# 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

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

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

| $\lambda$ [nm] | $\theta_{m=1}$ [°] | $\theta_{m=2}$ [°] | $d_{m=1}$ [nm] | $d_{m=2}$ [nm] | $d_{avg}$ [nm] |
|---|---|---|---|---|---|
| 589 | 9.2 | 18.4 | 3683.99 | 3655.37 | 3669.68 |
| 505 | 8.0 | 16.0 | 3628.58 | 3664.24 | 3646.41 |
| 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

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

In this case, the percent error indicates that the experimental value is within 1% of the theoretical value which shows that the experiment is relatively accurate.

# 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 to obtain a percent error between the two. We can calculate the experimental values by simply measuring the distance between the central bright maxima and the *mth* maxima in the experiment. Below we into a table the locations of the diffraction maxima for yellow light.

Table 2: Location of Diffraction Maxima for Yellow Light (589nm)

| $x$ [cm] | m | $\theta_m$ [°] | $y_{m-theory}$ [cm] | $y_{m-exp}$ [cm] | % error |
|---|---|---|---|---|---|
| 500 | 2 | 18.4 | 170.21 | 171 | 0.462 |
| 500 | 1 | 9.2 | 80.98 | 81 | 0.022 |
| 500 | -1 | 9.2 | 80.98 | 81 | 0.022 |
| 500 | -2 | 18.4 | 170.21 | 170 | 0.125 |

(1) In this case, we get that the percent error was within 1% of the theoretical values. (2) Additionally, if the frequency of the light is decreased, the position of the maxima relative to the central axis decreases.

# 4 Conclusion

In this lab, we get that the distance between adjacent slits on a glass grating can be calculated by analyzing the diffraction pattern projected onto a screen by the grating slide. Using this method, we are able to calculate the distance within 1% of the theoretical value, which indicates the experiment was a success. Furthermore, the pattern projected onto the screen was consistent with what theory predicted the pattern to be. That is, the distance between the central bright and any *mth* diffraction maxima was equivalent to $y_m = xtan(\theta_m)$ within 0.5% error. The biggest takeaway was gaining a better understanding of how the theory can be applied to and is consistent with real world phenomena.