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Theory :

When a parallel beam of light is incident on a grating surface, the transmitted light gives rise to primary maximum in certain directions. Now if θ be the angular deviation of light, which forms the nth order primary maximum and $(a+b)$ be the grating element. Then,

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

$$\Rightarrow \quad \sin\theta = nN\lambda$$

Here, $a+b = 1/N$, where N is the number of lines on ruling per inch (1 inch = 2·54 cm) of the grating surface.

$$\Rightarrow \lambda = \frac{\sin\theta}{nN} \quad \text{-------(i)}$$

By measuring the angel of diffraction of the various spectral lines with the help of spectrometer and by knowing the number of lines per cm of the grating surface, the wavelength of various spectral lines can be determind from the above eqn (i)

Apparatus :

(i) Spectrometer
(ii) Spirit level
(iii) Magnifying glass
(iv) Plane diffraction grating
(v) Discharge tube with damping arrangement etc.

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Procedure :

A. We made all the arrangements should be made in connection with the mounting of the grating

I) Adjusted the position of the eye-piece of the telescope so that the cross-wires were clearly vissible. We focused the telescope on a distant object and set it for parrallel rays. We leveled the spectrometer by the leveling screws and then planted the prism table with the help of a spirit level.

II) We fixed the grating stand on a circular table with two screws in the holes drilled on one of the lines parallel to the live joining two of the screws meant for the purpose. The face of the stand to which the clamps were attached was at the center of the table. We took out the grating carefully from the box. Holding it from the edge and without touching its surface, fixed it to the frame with its ruled surface towards the telescope.

III) Rotated the prism table till we got on the cross wires by the telescope, and image of the slit formed by reflection at the grating surface. In this position, the plane of grating is inclined at an angle of 45° to the incident light. Read the position of the prism table, using both the verniers. Turned the table

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through 45° from the position so that the plane of the grating is normal to the incident light with its plane faced towards the collimator clamped the table in that position.

iv) Now we took the grating on the table and ascertained whether the surface of the grating which first receives the light is the one which also contains the lines. Turned the prism table either through 135° or 45° in the appropriate direction so that at the end of that rotation, the ruled surface would face the telescope while light from the collimator would be incident normally on the grating. If it was the unruled surface of the grating which first receives the light, then the prism table was rotated through an angle of 45° or 135° in the proper direction to bring the grating into the position specified above. Fixed the prism table in its new direction.

B. To make the grating vertical –

i) Rotated the telescope to receive the diffracted image on one side of the direct image would appear displaced upwards while that on the other side will appear displaced downwards. But the spectre were formed in a plane perpendicular to the lines of the grating.

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ii) We set the telescope to receive the diffracted image in the highest possible order on one side and turned the third screw of the prism table till the center of the image is brought on the junction of the crosswires. On turning the telescope, that was observed that the centers of all the diffracted images lie on the junction of the cross-wires.

c. Then we proceeded to take reading as follows -

I) With discharge tube placed in front of the collimator slit, set the telescope on, the first order of the diffracted image on one side of the direct image. Then, we focused the telescope and took the reading using both the verniers.

II) Helium discharge tube was monted practically in contact with the slit. Instead we saw a large number of spectral lines of different line of spectrum and angle diffraction. Then we had a direct image and calculated its wave length.

III) We replaced the tube with Neon.

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Experimental Data :

Vernier constant of the spectrometer (V.C) :

Value of the smallest circular scale division $= (1/2)^\circ$

Here,

$$60 \text{ VSD} = 59 \text{ MSD}$$

$$\Rightarrow 1 \text{ VSD} = \frac{59}{60} \text{ MSD}$$

We know, $= 0.983$ MSD

$$V.C = 1 \text{ MSD} - 1 \text{ VSD}$$

$$= \left(1 - \frac{59}{60}\right) \times \text{MSD}$$

$$= 0.0167 \times (1/2)^\circ$$

$$= 8.33 \times 10^{-3\,\circ}$$

Number of lines per 1 cm on the grating surface

$N = 15,000$ Lines per inch

$= 5905.51$ Line per cm

Table – 1 :

