Experiment 11

THE DIFFRACTION GRATING

Light, when passed through a diffraction grating will be separated into its constituent colors. Particular wavelengths of color can be calculated by using multiple slit theory of interference.

THEORY:

     A diffraction grating contains many slits separated by a very small distance "d". With many slits, antinodes are very sharply defined and different wavelengths can be resolved more easily.

    For slits separated by a distance "d", the position of the antinodes is given by,

$$\sin \phi = m\lambda/d \qquad \text{where m= 1,2,3... is the "order"} \tag{1}$$

     The position of an anti-node (YA) from the central maximum at a distance "L" from the grating is given by,

$$\tan \phi = YA/L \tag{2}$$

The wavelength can be determined for small angles by combining the two formulas into,

$$\lambda = d\ YA/mL \tag{3}$$

The uncertainty in the measurement of the wavelength is given by,

$$\delta\lambda = \lambda[\delta Y_A/Y_A + \delta L/L]$$

APPARATUS:

       diffraction grating holder   meter stick
       discharge tube power supply   diffraction scale
       hydrogen discharge tube   diffraction grating
       sodium light source

PROCEDURE:
1. Turn on the sodium lamp to let it warm up.

2. Record the lines/length rating of the grating. From this you will determine "d".

3. Set the grating in its holder, making sure that you don't touch the lines of the grating.

4. Set the holder on the meter stick. Also set the scale on the meter-stick some distance away from the grating. This distance will be "L" and you can change it as it becomes convenient to do so in the experiment.

5. Aim the small opening on the scale toward the light source so that some light passes through it. Observe the first order spectrum on either side of the opening.

6. Record the Position of the sodium yellow line on the scale and estimate its uncertainty. Make sure that you are measuring the line that fall <u>on</u> the scale and not the lines that you may see in the space above or below the scale.

7. Adjust the distance L so that you can see the second order spectrum on the scale. Again, record the position of the yellow line and its uncertainty. Also record L and its uncertainty.

8. Attempt to observe the third order spectrum. It is possible that you will not be able to do this.

9. Replace the sodium lamp with a hydrogen discharge tube. Be aware not to touch the tube when it is on, as it is high voltage. Repeat the experiment for all the colors that can be seen in the hydrogen spectrum.

ANALYSIS:

Use the data collected above to calculate the wavelength (and uncertainty) of the sodium yellow line, and of the various wavelengths of the visible hydrogen spectrum. Perform a separate calculation for each order of spectra and compare values of the same wavelengths to each other and to the known values of these wavelengths.

RESULTS:

Summarize all your final results in a table. Use one-dimensional graphs to compare the wavelengths obtained with the known values.