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An Efficient Technique of Wavelength Severance of Sodium Doublet Lines Using Diffraction Grating

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***Abstract*- The lamp using Sodium vapor is used widely as a light source in experiments related to diffraction grating. The main point of sodium is that,it has high end emission wavelengths values. Also it is to be noted that without the help of sensitive equipment, the values of its wavelength cannot be measured. The purpose of this paper is to find out the wavelength of Sodium Doublet Emission (SDE) lines using diffraction grating. In this paper, it is proposed to find the values of SDE lines, F_1 and F_2, and also the mean wavelength as well as difference between the two SDE lines of sodium. In this approach, standardizing a spectrometer for evaluating the SDE lines has been proposed with the help of interference pattern created. With the aid of diffraction grating it is possible to obtain a well-defined and well resolved spectrum for the analysisofSDE lines. In this approach, the values for D_1 and D_2 are given by 588.9950 and 589.5924 nanometres respectively. In addition to the above, wavelength of SBE lines is evaluated and compared with theoretical value. The other parameters like angular separation, resolving and dispersive power of spectrum are also evaluated using this technique.**
***Keywords:* Efficient Technique, Wavelength, Sodium, Doublet Lines, Diffraction Grating**

I. INTRODUCTION

A sodium lamp consists of easily evaporated vapour sodium metal. Usually in a sodium vapour lamp, a current inside the lamp excites the sodium atoms. During this time, it emits a monochromatic simple spectrum of light. It is clear that if we observe the light with a spectrometer, we can see yellow coloured interference fringes. It is possible to measure the wavelength of this monochromatic light likewise as we measure the wavelength of the polychromatic light, where 'λ' is the distance. In this paper, it is proposed to measure the wavelength of this monocromatic yellow light using diffraction grating [1]. In optics, a diffraction grating is an optical component with a periodic structure that splits and diffracts light into several beams travelling in different directions. The emerging coloration is a form of structural coloration. The directions of these beams depend on the spacing of the grating and the wavelength of the light so that the grating acts as the dispersive element. Because of this, gratings are commonly used in monochromators and spectrometers. As we perform this experiment, we can observe some interesting features of the obtained fringes. Sometimes they appear like yellow and black tiger stripes and sometimes as pale and unclear. This is because, actually there exists two wavelengths with comparable intensity forming a pattern of interference fringes [2]. By observing through a spectrometer we can see that two fringe patterns are overlapping. We can see clear images if the dark fringes coincides with bright areas during the proper alignment of spectrometer. But if the spectrometer is not aligned properly we can see that the bright parts of one fringe pattern overlap the dark parts of the other fringe pattern, and vice versa. In this case we cannot see the pattern clearly. In this paper we have done the wavelength measurement of SBE lines using the spectrometer for the calculation of angular separation, resolving and dispersive power of spectrum [3].

II. THEORY

The main objective of diffraction grating leads to application for measuring atomic spectra in both laboratory instruments and telescopes [4]. Consider there are N parallel slits,each having a width of 'a' which is separated by an opaque space of width 'b', in this case the obtained fringe pattern are in diffraction modulated form. The quantity called the grating element is given by (a+b) and the parallel slits is given by (N = 1/ (a+b)), where N is the number of slits per unit length [5, 6]. The value of N is in the range 300 to 15000 lines per inch. In the experiments having large number of slits,the diffraction pattern thus obtained consists of extremely sharp or narrow lines in the principal maxima, and weak lines in the secondary maxima as shown in figure 1 [7, 8].

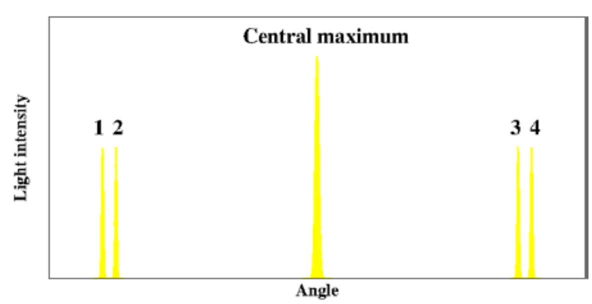

Fig. 1Principal maxima and secondary maxima

The various principal maxima are called orders. When a normal sodium light falling normally on a diffraction grating plane, the principal maxima is given as in equation 1.

$$(a+b)sin\theta = \pm n\lambda \text{or d } sin\theta = \pm n\lambda \quad (1)$$

Where ‘n’ is the order of principal maximum, ‘d’ is the grating element, (a+b) is the sum and ‘θ’ is the angle of diffraction.The angular dispersive power of the grating is defined as the rate of change of angle of diffraction with the change in wavelength. It is obtained by differentiating equation 1 and is given as in equation 2.

$$\frac{d\theta}{d\lambda} = \frac{Nn}{\cos\theta} \qquad (2)$$

The sodium spectrum obtained through spectrometer has a bright doublet light wave of SDE lines at 588.9950 and 589.5924 nanometers. The SDE line at 589.0 has double the intensity of the SDE line at 589.6 nm. We know that the visible range spectrum is from 400 to 700nm, the strongest visible line at 568.8205 has intensity about 0.7% of that of the strongest SDE line. All other lines are a factor of two or lesser than that one. The purpose of this paper is to measure the wavelength of the two SDE lines. When a sodium vapour lamp is used in conjunction with a spectrometer, the wavelengths of the two emission line will create interference fringe patterns. The distance between fringes within the interference patterns can be measured to calculate the wavelength of the emission source. From the resulting pattern the difference in the wavelengths and difference in angle can be determined [9].

