Diffraction Gratings

I. EQUIPMENT LIST

* Diffraction gratings
* White light source
* Rulers
* Optical bench
* Laser
* Meter Stick

II. BACKGROUND INFORMATION

A diffraction grating is made by constructing a system where many narrow slits close together are made by placing grooves onto a plate. Common laboratory gratings have 300 to 600 grooves per mm. When the light passes through the diffraction grating it produces an interference pattern of sharpo maxima which are well separate. The position of maximum intensity is given by

$d\ sin\theta = m\ \boldsymbol{\lambda}$ **,** where $d = 1/n$ is the spacing between the rulings and n is the number of rulings per unit length.

The equation for the intensity function for N slits of slit width a spaced at distance d is given by

$I(\theta) = I_m((\sin\alpha)/\alpha)^2 ((\sin N\beta)/\sin\beta)^2$ where $\beta = (\pi d/\lambda)\sin\theta$ and $\alpha = (\pi a/\lambda)\sin\theta$

A *Ronchi grating* is ruled so that the width of the slit is identical to the width of the black space between slits, i.e.: d=2a. This means that the diffraction pattern zeros occur exactly on top of the even-order interference maxima.

Depending on the light source the spectrum obtained from a diffraction grating can be continuous (like a rainbow) or discrete lines (individual frequencies of light separated from each other). The discrete spectra are typically emitted from a gas. The wavelengths present in the spectrum can be used to identify the material in the gas; this will be the subject of a different lab.

III. EXPERIMENTAL PROCEDURE

1. *Educational gratings*: 100, 300, 600 rulings/mm

Setup a diffraction pattern on a reasonably far away screen.
Carefully measure the distance L from the grating to the screen.
Measure the spacing between the interference maxima and record the order of interference for each peak.

2. *Course and/or Mystery gratings*

Use one of the course gratings and/or the “mystery grating” to set up diffraction patterns.
Make measurements aimed at calculating both distances *a* and *d*.

3. *Ronchi rulings*

Measure the patterns produced by a Ronchi ruling.

IV. CALCULATIONS

1. *Educational gratings*
    A. For each grating calculate the wavelength of the laser based on the average distance between the peaks; quantitatively compare with the known value. Which grating gives the best result? Why?
    B. With data from all three gratings:

Calculate the angle θ corresponding to the first-order interference peaks you measured based on the av
Build a linear graph of d vs. 1/sin θ.
Identify the slope of the graph, use it to determine the wavelength of the laser and quantitatively compare it with the known value of 633 nm.

2. *Course and/or Mystery grating*

Calculate the opening *a*, the distancing *d* for your grating and the *n* value.

3. *Ronchi rulings*

Compute the opening *a* and the distance *a* and quantitatively compare the value of *n* with labeled one.

4. Use MATLAB or EXCEL to compute and plot the intensity patterns I/I_m for general slits using N>4.

V. CONCLUSION/QUESTIONS

1. What happens to the spacing of the spectrum as the grating had more lines per unit length? Why?

2. What happens when the grating is illuminated with white light? Is it possible for a first-order spectrum to overlap the second-order spectrum? Why?

3. What is the advantage of Ronchi gratings with $d=2a$, meaning the diffraction pattern zeros occur exactly on top of the even-order interference maxima?

4. Compare your calculated intensity pattern for general slits with
    a. the double slit pattern calculated in the previous lab, and
    b. the experimental patterns observed in the current lab.