7 Interference, Diffraction and Polarization of Light

Two-Slit Interference

In two-slit interference, light falls on an opaque screen with two closely spaced, narrow slits. As Huygen’s principle tells us, each slit acts as a new source of light. Since the slits are illuminated by the same wave front, these sources are in phase. Where the wave fronts from the two sources overlap, an interference pattern is formed.

![Procedure Image](image)

Table 9.1: Experimental Apparatus

**Procedure**

1. Set up the Equipment as shown in Figure 9.1. The Slit Mask should be centered on the Component Holder. While looking through the Slit Mask, adjust the position of the Diffraction Scale so you can see the filament of the Light Source through the slot in the Diffraction Scale.
2. Attach the Diffraction Plate to the other side of the Component Holder, as shown. Center slit D, with the slits vertical, in the aperture of the Slit Mask. Look through the slits. By centering your eye so that you look through both the slits and the window of the Diffraction Plate, you should be able to see clearly both the interference pattern and the illuminated scale on the Diffraction Scale. You might want to shine a flashlight on the Diffraction Plate. Interference maxima will be observed at angles such that the path difference to the observation point is an integral number of wavelengths of the light.

\[
\sin \theta = n \lambda / d
\]

where \(d\) is the distance between the slits. In the figure below \(d\) is the length AB. For slit D on the
The Intensity Pattern

In the "ideal" two-slit interference experiment, the width of each of the 2 slits is much smaller than a wavelength of light. This makes each slit produce an approximately isotropic distribution, i.e. the same in all directions. But in order to produce enough light for you to see, this apparatus has slits which are large enough that their angular distribution is not isotropic; each slit produces an intensity pattern which corresponds to diffraction by a single narrow slit. The overall result you will see is the combination of these patterns, shown in Figure 9.2.

Measurements

3. Measure the distance, \( L \), from the diffraction plate to the diffraction scale. Then measure the distance, \( X \), on the Diffraction Scale, which corresponds to the \( n \)th intensity maximum. Remember, the central peak has \( n = 0 \). Choose a \( n \) less than that for the first diffraction minimum. From \( X \) and \( L \), determine \( \sin \theta \), and then compute the wavelength. Repeat this for all 3 colors (red, green and blue). Compare your results with approximate nominal wavelengths for these colors.

Polarization

Introduction

Light is a transverse wave; the electric and magnetic field vectors are always oriented in a direction perpendicular to the direction of propagation (see Figure 9.1). Light is linearly polarized when the electric field vector has a fixed orientation in the transverse plane. Figure 9.2 and 9.3 show vertical and horizontal linear polarization, respectively. Figure 9.4 depicts random polar-
Polarization, which occurs when the direction of polarization changes rapidly and randomly with time, as it does in the light from most incandescent light sources. Your optics equipment includes two Polarizers, which transmit only light that is polarized along the line defined by the 0 and 180 degree marks on the Polarizer scales. The components of the electric field in a direction perpendicular to this axis is absorbed by the polaroid material. Therefore, if randomly polarized light enters the Polarizer, the light that passes through is linearly polarized along the direction of this "pass axis". In this experiment, you will use the Polarizers to investigate the phenomena of polarized light.

Table 9.3: Intensity and diffraction "envelope" vs. angle for a similar setup.

Table 9.4: Electric field vectors for various forms of Polarized light
Linearly polarized light is also sometimes called "plane polarized" light. (There is another type of polarization, circular polarization, in which the electric field vector rotates in the transverse plane. We will not study this type in this laboratory.)

**Table 9.5: Setup for study of linearly polarized light**

**Procedure**
Set up the equipment as shown in Figure 9.5. Turn the Light Source on and view the Crossed Arrow Target with both Polarizers removed. Replace Polarizer A on the Component Holder. Rotate the Polarizer while viewing the target.

1. Does the target seem as bright when looking through the Polarizer as when looking directly at the target? Why?
2. Is the light from the Light Source linearly polarized? How can you tell?
3. Align Polarizer A so it transmits only vertically polarized light. Place Polarizer B on the other Component Holder. Looking through both polarizers, rotate Polarizer B. For what angles of Polarizer B is a maximum of light transmitted? For what angles is a minimum of light transmitted?

**Polarization by Reflection; Brewster’s Angle**

**Table 9.6: Setup for measurements of Brewster’s Angle**

Set up the equipment as shown in Figure 9.6. Adjust the components so a single ray of light passes through the center of the Ray Table. Notice the rays that are produced as the incident ray is
reflected and refracted at the flat surface of the Cylindrical Lens. (The room must be reasonably
dark to see the reflected ray.)

1. Rotate the Ray Table until the angle between the reflected and refracted rays is 90°. Arrange
the Ray Table Component Holder so it is in line with the reflected ray. Look through the
Polarizer at the filament of the light source (as seen reflected from the Cylindrical Lens), and
rotate the Polarizer slowly through all angles. Is the reflected light plane polarized? If so, at
what angle from the vertical is the plane of polarization?

2. Observe the reflected image for other angles of reflection. Is the light plane polarized when the
reflected ray is not at an angle of 90° with respect to the refracted ray? Explain.

The angle of incidence for which the reflected and refracted rays are perpendicular is called
Brewster’s Angle. It can be shown to be given by

\[ \tan \theta = n \]

for the case in which the incident ray is in air or vacuum. Measure the angle of incidence
and , using the previous measurement of n, compare it with the predicted value.