

Exercise 2 Report

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01.12.2025

Abstract

This exercise aimed to use numerical integration methods to investigate diffraction of light through an aperture onto a screen. Two calculation methods were used, a numerical calculation and Monte Carlo integration. The numerical method gave cleaner, less 'noisy' data, but the Monte Carlo method was considerably quicker.

1 Introduction

In this exercise we will use numerical methods to investigate the diffraction of light when passed through an aperture of different shapes. We will use two methods, first pure numerical integration methods, and then the Monte Carlo method, and compare the accuracy and speed of these two methods. We will first create a 1 dimensional plot of the diffraction to ensure the results are as expected, and then 2 dimensional plots, using both square and circular apertures.

2 Theory and Methods

To calculate the diffraction pattern of light passing through a single aperture, we will use the Fresnel diffraction integral, given by:

$$E(x, y, z) = \frac{e^{ikz}}{i\lambda z} \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} E(x', y') \exp\left\{\frac{ik}{2z}[(x - x')^2 + (y - y')^2]\right\} dx' dy' \quad (1)$$

To allow for this to be calculated computationally, we will simplify it, integrating over the area of the aperture, and separating out the real and imaginary parts of the equation:

$$\begin{aligned} E(x, y, z) = & \frac{kE_0}{2\pi z} \int_{x'_1}^{x'_2} \int_{y'_1(x')}^{y'_2(x')} \cos\left\{\frac{k}{2z}[(x - x')^2 + (y - y')^2]\right\} dx' dy' \\ & + i \frac{kE_0}{2\pi z} \int_{x'_1}^{x'_2} \int_{y'_1(x')}^{y'_2(x')} \sin\left\{\frac{k}{2z}[(x - x')^2 + (y - y')^2]\right\} dx' dy' \end{aligned} \quad (2)$$

3 Explanation of Code

4 Results and Discussion

5 Conclusion