III. EXPERIMENTAL SET UP

The spectrum obtained from a sodium vapour lamp is often called "the sodium doublet". With the help of a spectrometer, it is capable of resolving nearby wavelengths. We can see that there are two bright yellow lines next to each other like a doublet as in figure 1. The experimental setup is shown in 2a and 2b. As shown in figure 2b, a spectrometer has been used to create interference patterns. This helps to allow measurements of the wavelength of the light sources. With a telescope we can see doublet of two fringe patterns. In this arrangement, a large number of parallel slits of the same width is separated by equal opaque spaces. This is commonly called diffraction grating. It is possible by ruling equidistant, extremely close tiny grooves with a diamond point on an optically plane glass plate. A photographic replica of a plate made in this way is often used as a commercial transmission grating.

The experiment is done with the help of the following steps. The foremost step is to find the vernier constant of the spectrometer. Next is to remove the prism from the turntable. Then adjust the grating on the turntable so that its lines are vertical, i.e. parallel to the axis of rotation or the turntable. Moreover, the light from the collimator should fall normally on the grating.To achieve this the telescope is brought directly in line with the collimator so that the centre of the direct image of the slit falls on the intersection of the cross-wires. In this setting of the telescope, its vernier reading is taken. The telescope is now turned through 90° from this position in either direction so that the reading of the vernier becomes (ϕ+90^0) or (ϕ-90^0). Now the axis of telescope is at right angles to the direction of rays of light emerging from the collimator. The telescope is clamped in this position. The grating of known grating element is then mounted on the grating holder, which is fixed on the turntable in such a way that the ruled surface of the grating is perpendicular to the line joining two of the levelling screws (say Q and R).

(a) (b)

Fig. 2Experimental setup of the proposed approach

The table is now rotated in the proper direction till the reflected image of the slit from the grating surface coincides with the intersection of the cross-wires of the telescope.By the help of two levelling screws (Q and R), perpendicular to which grating is fixed on the table, the image is adjusted to be symmetrical on the horizontal cross- wires.The plane of the grating, in this setting, makes an angle of 45° with the incident rays as well as with the telescope axis. The reading of vernier is now taken and with its help, the turntable is rotated through 450 from this position so that the ruled surface becomes exactly normal to the incident rays. The turntable is now firmly clamped.The final adjustment is to set the lines of the grating exactly parallel to the axis of rotation of the telescope. The telescope is rotated and adjusted to view the first order diffraction pattern. The third levelling screw (P) of the prism table is now worked to get the fringes (spectral lines) symmetrically positioned with respect to the horizontal cross-wire.If this adjustment is perfect, the centres of all the spectral lines on either side of the direct one will be found to lie on the intersection of the cross-wires as the telescope is turned to view them one after another. The rulings on the grating are now parallel to the axis rotation of the telescope. The grating spectrometer is now fully to make the measurements. Do not disturb any of the setting of the spectrometer henceforth throughout the experiment.

IV. RESULTS

After the experimental setup is completed, see through the telescope to notice the first or second order D lines of sodium. Thus we can see two yellow lines on both sides of the direct image of the slit at the center. Note down the positions of the cross wire for each line on one side using the two verniers on the spectrometer. Use a magnifying lens to read the verniers. Repeat the above step by turning the telescope to the other side too. Determine the diffraction angle, for all the two spectral lines. Take two sets of reading for each D-line and calculate the corresponding wavelength λ1 and λ2 using equation 1. For this experiment, it is made as Least count =1msd, No: of div on vernier=1' and N= 15000lines/inch. The results of the wavelengths measured are shown in table I.

TABLE I MEASUREMENT OF WAVELENGTHS

Order n	**Yellow lines**	**Diffracted Readings**							**Average**	**Wavelength**
		Left		**Right**		**Difference**				
		V_1	**V_2**	**V_1**	**V_2**	**V_1**	**V_2**	**Mean2θ**	**θ**	**λ nm**
1	D_1	$115^0 20$"	295^0 15'	155^0 13'	335^0 1'	39.88367^0	39.76667^0	39.82517^0	θ_1=19.912585^0	λ_1=576.726×10^{-9}
2	D_2	115^0 17'	295^0 10'	155^0 20'	335^0 5'				θ_2=19.991575^0	λ_2=578.920×10^{-9}

From the table we get the angular separation, $d\theta = \theta_1 - \theta_2$ =0.07899, wavelength is given as $\lambda = \lambda_1 + \lambda_2/2$ =577.823×10^{-9} and $d\lambda = \lambda_1 - \lambda_2 = 2.194\times10^{-9}$. The Dispersive power is measured as =$\frac{d\theta}{d\lambda}$ = 36002,734.731 and Resolving Power = 263.365087.

V. CONCLUSION

A well-defined and well resolved spectrum is obtained by diffraction grating. It helps in the analysisofsodium light. The Wavelength of D lines is calculated and compared with theoretical value. The angular separation, dispersive power is calculated and the calculated value is comparable with theoretical value. Due to it's ability to form well resolved spectrum and calculation of wavelengths, diffraction grating finds applications in spectrometers. It helps in understanding the structure and properties of sodium. Astronomers have an easier time removing the spectral data of these lights as an outlier because it is so specific to the wavelengths of 588.9950 and 589.5924 nanometres. In future application, the experiment can be carried out with Neon and Magnesium.

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