EXPERIMENT NO. 2

Object: To find the wavelength of white light with the help of a plane transmission diffraction grating.

Apparatus required: A diffraction grating, spectrometer, mercury vapour lamp, reading lens and sprit level.

Formula used: The wavelength λ of any spectral lines can be calculated by the formula:

$$(a + b) \sin \theta = n\lambda$$

$$\lambda = \frac{(a + b) \sin \theta}{n}$$

Where, $(a + b)$ = grating element, θ = angle of diffraction and n = order of the spectrum

Procedure: The following initial adjustments of the spectrometer and the grating are made first.

- The spectrometer and the prism table are arranged in horizontal position by using the leveling screws.
- The telescope is turned towards a distant object to receive a clear and sharp image.
- The slit is illuminated by a mercury vapour lamp and the slit and the collimator are suitably adjusted to receive a narrow, vertical image of the slit.
- The telescope is turned to receive the direct ray, so that the vertical slit coincides with the vertical crosswire. The readings of one vernier are noted. The vernier table is firmly clamped.
- Now, the telescope is rotated through 90° and is fixed in this position. The grating is mounted vertically on the prism table with its ruled surface facing the collimator. The vernier table I released and is slowly rotated till the reflected image coincides with the vertical crosswire.
- The leveling screws are adjusted so that the image is at the centre of the field of view of the telescope. The prism table is fixed and after making fine adjustments with the tangential crew, the reading of the vernier are noted. Now, the angle of incidence is 45° (Figure 1).
- The vernier table is then released and rotated exactly through 45° (or 135°) in the proper direction so that the surface of the grating becomes normal to the incident light. The vernier table is firmly clamped in this position.
- The telescope is then released and is brought to observe the direct image.

(B) Measurement of angles of diffraction for different colours.

The spectrum obtained in a grating is shown in Figure 2.

- Rotate the telescope to the left side of direct image and adjust the different spectral lines (violet, yellow and red) turn by turn on the vertical cross wire for first order. Note down the reading of both the verniers in each setting.
- Rotate the telescope further to obtain the second order spectrum and again the spectral lines on the vertical cross wire and note the readings.

- Now rotate the telescope to the right of the direct image and repeat the above procedure for first order as well as for second order.
- Find out the difference of the same kind of verniers (V_1 fromV_1 and V_2 fromV_2) for each spectral line in the first order and then in the second order. The angle is twice the angle of diffraction for that particular colour. Half of it will be angle of diffraction.
- Find out the angles of diffraction for other colours in first and second orders.

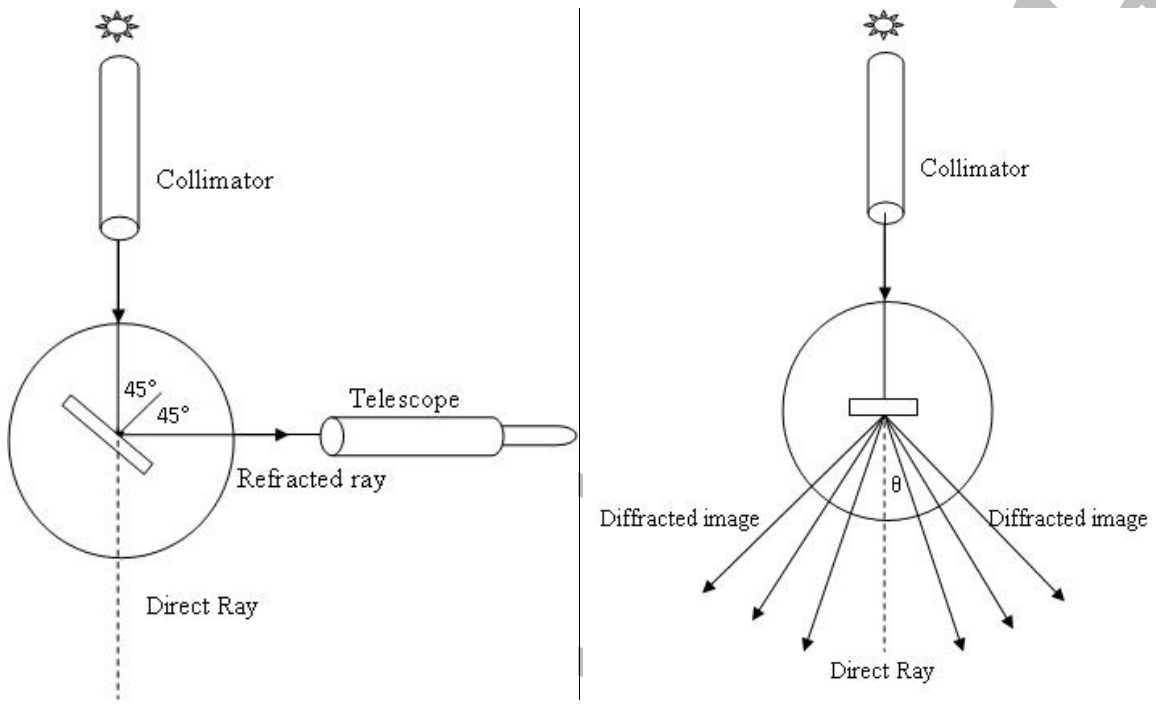

Figure 1 Setting diffraction grating normal to the incident light.

