Diffraction Grating

Lab: 06

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1 Introduction

In this lab, we measure the distance between the slits on a diffraction grating glass slide by analyzing the diffraction pattern projected onto a screen and compare it to the theoretical value. We then experimentally measure the distance between bright spots and the central bright maxima and compare it to the theoretical values.

2 The Spacing for a Diffraction Grating

Consider the experiment provided by Physlet® Physics Exploration 38.2: Diffraction Grating. The location of the intensity maxima on a screen created by any diffraction grating is calculated such that

$$dsin(\theta) = m\lambda_{light} \tag{1}$$

Where d is the distance between adjacent slits. We set the experiment up such that the distance between slits is $d_{theory} = 3663\,\text{nm}$. That is, there are 273 slits per millimeter. Thus, we can experimentally calculate the distance between slits such that

$$d = \frac{m\lambda_{light}}{sin(\theta)} \tag{2}$$

Where m = 1,2. Below we put into a table the experimental data gathered from different wavelengths of light.

Table 1: Diffraction Pattern Data

λ [nm]	θ_1 [°]	θ_2 [°]	d_1 [nm]	d_2 [nm]	d_{avg} [nm]
589	9.2	18.8	3683.99	3655.37	3669.68
505	8.0	16.0	3628.58	3664.24	3646.405
470	7.3	15.0	3649.19	3631.88	3640.54

Thus, we can calculate d_{exp} by taking the average of the d_{avg} values for each wavelength in Table 1. That is,

$$d_{exp} = \frac{3669.68 + 3646.41 + 3640.54}{3} = 3652.21\,\text{nm} \tag{3}$$

We can then calculate the percent error between the theoretical distance d_{theory} and the experimental value such that

$$\%\text{ error} = \left(\frac{d_{exp} - d_{theory}}{d_{theory}}\right)100 = \left(\frac{3652.21nm - 3663nm}{3663nm}\right)100 = 0.295\,\% \tag{4}$$

3 Measuring the Location of the Diffraction Maxima

From the experiment, we can calculate the distance between the central bright maxima and any other diffraction maxima that corresponds to the *mth* bright fringe. If we let x be the distance from the middle grating to the central bright maximum, we can calculate the distance such that

$$y_m = xtan(\theta_m) \tag{5}$$

Using the previous case of yellow light where $\lambda = 589$nm, and taking the distance between the grating and the screen $x = 500$cm. We can compare the theoretical distances y_m to the experimental distances. Below we into a table the locations of the diffraction maxima for yellow light.

Table 1: Diffraction Pattern Data

x [cm]	m	θ_m [°]	$y_{m-theory}$ [cm]	y_{m-exp} [cm]	% error
500	2	9.2	82.774	3655.37	3669.68
500	1	18.8	3628.58	3664.24	3646.405
500	-1	9.4	3649.19	3631.88	3640.54
500	-2	18.8	3649.19	3631.88	3640.54