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Pledge

I solemnly affirm that I am presenting this journal based on my own experimental work. I have neither copied the observations, calculations, graphs and results from others nor given it to others for copying.

Signature of the student

Experiment 2: Diffraction Grating

Aim: To measure the wavelengths of spectral lines of a Mercury (Hg) source using diffraction grating and a spectrometer.

Apparatus:
1. Diffraction grating
2. Spectrometer
3. Mercury source (Hg)
4. Spirit level
5. Reading lamp and reading lens

Significance of the experiment: *Diffraction grating is basically a super-prism. It disperses the light in to its spectrum, with dispersive power and resolving power quite higher than that of prism. The grating assists an analytical technique called spectroscopy in the formation and analysis of spectra.*

Theory: Diffraction grating is an arrangement of large number of equidistant and parallel slits (Fig 2.1). One of the techniques to manufacture diffraction grating is to rule the equidistant lines on glass plate. Typical diffraction gratings consist of 15000-20000 lines per inch (this number can reach up to 100000 lines per inch). The qualities i.e. dispersive power and resolving power depend upon number of slits and slit density.

Using theory of diffraction to multiple slits, following grating equation can be derived

$$d \sin\theta = m\lambda \tag{2.1}$$

Where
- d = grating element
- θ = angle of diffraction
- m = order of spectrum
- λ = wavelength of light

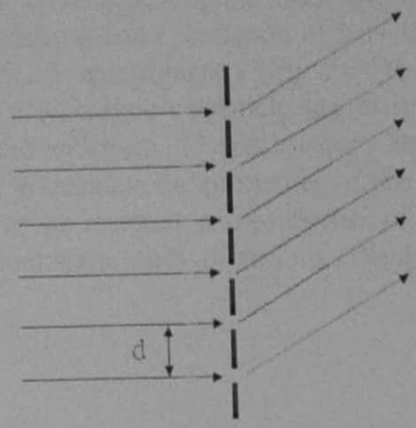

Figure 2.1: Diffraction grating

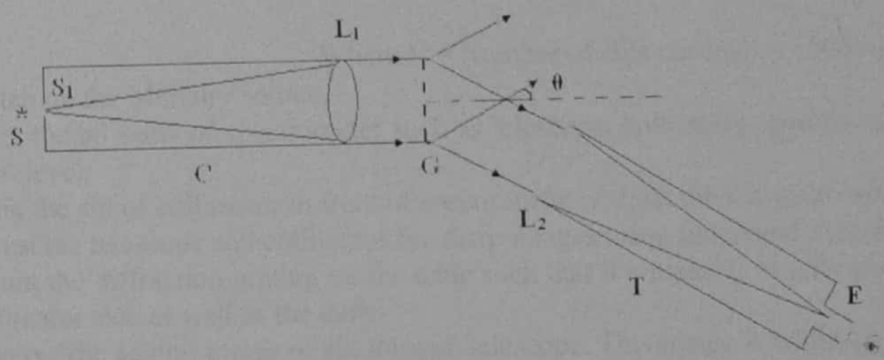

Figure 2.2: Spectrometer

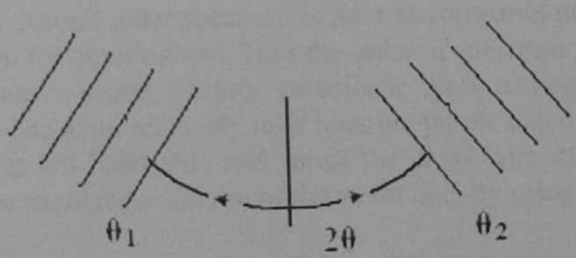

Figure 2.3: Definition of 2θ

In equation (2.1), d and m are constant. This implies that θ is proportional to λ. Thus if a grating is exposed to light from polychromatic source, the colors are separated on account of their different wavelengths. Thus diffraction grating can form the spectrum of the light. With respect to dispersive power and resolving power, grating is far better than prism. Further, if d and m are known and if θ is measured then λ, the wavelength of spectral lines can be calculated. Due to its ability to form well resolved spectrum and calculation of wavelengths, diffraction grating finds applications in spectrometers. Such spectrometers (Fig 2.2) find applications in an important discipline called spectroscopy, a technique extremely useful in science and technology. Each source has its own characteristic spectrum. In spectroscopy the spectra of various atomic or molecular species are analyzed to evaluate the properties of the sources. A few applications of spectroscopy are - understanding the structure and properties of atoms and molecules, detection of various elements in planets and stars, study of various effects such as Zeeman effect, Raman effect, Stark effect etc.

