EXPERIMENT NO.3

DIFFRACTION GRATING

OBJECT:
To determine the wavelengths of prominent spectral lines of mercury light by a plane transmission diffraction grating.

APPARATUS USED: Mercury lamp (Polychromatic source of light). Spectrometer, Plane transmission diffraction grating, sprit level, table lamp and reading lens.

FORMULA USED: The wavelength of spectral line is calculated as

$$\lambda = \frac{(e+d)\sin\theta}{n}$$

Where $(e+d)$ = Grating element
θ = Diffraction angle
n = Order of principal maxima

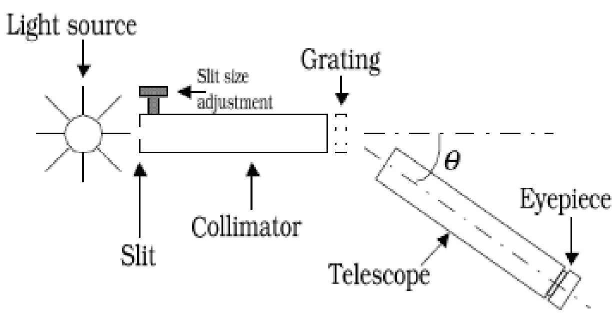


Fig.1. Diffraction Grating set-up

THEORY:

Diffraction grating is an optical device used to disperse light into a spectrum. It is ruled with closely-spaced, fine, parallel grooves, typically several thousand per cm, that produce interference pattern in a way that separates all the components of the incoming light.A fundamental property of gratings is that the angle of deviation of all but one of the diffracted beams depends on the wavelength of the incident light. Therefore, a grating separates an incident polychromatic into its constituent wavelength components, i.e., it is dispersive. Each wavelength of input beam spectrum is sent into a different direction, producing a rainbow of colors under white light illumination. This is visually similar to the operation of a prism, although the mechanism is very different. According to Huygen's theory of light wave, when a plane wave-front of light is incident on grating AB, then each point on the wave-front behave as a secondary source of light and sends out the secondary wavelets in all possible directions.

The constructive interference takes place between two wavelets diffracted through the same angle if the path difference between them is an integral multiple of wavelength.

The path difference between to light wave diffracted through the same angle θ is given as

$$(e+d)\sin\theta \qquad (1)$$

For constructive interference, this path difference should be equal to integral multiple of wavelength i.e. $n\,\lambda$ (2)

From equations (1) and (2), we get

$$(e+d)\sin\theta = n\,\lambda \qquad (3)$$

Equation (3) is known as grating equation and used to determine the wavelength of light.

A diffraction grating can be used spectrographs or as beam splitters for monochromatic light sources, such as lasers.

PROCEDURE:

(A) To position the grating in normal to incident light

(1) Spectrometer should be adjusted for parallel rays.
(2) Prism table must be optically leveled using sprit level.
(3) The grating is mounted on the prism table such that it is made approximately normal to the axis of the collimator by rotating the prism table.
(4) The direct image of the slit is then made to coincide with the vertical cross wire of the telescope.

(B) For angle of diffraction

(1) Place the grating in its holder normal to the surface of the turn table.
(2) Rotate the telescope (without disturbing the above adjustment) to the left side of the directed rays (white light).
(3) Set the cross –wire on different spectral lines one by one and note down the reading of both the Verniers.
(4) Now rotate the telescope to the right side of the directed rays and note down the reading of both the Verniers keeping cross-wire on the corresponding spectral lines.

OBSERVATIONS :

(1) Least count of the spectrometer= ………..
(2) Lines per inches (LPI) on grating N = ……….
(3) Grating element $(e+d) = \dfrac{2.54}{N}$ =…………

(4) Observations for angle of diffraction :

Order Of Spectrum	Colour	Vernier	Position of line on the						2θ (a-b)	θ	θ Mean
			Left Side			Right Side					
			M.S. (Degree)	V.S	Total (a) (Degree)	M.S. (Degree)	V.S	Total (b) (Degree)			
(n=1)	Violet	V_1									
		V_2									
	Green	V_1									
		V_2									
	Yellow	V_1									
		V_2									

CALCULATIONS:
The wavelength of spectral line is determined using

$$\lambda = \frac{(e+d)\sin\theta}{n} = ...A^0$$

Fig.2. Diffraction Grating set-up in the Lab.

RESULT:
The wavelengths of various spectral lines of mercury are as:

Colour	λ (Standard)	λ (Observed)
Violet	$4047\ A^0$	
Green	$4916\ A^0$	
Yellow	$5770\ A^0$	

ERROR:
% error =……………..

PRECAUTIONS:

(1)Grating should be properly normal to the axis of the collimator.
(2)The prism table must be leveled optically.
(3)The slit should be as narrow as possible.
(4)While taking observations the turn table must remain clamped.

