Phys 4910 Spectroscopy
Diffraction Gratings

IMPORTANT

This laboratory also uses lasers. Please review and practice the simple laser measures from the lab on refractive index.

Introduction

This laboratory exercise looks at the interference pattern produced by a diffraction grating, from the simplest ratings (2 and 5 openings) to ones with hundreds of openings

Grating formula

If d is the separation of each slit (not their width) then intensity maxima are observed when

$$m\lambda = d\,(\sin\theta + \sin\varphi)$$

where θ and φ are the incident and diffraction angle respectively. The mode number m can be any integer.

Lab objectives

2 slit patterns

1. Place the 2 slit slide in the red laser beam (λ = 632.8 nm) so that the beam passes through any pair of slits (there are four pairs to choose from). Measure the interference pattern on the wall.
2. Plot $\sin\theta$ as a function of m ($-10 \le m \le +10$), and deduce the slit separation. (Don't ignore uncertainties) Note: the actual slit separations are typed on the slide for comparison. Also their may be some “missing orders” as a result of the variation with intensity die to diffraction. Ignore these orders.
3. Replace the red laser with a green laser, a measure its diffraction pattern.
4. Plot $\sin\theta$ as a function of m ($-10 \le m \le +10$), and using your measured slit separation, deduce the wavelength of the green laser. You can compare with the known wavelength, and don't forget uncertainties.

Diffraction Grating

1. This is a repeat of the 2 slit procedure, except that with the diffraction grating you should get better results.
   1. Place the diffraction grating in the red laser beam (λ = 632.8 nm) so that the beam passes through any pair of slits (there are four pairs to choose from). Measure the interference pattern on the wall.
   2. Plot $\sin\theta$ as a function of m ($-3 \leq m \leq +3$), and deduce the slit separation. (Don't ignore uncertainties) Note: for comparison the actual slit separation can be found from the number of lines per millimeter printed on the slide.
   3. Replace the red laser with a green laser, a measure its diffraction pattern.
   4. Plot $\sin\theta$ as a function of m ($-3 \leq m \leq +3$), and using your measured slit separation, deduce the wavelength of the green laser. Again, you can compare with the known wavelength, and don't forget uncertainties.
2. An important property of diffraction gratings is the resolution, defined as $\lambda/\Delta\lambda$. Theoretically it is should equal mN, where m is the order number and N is the number of illuminated (not total) slits. In practice it is usually less than less.
   1. A good rule of thumb says that the minimum uncertainty in the position of any one maximum is one half of its width. Measure the width of the m=1 and the m=2 maxima (there is some subjective judgment here.)
   2. Use the grating equation (above) to relate the uncertainty in the position in the maxima to the uncertainty in wavelength ($\Delta\lambda$), and hence determine the resolution.
   3. For each mode number (m) use the result from part 2 to estimate how many lines were illuminated by your beam. Does the average correspond to the number you can calculate from the stated number of lines/mm for the grating and the width of the incident laser beam.

Problem assignment

A CD has a single track which starts at the inside edge of that part of the CD which contains information, and spirals outward from there. Use the information that you have being using about diffraction gratings (plus the physical measurements of the CD itself) to ***estimate*** the total length of this track.