**Experiment 8: Diffraction Patterns and Gratings**

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**Abstract**

Using a laser light source with wavelength of 651nm, diffraction patterns due to single slits, double slits, and hexagonal orientations were studied. Using equations derived from Huygen’s principle the single slit widths were verified to within about 20%. Measured data from double slit patterns indicates fringe spacing is consistant when slit width is. The spacing between slits only affects the observed ‘micro-fringes’. Components of white light are diffracted at different angles using a grating, separation of colors like blue, red, and green was observed. Other shapes only diffract constructively in planes perpendicular to flat edges of the mask shape.

**Introduction**

In this lab we study diffraction patterns resulting from the way light diffracts as it passes through masked holes of varying geometries. The pattern itself is an observation of interference due to the superposition of field vectors comprising the incident light, where relative phase differences govern whether it is constructive or destructive. A laser light of wavelength 651 nm was shined through several different masks then projected onto a screen far enough downstream that we can consider the diffraction to be ‘far-field’ and utilize handy approximations of small angles. Frauenhofer Diffraction is what we call this type of diffraction where the mask and screen are separated at distance much greater than that of individual slits in the mask.

A metal rail support system was utilized to set up our optical arrangements. Elements like the rotating masks, the laser, and the screen for projecting patterns downstream can all be screwed into clamps which secure these elements to the support rail in optical alignment.

Huygens’s Principle says to treat each point on a wavefront as an independent light source. As these intermediate sources radiate, one considers the line tangent to each of their wavefronts as the wavefront to the light as a whole. By drawing this tangent line one sees how the geometry works out to find respective optical path differences resulting in destructive interference:

**Analysis & Discussion**

The first mask geometries studied were single slit, but with four different widths: 0.04 mm, 0.08 mm, and 0.16 mm. The mask for each was rotated into the path of the laser one at a time. For each slit, the spacing of the fringes in the resulting pattern were marked on the screen downstream, measured, and logged.

Using the angle made between the line going from slit center to position of a dark fringe, and that of the optical axis, one can correlate transverse displacement on the screen (y) with the distance of the screen from the mask (L):

The equation in the initroduction correlating slit width (b) with wavelength lambda and theta can be substituted into the one above given that theta is the same in this case and that with small angles one can approximate sin(theta) = tan(theta). In doing so, an equation for slit width (b) can be found and shown to verify the slit width. Length L from the mask to the screen was measured to be 24.5 +/- 1cm.

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| --- | --- | --- |
| Slit 1: 0.02 mm | Slit 2: 0.04 mm | Slit 3: 0.08 mm |
| 8.0 | 3.5 | 1.5 |
| 16.5 | 7.5 | 3.5 |
| 24.5 | 11.0 | 5.5 |
| 33.5 | 29.0 | 7.5 |

Table 1: Distances measured from center of patterns to nth order destructive fringes. (1st, 2nd, 3rd, & 4th)

Using the distance from center to the first destructive fringe alone for y (row 1 in table 1) we calculated these values for slit widths, which happen to match their stated values quite well.

|  |  |  |
| --- | --- | --- |
| Slit 1 | Slit 2 | Slit 3 |
| 0.00199 mm | 0.00456 mm | 0.0106 mm |

**Q1** It’s clear from the data above that the width of the central constructive interference grows larger as the slit width decreases. This is a neat result as it would seem counterintuitive, however referring to huygen’s concept of a wavefront emitting from separate and intermediary point sources helps us. As the width of sources (the width of the slit) decreases, the wavelength and the factor of ½ stays constant, meaning the angle in sin(theta) must grow and the transverse distance y must as well.

We then tried masks with double slits. There were two with slit width (we’ll call width ‘a’) 0.04 mm: one had a slit spacing (we’ll call spacing ‘d’) of 0.25 mm, the other 0.5 mm. And there were two with slit width of 0.08mm and slit spacing 0.25mm and 0.5mm.

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| --- | --- | --- | --- |
| Slits 1: a=0.04mm, d=0.5mm | Slits 2: a=0.04mm, d=0.25mm | Slits 3: a=0.08mm, d=0.25mm | Slits 4: a=0.08, d=0.5mm |
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**Conclusion**