Procedure:

1. At first calculate the grating element d of the grating by using following formula

$$d = \frac{1}{N}\ inches = \frac{2.54}{N}\ cms = \frac{2.54\times10^{8}}{N} A^{o} \tag{2.2}$$

Where N = Number of slits per inch = 15000 slits per inch

2. Switch on the Mercury source.
3. Level the all parts of spectrometer such as telescope, collimator, grating table etc. using spirit level.
4. Bring the slit of collimator in front of spectrometer. Adjust the slit width optimum value.
5. Adjust the telescope and collimator for sharp images using prism and Schuster's method
6. Mount the diffraction grating on the table such that it's plane is exactly perpendicular to collimator axis as well as the table
7. Observe the central image of slit through telescope. This image is white, as colors cannot be separated in zeroth order. This is called as zeroth order spectrum. Make the image sharp by focusing the telescope and collimator
8. Unlike prism, grating produces multiple spectra. Move the telescope on both sides of the central image to observe the first as well as second order spectra on both the sides of the central image. The second order spectrum is faint as compared to first order. So consider first order spectrum for observations. Thus the order of spectrum m in Eqn (2.1) is 1. The first order spectrum consists of four prominent lines namely violet, green, yellow (doublet) and red. The other relatively faint lines are purple and orange.
9. Move the telescope on left hand side and adjust the cross wire on violet line. Clamp the telescope. Measure the angular position θ_l of the violet line, by using following procedure

$$\theta_1 = MSR + VSR \times LC$$

Where **MSR:** Main scale reading: a reading on the scale which coincides with the zero of the vernier scale. If no reading coincides then MSR is the reading on the main scale previous to zero of the vernier scale.
VSR: Vernier scale reading is the sequence number of the division on the vernier scale which exactly coincides with the division on main scale
LC = Least count of the angular scale.

$$LC = \frac{Smallest division on the main scale\ (X)}{Number of divisions on the vernier scale\ (Y)} = \frac{{}^{o}}{} = \frac{}{} = \cdots, minute$$

10. Now unclamp the telescope and move it on right side of the central image and focus the cross wire on the violet line. Measure its position θ_2 by using the procedure in step 9.
11. Calculate θ by using following procedure

$$2\theta = |\theta_2 - \theta_1| \text{ and } \theta = \frac{2\theta}{2} \qquad (2.3)$$

12. Calculate the wavelength of violet line by substituting θ in the following Eqn.

$$\lambda_e = \frac{d \sin\theta}{m}$$

Where d = grating element as calculated in step 1
m = order of the spectrum = 1

13. Calculate the percentage deviation by using following formula

$$\%\ deviation = \left|\frac{\lambda_e - \lambda_s}{\lambda_s}\right| \times 100\%$$

Where λ_e = experimental wavelength as calculated in step (12)
λ_s = standard wavelength, given in the table 2.1

14. Repeat the same procedure in step 9 to 13 for remaining spectral lines i.e. green, yellow and red.
15. Tabulate your observations, calculations and results in table 2.1.

ROUGH WORK:

Table (2.1) Observations, Calculations and Results

d = grating element $= d = \frac{2.54\times10^8}{N} A^o = \frac{2.54\times10^8}{15000} A^o =$ 16933.33 A^o

m = order of the spectrum = 1

Sr. No.	Spectral Line	Angular positions Left, θ_1 (deg. min.)	Right, θ_2 (deg. min.)	2θ (deg. min.)	Angle of diffraction θ (deg. min.)	Experimental wavelength $\lambda_e(A^o)$	Standard Wavelength $\lambda_s(A^o)$	% deviation %
1	Violet	138° 10'	170° 26'	32° 16'	16° 8'	4705.32	4387	7.255
2	Green	136° 21'	176° 05'	39° 44'	19° 51'	5754.49	5460	5.393
3	Yellow	135.21	177° 10'	41° 22'	20° 40'	5980.69	5790	3.296
4	Red	133.31	178° 47'	45° 16'	22° 38'	6516.49	6330	2.946

FAIR WORK:

Table (2.1) Observations, Calculations and Results

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My Understanding of the Experiment

(Not exceeding 5 to 6 lines)

In this exp. when light waves overlap they create interference, & patterns caused by this can be used to determine the wavelength of light. By using closely spaced slits, the light is diffracted to large angles, by doing this we can get more accurate measurements.