<u>Experiment No. 9.</u>

AIM: To understand the diffraction phenomenon and to determine the wavelengths of different spectral lines of mercury using a plane transmission grating.

APPRATUS REQUIRED: A plane transmission grating and it's grating, a spectrometer, mercury lamp, reading lens, reading lamp and a glass prism etc.

THEORY: **Diffraction-** When a wave encounters obstacles or small apertures whose dimensions are comparable to their wavelength; they bend round the corners of the obstacles or aperture. Such bending of waves round obstacles is called diffraction. As light propagates in the form of waves, it also exhibits the phenomenon of diffraction. Diffraction is well noticeable only when the size of the obstacles (or aperture) is comparable to the wavelength of the incident light. The smaller the obstacles the more manifest is the diffraction.

When a parallel beam of monochromatic light of wavelength λ is incident normally on a grating of grating element (a+b), by Huygen's principle each slit emits out secondary wavelets in all directions which interfere and get focussed in the focal plane of a telescope. The path difference between the diffracted waves at an angle θ from the corresponding points of two consecutive slits is $(a+b) \sin \theta$. When this path difference is equal to the integral multiple of wavelength λ, the waves produce constructive interference. Hence, for principal maxima

$$(a+b) \sin \theta = e \sin \theta = m\lambda$$

Where,

a is the width of a slit,

b is the width of opaque space between two consecutive slits,

n is called order of spectra ($m = 0, \pm1, \pm2, \pm3$........).

e is the grating element

Θ is the angle of diffraction.

If the white light is incident on a grating, in each order the value of θ will be different corresponding to different wavelengths present in the incident white light. Thus we get spectrum in each order as shown in fig 9.1. The first order (m = 1) principal maxima of wavelength in the incident light from the first order spectrum. Similarly, the second order (m =2) principal maxima of wavelength in the incident light from the second order spectrum. Since angle of diffraction θ = 0 º for the principal maxima of all the wavelengths corresponding to m = 0 therefore the 0 order maxima is white in the direction of incident light.

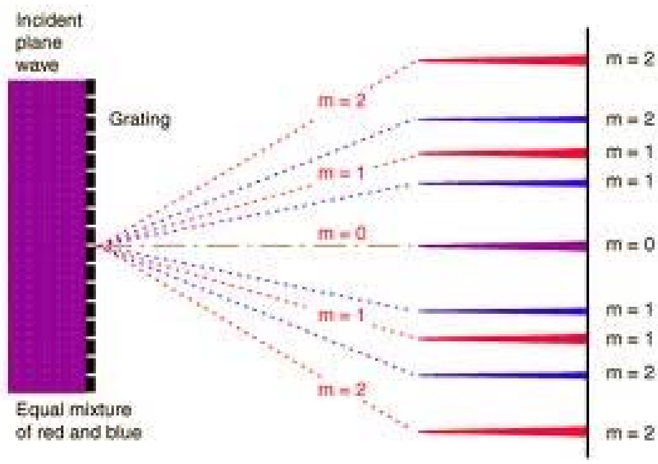

Fig 9.1.

FORMULA USED: The wavelength λ of a spectral line is calculated by:

$$e \sin\theta = m\lambda$$

where e =2.54/N

$$\lambda = \frac{2.54}{mN}\sin\theta$$

Where N is the number of lines rubbed per inch on grating,

M is the order of the spectrum

Θ is the angle of diffraction.

PROCEDURE:

i. First level the base of spectrometer and then prism table, by the help of spirit level.
ii. The slit of the collimator is made narrow and vertical so that light on the prism table falls horizontally.
iii. The grating is mounted in the middle of prism table such that light incident from collimator falls normally on the grating.
iv. Note the least count of the spectrometer.

v. The telescope from the position of direct image of slit is rotated towards left till the first order spectrum is seen in the field of view. The telescope is then gradually rotated with the help of its tangential screw and its vertical cross-wire is made to coincide the violet, green and red spectral lines one by one and each time the readings of both Vernier V_1 and V_2 are noted.

