Diffraction with a Single Slit

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1 Introduction

Single slit diffraction demonstrates the wave-particle duality of light. Depending on both the wavelength of the light and the width of the slit, interference patterns with troughs of different amplitudes are formed at angles: $sin(\delta\theta) = \frac{\lambda \cdot n}{d}$, where d describes the width of the slit. Depending on λ and d, small angle approximation may be used.

2 Materials and methods

2.1 Brief description

In general He-NE laser with a narrow waveband 632.8 nm is used to approximate a monochromatic source. Ideally, a prism or a spatial filter is used in order to reduce the aberration of the source. The laser beam passes through the first filter to coarsely filter the source. The light then passes through another filter with narrower width such that we get our final diffraction pattern on the viewing screen or the photon detector. The viewing screen or the photo detector is installed on the right-end of the table such that the diffracted angle can be measured more precisely, under the assumption that our source is a monochromatic source. **Verify that whether we do need the first slit or not.**

2.2 Equipment

HeNe laser; calibration tool; optical breadboard Table; coarse slit on a film; a finer slit (around 100 µm); viewing screen; photo-detector with a coarse slit installed in front; a ruler is also required to measure the distance between the slit and the measurement device.

2.3 Setup

We utilize the length of the table by installing the laser on the far left-end of the table. Calibration of the laser then need to be done both vertically and then horizontally, according to laser's manual, or use the ThorLab alignment tool. First slit should be installed perpendicular to the light path around 10cm away from the source. The second slit should then follow closely at around 3-5cm away. Place the viewing screen on the far right end of the table such that the angle difference can be measured as precisely as possible.

3 Error Analysis

The uncertainties come from the width of laser beam, the width of the slit first and second, distance between the slit and the viewing screen/ detector, and the transverse displacement of the detector.

Data Analysis Bandwidth theorem is used, referring to Lab Manual of optical pumping experiment. We combine this into our calculation.

We estimate that the primary source of error comes from the uncertainty in the width of the slit because it is used inversely in the *arcsine* formula. Similar to the single slit experiment done with neutron, we will expresses our uncertainty

4 Data Analysis

The data we have post-experiemnt are the l, the distance between slit and the screen, d, the width of the slit, λ, the wavelength of laser, and a serie of transverse displacement δd_i,where the peaks interference are measured. For the photo-detector, we can measure more data such that we can generate a continuous plot with peaks and troughs at various angles. The purpose of generating this plot is to compare with the amplitude plot generated by the Fresnel Integral $I(\delta d_i)$.

For comparisons of the result, Fresnel Diffraction and Fraunhofer Diffraction theories can be applied to compared the calculated values and measured values.

5 Goals

1. Verify that the wavelength λ is indeed 632.8 nm.
2. Verify our amplitude function $A(\theta)$ as a function of the angle against the Fresnel Integral equation.

References

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