction. The second factor is referred to as the interference term. Principal maxima occur when $d(\sin(\theta)) = m\lambda$ where m is an integer. This can be obtained by allowing γ to approach $m\pi$. The interference term becomes indeterminate, application of l'Hopital's rule permits evaluation of the limit $\gamma \rightarrow m\pi$.

III. Procedure:

- 1) The set up is exactly as in the Fraunhofer diffraction lab. Hopefully, this will be in place from last week. In terms of the $\sin(\theta)$ the geometry is exactly the same as well.
- 2) Place the grating in the lens holder. Pattern D-5 slits (Pasco 9165c slide) should give good results. Record the distance from the grating to the photodetector. When the pattern is clearly visible begin taking data. For a 1/2 inch micrometer screw take 4-5 readings per turn. Make sure to start to the left of the central maximum as you begin taking data. You should get about 500 data points. This should take approximately one hour. As before, if you need to take data over a range larger than 1/2 inch, translate the diode on the optical rail and overlap your data from the two scans.
- 3) Plot your normalized data and the theoretical pattern on the same graph. Record the positions of the principle maximum and compare them to theory. Discuss any discrepancy between the two curves.

IV. Discussion :

- 1) Can you clearly see the positions of secondary maxima? If they are visible, do their positions correspond to theory. If they are not visible, why don't you see them. (Consult Jenkins and White, page 358). Where are the minima positioned? Can you clearly see this in your pattern? If they are visible, do their positions correspond to theory. If they are not visible, why don't you see them.
- 2) Describe a way (include a diagram) in which you could use this grating to measure the wavelength of the He-Ne laser.