Step 1

Step 2

Step 3

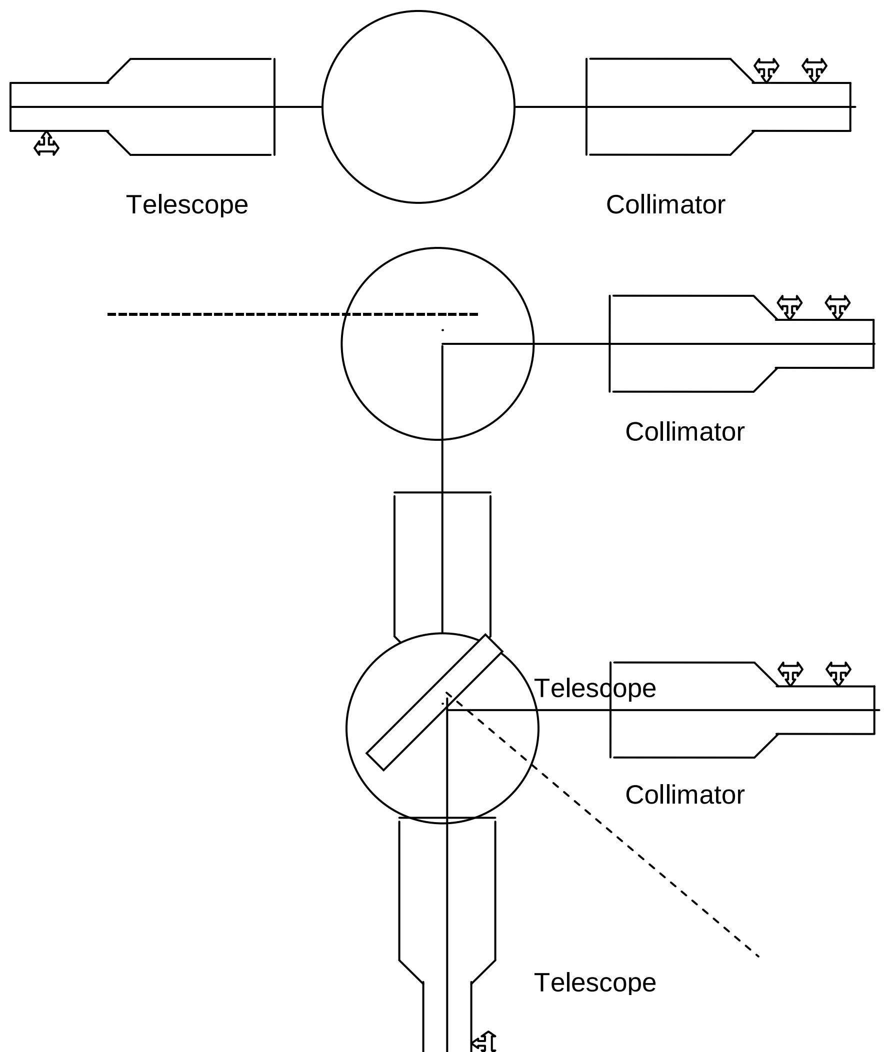
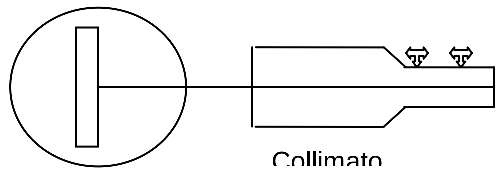
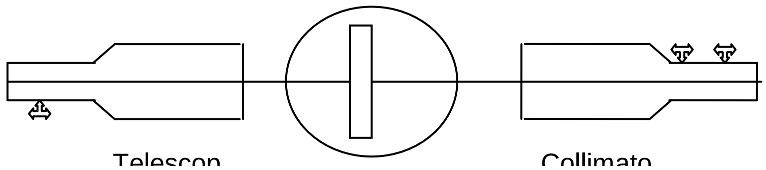


Fig.3.Adjustment of grating for normal incidence (step 1-3)

Step 4



Step 5



Step 6

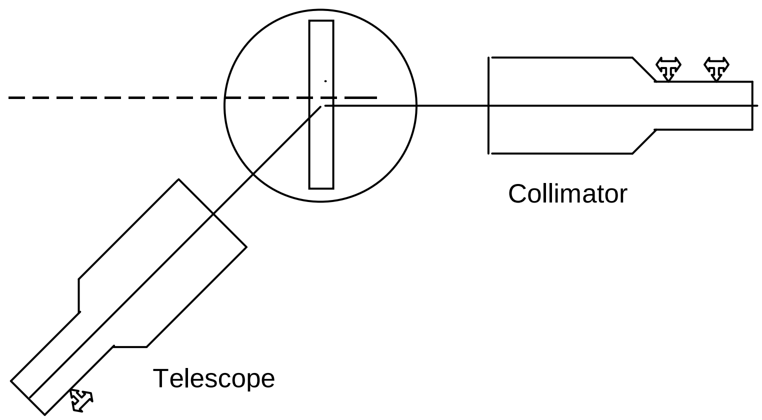


Fig.4.Adjustment of grating for normal incidence (step 4-6)

VIVA-VOCE

(1)What do you mean by wavelength of spectral lines?
(2) What is a spectrometer?
(3) What is optical diffraction?
(4) What is plane transmission diffraction grating?
(5) What do you mean by grating element?
(6) What do you mean by monochromatic and polychromatic light?
(7) What is order of spectra and principal maxima?
(8) How many order do you see in your experiment?
(9) What is the condition of being optical diffraction?
(10) What is Fraunhoffer type diffraction? Does it occur in your experiment?