Diffraction from One Dimensional Grating *

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Experiment 3.2 introduced diffraction patterns for single slit arrangements. This exercise will show you diffraction patterns for a one dimensional transmission diffraction grating. This experiment will help you understand the reciprocal relation between the shape of the diffraction pattern and that of the grating that creates it.

Essential pre-lab reading:

1. "*Physics of Light and Optics*" by Justin Peatross and Michael Ware, Brigham Young University, 2013; (Chapter 10: Diffraction; Sections 10.2 to 10.4).
2. "*Physics of Light and Optics*" by Justin Peatross and Michael Ware, Brigham Young University, 2013; (Chapter 11: Diffraction Applications; Sections 11.3 to 11.5).

1 Test your understanding

1. Derive the Fraunhofer diffraction pattern for a one dimensional diffraction grating with narrow slits. Doing this exercise, you should be able to see that the diffraction pattern is the Fourier transform of the grating that creates it.
2. Calculate the slit separation as a function of the distance between the bright spots of the diffraction pattern.

2 The Experiment

A laser beam from a HeNe laser is incident on a diffraction grating. The grating part number is GT13-03 (Thorlabs), and it has 300 grooves/mm. The diffraction pattern is observed on a paper screen which is placed at a distance of $\approx$ 26 cm from the grating (Figure 1). Photographs of the diffraction pattern are recoded for quantitative analysis.

Turn on the laser and adjust the setup as shown in Figure 1. The laser beam should pass straight through the diffraction grating and fall on the paper screen. The diffraction pattern should be observable on the screen.

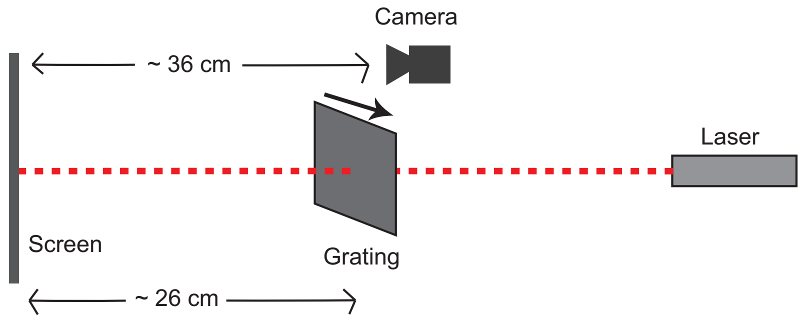

Figure 1: Schematic of the experimental setup. The red line represents the conceived path of the laser beam. The arrow shows orientation of the grating.

Connect the camera to the computer and open the software `uc480 Viewer`. Click on `Live video` icon. Now click on `Open camera` icon. You should now be able to see the image viewed by the camera. Adjust the intensity and focus of the camera using two knobs on it to achieve a clear result.

Turn off the lights and take an image of the diffraction pattern at an exposure time where you observe bright fringes on a black background. For adjusting the exposure time, click on the `uc480` menu and follow the path `Properties...`→ `Camera`→ `Exposure time`.

Click on `Save Image` icon to save the image in `.jpeg` format. Now, you have to convert it into an intensity graph using `ImageJ`. After opening the picture on `ImageJ`, use the mouse to select the area for which you want the intensity plot. Click on the `Analyze` menu and select the `Plot Profile` option. You will get an intensity plot with x-axis in pixels and y-axis in greyscale magnitude. Convert the pixels to cm and plot again the normalized intensity profile using `MATLAB` or a software of your choice.

Q 1. How would you find out the pixel-to-cm conversion factor?

Q 2. Plot the experimentally obtained intensity profile with the theoretically predicted profile. Do they agree?

Q 3. Using the number of grooves per mm, calculate the slit separation of the diffraction grating.

Q 4. Find the slit separation from the experimental intensity profile. Does it agree with the previously calculated slit separation. Quote the uncertainty as well.