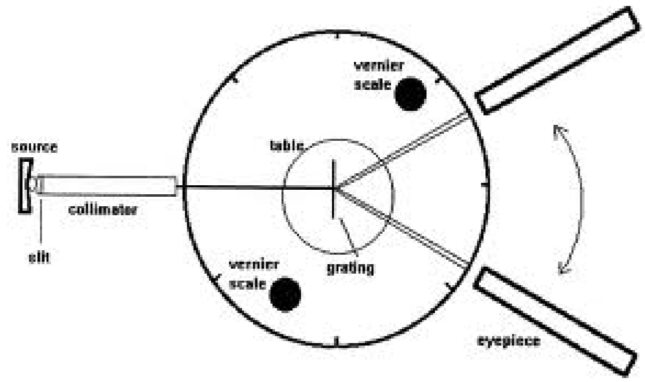

Fig 9.2.

vi. Then the telescope is further moved in the same direction as shown in fig 9.2 to bring the second order spectrum and again the readings of both Vernier V_1 and V_2 are noted for the second spectrum.

vii. Now the telescope is turned on the right side of the direct images of slit and again the reading of both the Vernier V_1 and V_2 are noted for same spectral lines in the first and second order.

viii. Then for the spectral lines of each colour, find the difference of reading of either side of the slit for the same Vernier V_1 or (V_2). Take the mean and find the half of it which will give the angle of diffraction θ for the spectral line of that colour.

STANDARD WAVELENGTH VALUE FOR MERCURY LIGHT

Colours	Wavelength (λ) in Å
Violet	4047 4358
Green	4960 5461

OBSERVATION:

1. Value of one division on main scale of spectrometer x =................................
2. Total number of division on the Vernier scale n =.............................
3. Least count of Vernier = (x/n) =...

4. For angle of diffraction:

Order of Spectrum	**Color of light**	**Kinds of Vernier**	**Reading of Spectrometer**						**2θ = x-y**	**θ**
			Position of telescope on the left image of slit direct			**Position of telescope on the right image of slit direct**				
			M. S. R.	**V. S. R.**	**Total Reading (x)**	**M. S. R.**	**V. S. R.**	**Total Reading (y)**		
First	Violet	V_1								
		V_2								
	Green	V_1								
		V_2								
Second	Violet	V_1								
		V_2								
	Green	V_1								
		V_2								

CALCULATIONS:

Grating element (e) = 2.54/ N =

Wavelength $\lambda = \frac{2.54}{mN} \sin\theta =$

$$\text{Percentage Error} = \frac{s\tan dard\ value - observed\ value}{s\tan dard\ value} \times 100\ \%$$

$=$

RESULT:

The wavelength of different colours for the given source of light is given below:

Colour of spectral lines	**Observed wavelength (λ) in Å**	**Standard wavelength (λ) in Å**	**% error**

PRECAUTIONS:

1. The spectrum should be properly adjusted.
2. The diffraction grating is a photographic reproduction and should not be touched.
3. Affirm maximum brightness for the straight through beam by adjusting the source-slit alignment.
4. Grating should be mounted with its lines parallel to the slit or vertical wire of the cross wires.
5. Telescope should be rotated slowly; otherwise there is a possibility of missing an order.
6. For every observation, both Vernier's should be read.

VIVA-VOICE

1. What is diffraction grating?

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2. How many type of diffraction are there? Distinguish between the two.

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3. What is meant by diffraction of light?

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4. What is the relationship between the grating spacing and the number of ruling per cm on the grating?

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5. What is meant by zero of the spectrum?

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6. Where is the zero order rings formed?

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7. Do the spectra of different orders have the same intensity?

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8. Do you find any difference in the separation of lines in the various orders?

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9. How many lines are there in the grating given to you?

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10. What is angle of deviation?

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11. Why is it necessary that the base side of the grating face toward the light source?

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