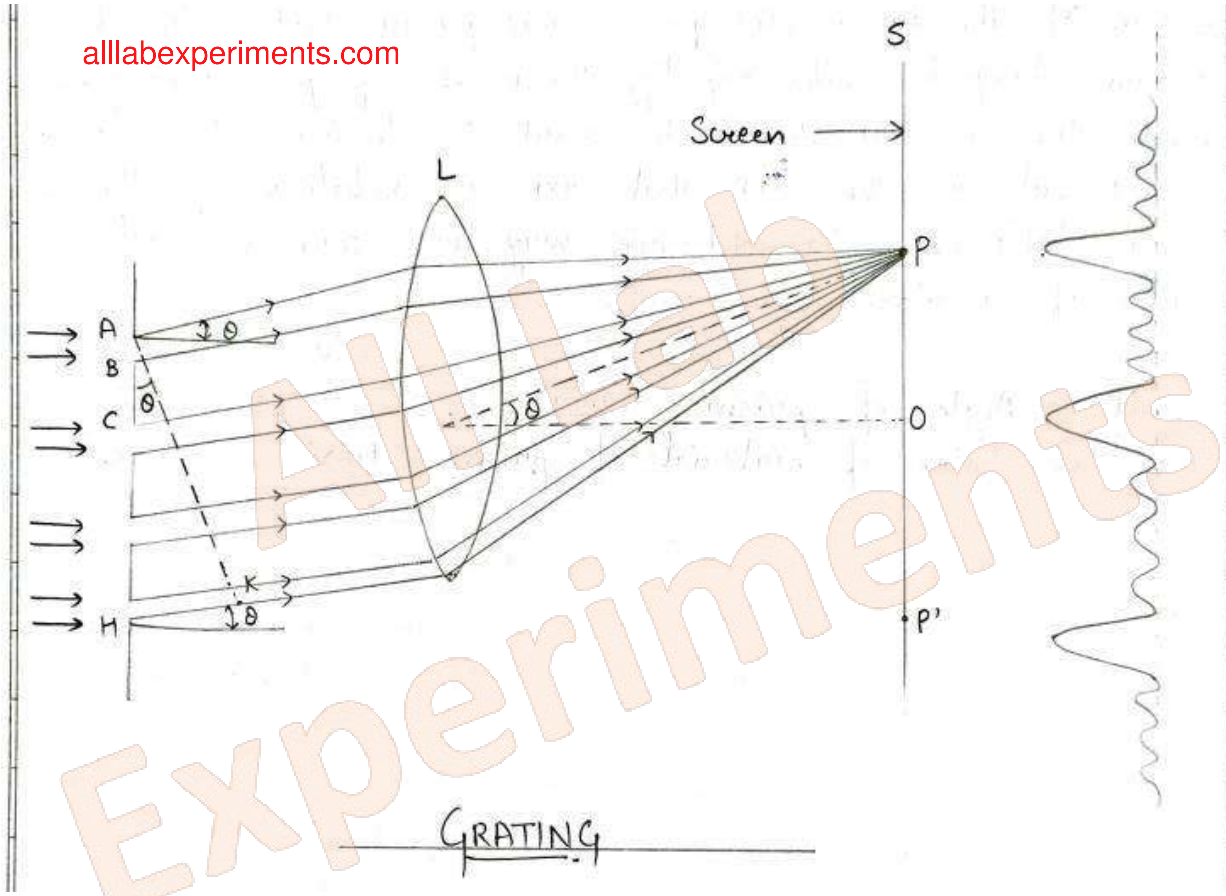
To determine the wavelength of sodium light using a plane diffraction grating



Aim :- To determine the wavelength of sodium light using a plane diffraction grating.

Apparatus :- Spectrometer, plane diffraction grating, sodium light and spirit level.

Theory :- Diffraction grating combines a problem in diffraction with one in interference. Each slit in the grating sends out a diffracted beam and these diffracted beams then interfere with one another to produce the final pattern. In the diagram, ABC ..... H represents the section of a plane transmission grating having total number of N clear spaces placed perpendicular to the plane of the paper. When monochromatic light of wavelength λ falls normally on the grating, most of the light goes straight from the spaces but a part of it gets diffracted in various directions. This light after passing through a convex lens L is made to converge on the screen in its focal plane forming dark and bright bands on both sides of the central maximum.

The waves proceeding in a particular direction, when focussed by a lens, produce maximum or minimum intensity depending on the path difference between them.

Observations and Calculations :-

Grating element (b+d) = $\frac{2.54}{\text{No. of lines per inch on grating}}$

→ $b+d = \frac{2.54}{12500} = 0.0002032$ cm

Order	Vernier	Telescope on left	Telescope on right	2θ	θ (Degree)
1st Order	V_1	335.5	301.33	34.17	16.92
	V_2	154.16	120.64	33.52	
2nd order	V_1	350.38	283.40	66.98	33.55
	V_2	169.66	102.45	67.21	

i) 1st order -

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

Here, $n = 1$, $b+d = 0.0002032$, $\theta = 16.92°$

→ $\lambda = 0.0002032 \times \sin(16.92) = 5.91 \times 10^{-5}$ cm

ii) 2nd order -

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

$n = 2$, $b+d = 0.0002032$, $\theta = 33.55°$

→ $\lambda = [0.0002032 \times \sin(33.55)] / 2 = 5.61 \times 10^{-5}$ cm

Mean = $(5.91 \times 10^{-5} + 5.61 \times 10^{-5}) / 2 = 5.76 \times 10^{-5}$ cm

Let the rays diffracted at an angle θ with the grating normal which reach a point P after passing through the lens L. Draw AK perpendicular to the diffracted rays. Then CN is the path difference between the rays diffracted from the two corresponding points A and C at an angle θ. If a is the width of each clear space and b is the width of the opaque part,

the path difference $CN = AC \sin\theta = (a+b)\sin\theta$

If this path difference is an even multiple of $\lambda/2$, then point P will be bright and if an odd multiple of $\lambda/2$, the point P will be dark.

Thus, $(a+b)\sin\theta = \pm n\lambda$ for maximum

$(a+b)\sin\theta = \pm(2n+1)\lambda/2$ for a minimum

where $n = 0, 1, 2, 3, \ldots$

When the path difference is zero, all the rays are in phase and we get the central bright maximum. When $(a+b)\sin\theta = \lambda$, we get the first bright maximum and so on.

Result :- Wavelength of sodium light as determined in the experiment $= 5.76 \times 10^{-5}$ cm.

Precautions and Sources of Errors :- 1. All the adjustments of the spectrometer must be correctly done.

2. The rulings of the grating must be vertical.

Teacher's Signature :...................................

3. The grating should always be handled by the edges and the faces should not be touched with the hand.

4. The slit should be as narrow as permissible and parallel to the rulings of the grating.

5. While taking readings of the telescope, the turn table should be clamped and vice-versa.

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