Determination of angle diffraction for Neon discharge table

Order of Spectrum	Description of lines	Vernier No.	Reading Left Image MSR M degree	VSR V degree	total L degree	Reading Right Image MSR M degree	VSR V degree	total R degree	2θ = L ~ R degree	θ degree	θ degree
1st Order	Bluish Green	V_1	129	30	129.25	91.5	30	91.75	37.5	18.75	18.73
		V_2	309.5	5	309.54	272	15	272.125	37.415	18.71	
	Yellow	V_1	131	50	131.42	90	32	90.26	41.16	20.58	20.515
		V_2	311	9	311.07	270	20	270.17	40.9	20.45	
	Orange	V_1	131.5	10	131.58	89.5	36	89.80	41.78	20.89	20.99
		V_2	311.5	40	311.83	269.5	20	269.66	42.17	21.085	
	Red	V_1	133	40	133.33	88	17	88.14	45.19	22.59	22.55
		V_2	313	10	313.08	268	5	268.04	45.04	22.52	
2nd Order	Yellow	V_1	155	30	155.25	66	29	66.24	89.01	44.505	44.51
		V_2	335	5	335.04	246	3	246.02	89.02	44.51	
	Orange	V_1	157.5	10	157.58	65	30	65.25	92.33	46.165	46.27
		V_2	337.5	40	337.83	245	10	245.08	92.75	46.375	
	Red	V_1	160.5	19	160.66	60	20	60.17	100.49	50.245	50.23
		V_2	340.5	22	340.68	240	30	240.25	100.43	50.215	

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Calculation :

From the theory, we know the wavelength of various spectral lines, $\lambda = \frac{\sin\theta}{nN}$

Here, n = Order of the spectrum

N = Number of lines per cm on the grating surface

θ = Angle of diffraction of various spectral lines

For 1st order : n = 1

For ~~Violet~~ Bluish Green light : N = 15,000 lines/inch = 5905.51 lines/cm

$\theta_{BG} = 18.73^\circ$

So, the wavelength of Bluish Green light is,

$$\lambda_{BG} = \frac{\sin\theta_{BG}}{nN} = 5.437 \times 10^{-5}\ cm = 5437.44\ \mathring{A}$$

For Yellow light : N = 15,000 lines/inch = 5905.51 lines/cm

$\theta_Y = 20.515^\circ$

~~$\lambda_Y = \sin\theta_Y$~~

So, the wavelength of Yellow light is,

$$\lambda_Y = \frac{\sin\theta_Y}{nN} = \frac{\sin 20.515}{1 \times 5905.51} = 5.9343 \times 10^{-5}\ cm$$
$$= 5934.33\ \mathring{A}$$

For Orange light : N = 15,000 lines/inch = 5905.51 lines/cm

$\theta_O = 20.99^\circ$

So, the wavelength of Orange light is,

$$\lambda_O = \frac{\sin\theta_O}{nN} = \frac{\sin 20.99}{1 \times 5905.51} = 6.0560 \times 10^{-5}\ cm$$
$$= 6056.0\ \mathring{A}$$

For Red light : N = 15,000 lines/inch = 5905.51 lines/cm

$\theta_R = 22.55^\circ$

So, the wavelength of Red light is,

$$\lambda_R = \frac{\sin\theta_R}{nN} = \frac{\sin 22.55}{1 \times 5905.51} = 6.493 \times 10^{-5}\ cm$$
$$= 6493.7\ \mathring{A}$$

For 2nd Order : $n=2$

For Yellow light : $N = 15{,}000$ lines/inch $= 5905.51$ lines/cm

$\theta_Y' = 44.51$

So, the wavelength of Yellow light is,

$$\lambda_Y' = \frac{\sin\theta_Y'}{nN} = \frac{\sin 44.51}{2\times 5905.51} = 5.93542 \times 10^{-5}$$
$$= 5935.42\ \mathring{A}$$

For Orange light : $N = 15{,}000$ lines/inch $= 5905.51$ lines/cm

$\theta_O' = 46.27$

So, the wavelength of Orange light is,

$$\lambda_O' = \frac{\sin\theta_O'}{nN} = \frac{\sin 46.27}{2\times 5905.51} = 6.1180 \times 10^{-5}\ cm$$
$$= 6118.0\ \mathring{A}$$

For Red light : $\theta_R' = 50.23$

$$\lambda_R' = \frac{\sin\theta_R'}{nN} = \frac{\sin 50.23}{2\times 5905.51} = 6.5076 \times 10^{-5}\ cm$$
$$= 6507.6\ \mathring{A}$$

Discussion:

The objective of the experiment to determine the wavelength of various spectral lines of discharge tube by using a spectrometer and a plane diffraction grating. After doing this experiment I have learnt that the source must be infront of the collimator slit so that image appears bright. While taking reading I was cautious about whether the zero of the main circular scale has been crossed in going from one position to another. But, still while doing experiment there might be some unwanted mistake happend that's why ~~there~~ the calculated result is differen from the actual value.