



Overview

In his studies of light, the 17th century English physicist Isaac Newton noted how objects cast sharp shadows, and how sunlight through a pin hole forms a narrow beam. He took this as evidence that light consists of particles. If light were a wave, would it not diffract, bend around corners, even as water waves do? The 19th century physicist Thomas Young, through simple experiments, observed the diffraction of light and concluded that light is a wave. For awhile, the controversy was resolved in favor of waves. In the 20th century, Planck and Einstein stirred the pot. They explained, respectively, the blackbody and photoelectric effects by showing that light is apparently emitted and absorbed in discrete packets of energy. These “quanta” of energy are called photons, light particles. Nowadays we accept the paradox; light is both a particle and a wave, at times behaving like a particle and at other times like a wave.

We sense light with our eyes, but cannot see light waves. So how do we know that light is a wave? In this lab, you will shine a monochromatic beam of light through a grating and onto a blank sheet of paper. A grating is a small, transparent window inscribed with thousands of microscopic parallel lines. Light passes through the “window” slits between the lines. Theorizing that light is a wave whose wavelength is comparable to the slit spacing, we use simple geometric arguments to predict that the beam, having passed through the grating, will diffract and form an interference pattern on the paper.

Setup

Mount the laser pointer (of wavelength $630 \text{ nm} \leq \lambda \leq 680 \text{ nm}$) and grating on the stand as shown in the figure, and secure a blank sheet on the bench directly beneath the pointer. Place the grating labeled “1000 lines/mm” on the stand.

Procedure

Measure the distance L from the grating to the paper. Activate the laser beam, and mark the positions of the center spot and the diffracted spot. Measure the distance y from the center spot to the diffracted spot.

(1) Record L and y .

(2) Using the wave model, which predicts that $d \sin \theta = n\lambda$, where d is the spacing between grating lines and θ is the angle of deflection, predict the y deflection of the beam using $\lambda = 655 \text{ nm}$ and $n = 1$. Why do we use $n = 1$?

(3) Compare the predicted and measured deflections. What is the percent difference? Given the range of wavelengths of the laser pointer, is the difference acceptable?

(4) Repeat the experiment using the grating labeled “500 lines/mm”, but this time, work backwards from the measured values of L and y and determine the line spacing.

(5) Based on your experimental result, present an argument that light is a wave.