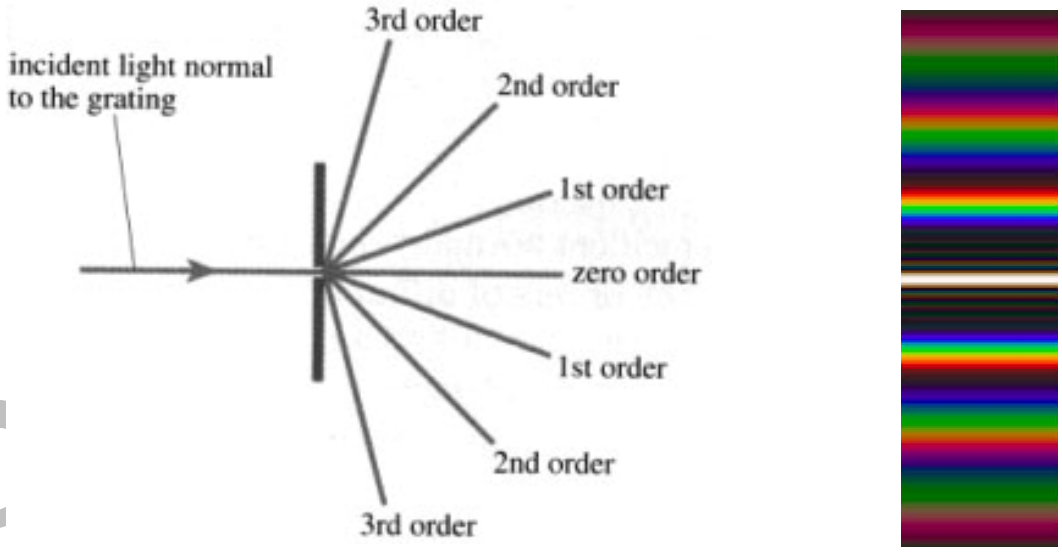

Figure 2 Orders and spectrum obtain visible through the diffraction grating.

Observations:

No. of rulings per inch on the grating, N = ……
Least count of spectrometer = ……. second

Reading of telescope for direct image = …….
Reading of telescope after rotating it through 90° = ……
Reading of circular scale when reflected image is obtained on the cross wire = …….
Reading after rotating the prism table through 45° or 135° = …….

Table for determination of angles of diffraction:

Order of spectrum n	**Colour**	**Vernier**	**Telescope reading of spectrum on**						**Angle of diffraction θ = (a – b)/2**	**Mean θ**
			Left side			**Right side**				
			MSR	**VSR**	**TR (a)**	**MSR**	**VSR**	**TR (b)**		
First	**Violet**	$\mathbf{V_1}$								}
		$\mathbf{V_2}$								
	Yellow	$\mathbf{V_1}$								}
		$\mathbf{V_2}$								
	Red	$\mathbf{V_1}$								}
		$\mathbf{V_2}$								
Second	**Violet**	$\mathbf{V_1}$								}
		$\mathbf{V_2}$								
	Yellow	$\mathbf{V_1}$								}
		$\mathbf{V_2}$								
	Red	$\mathbf{V_1}$								}
		$\mathbf{V_2}$								

MSR = Main Scale Reading, VSR = Vernier Scale Reading, TR = MSR+VSR = Total Reading.

Calculations: Grating element,

$$(a+b) = \frac{2.54}{N} = \text{ ……..cm}^{-1}.$$

Where, N is number of ruling per inch on the grating.

I. The wavelength of various spectral lines in the first order (n = 1) can be calculated by

$$\lambda = \frac{(a+b)\sin\theta}{1} = (a+b)\sin\theta$$

λ^I_{violet} = …… Å, λ^I_{yellow} = …… Å and λ^I_{red} = …… Å

II. Wavelength in second order (n = 2) is given by

$$\lambda = \frac{(a+b)\sin\theta}{2}$$

λ^{II}_{violet} = …… Å, λ^{II}_{yellow} = …… Å and λ^{II}_{red} = …… Å

Mean value of wavelength violet colour, $\lambda_{violet} = \frac{\lambda^{I}_{violet} + \lambda^{II}_{violet}}{2}$ = …….. Å

Mean value of wavelength yellow colour, $\lambda_{yellow} = \frac{\lambda^{I}_{yellow} + \lambda^{II}_{yellow}}{2}$ = …….. Å

Mean value of wavelength red colour, $\lambda_{red} = \frac{\lambda^{I}_{red} + \lambda^{II}_{red}}{2}$ = …….. Å

Result: The wavelength is given in the table.

Colour of spectral line	**Calculated wavelength**	**Standard wavelength**	**% Error**
Violet		4358 Å	
Yellow		5770 Å, 5791 Å	
Red		6678 Å, 7065 Å	

Precautions and sources of error:

(i) Before performing the experiment, the spectrometer should be adjusted.
(ii) Slit should be as narrow as possible.
(iii) Grating should be set normal to the incident light.
(iv) While taking observation, telescope and prism table should be kept fixed.
(v) Both verniers should be read.