USER'S MANUAL

TO STUDY ATOMIC SPECTRA OF TWO ELECTRON SYSTEMS

A Product of:

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TO STUDY ATOMIC SPECTRA OF TWO ELECTRON SYSTEMS (Hydrogen)

Object:

Determination of the wavelength of the most intense spectral lines of Hydrogen.

Principal :

In this set-up the spectral lines of Hydrogen are examined by using diffraction Grating. The wavelengths of these lines are determined from the geometrical arrangement and the diffraction grating constants.

Theory and Formula:

If light of any wavelength λ falls on a grating having grating constant k, it is diffracted. Intensity maxima
occur if the angle of diffraction satisfies the conditions.

$n.\lambda = k \sin\phi$ where n = 0, 1 , 2, ...

From Fig. 1 we have

$$\sin\phi = \frac{l}{\sqrt{d^2 + l^2}}$$

and hence

$$\lambda = \frac{k l}{\sqrt{d^2 + l^2}} \quad \text{for first order diffraction.} \qquad .... (1)$$

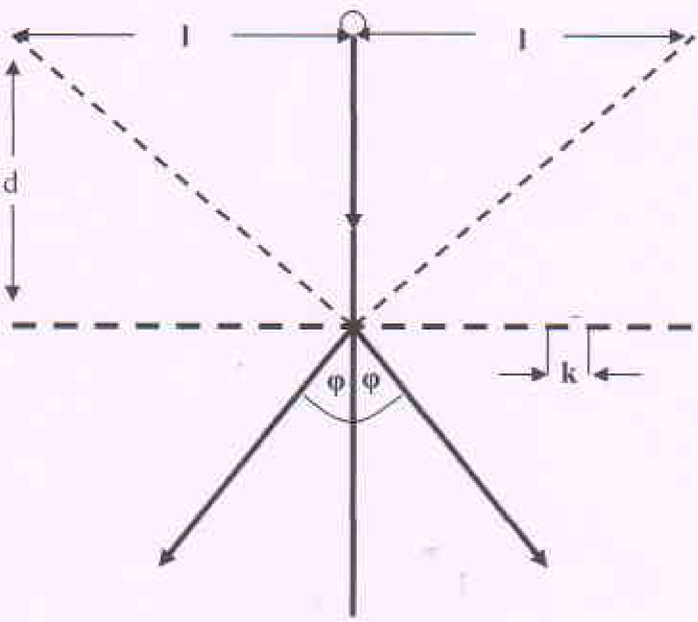

Fig. 1

Introduction:

Hydrogen Spectral Lines (Spectral Lines of Hydrogen)

Hydrogen atom forms line spectrum. When hydrogen gas filled in a discharged tube and applies electric voltage, it gets atomized. Due to the formation of hydrogen atom, some pink color light produced in visible region. When this light analyses through spectroscope, we will get line spectrum of hydrogen. There are many line of different wavelength

There is only one electron in hydrogen, the spectrum gives a large number of lines. This is because in a given sample, there can be many hydrogen atoms. In each atom, there is one electron which located in K-shell near to nucleus under normal condition. When energy supplied to the atoms by passing an electric discharge, these atoms absorbed some amount of energy and get excited. By using this energy, electrons in atoms can excited to any energy level, depends on their energy.

Since higher energy levels are unstable for electron, it drops back to lower energy level and emitted energy in the form of line spectrum, which contains various lines of different frequency and wavelength. The frequency of these spectral lines can be calculated by using wave number, which is reciprocal of wave length.

Apparatus Used:

Geometrical arrangement to study the atomic spectra fitted with 50-0-50 cm scale with two pointer to observe the position of diffracted pattern and holder to hold the gas discharge tube, Grating with post and holder, Hydrogen tube, High Voltage Power supply for discharge tube, Meter scale.

Description:

The experimental set-up is shown in Fig.2.The meter scale with two marker (pointer) is fixed at the height of the tube just behind the tube with two tripod stand. The insulated holder is used for the tube.

The diffraction grating is secured in the grating holder with post so that the diffraction plane is perpendicular to the grating slit combination. A variable output high voltage power supply is used so that single supply can be work for different gas discharge tube like He, Hg, Ne & H etc.

Fig. 2

Method:

1. The experiment be set-up in the dark room darkened to the point where it is still possible to read the meter scale.
2. Insert Hydrogen Tube in the tube holder.
3. Put the power supply in **'OFF'** position and connect the tube with power supply. Switch 'ON' the power supply and increase the output voltage slowly such that the gas discharges tube fully glowing.
4. Put the grating in the grating holder on the post at a distance **'d'** (say 50 cm) such that the diffraction plane is perpendicular to the grating slit combination.
5. See through the grating and observed the individual spectral line by means of grating. Measure the distance 2 l between equal lines of first order diffraction on the meter scale.
6. Calculate the wavelength of each spectral line using formula given in equation (1)
7. Repeat the experiment for second order.

Observations and Tabulations: **Distance between the grating and scale = 50 cm**

S. No.	Spectrum Line	Possition of Spectrum Line on Right side l_1 Cm.	Possition of Spectrum Line on Left side l_2 Cm	Mean $l = \frac{l_1 + l_2}{2}$
1.	Red	20.5	21.7	21.1
2.	Yellow	18.6	17.5	18.05
3.	Green	16.1	16.8	16.45
4.	Blue	15.0	15.8	15.4

Calculations:-

In this case the grating used is 15000 LPI
The grating constant k = 1.693x 10^{-4}
From Equation (1)

$$\lambda = \frac{k.l}{\sqrt{d^2 + l^2}}$$ for first order diffraction. ....(1)

Putting all proper values for each line of spectrum we can calculate the wavelength of each line as

(i) For Red line λ_R

$$\lambda_R = \frac{1.693x\,10^{-4}x21.1}{\sqrt{25^2 + 21.1^2}} = 6582\ A^{\circ}$$

(ii) For Red line λ_y

$$\lambda_Y = \frac{1.693x\,10^{-4}\,x18.05}{\sqrt{25^2+18.05^2}} = 5748A^o$$

Similarly λ_G = 5291 A° and λ_B = 4983 A°

Results:

The measured and Standard spectral line of Hydrogen is shown in Table-1

Table-1 Measured and Standard spectral lines of Mercury

S.No.	Colors	Standard λ nm	Measured Experimentally λ nm
1.	Blue	470	498
2.	Green	540	529
3.	Yellow	580	575
4.	Red	660	658

TEST RESULTS:

OBSERVATIONS AND TABULATIONS:

Type of Gas discharge tube used : Hg (Mercury)
Distance between the tube and Grating 'd' : 55 cm.
Grating used : 15000 LPI

S. No.	Spectral Line	Order of diffraction Pattern	Position of spectral line on left side from the tube l_1	Position of spectral line on right side from the tube l_2	Mean $l_1 + l_2/2$	Observed values of Wavelength
1.	Violet	1st order	13.2	13.6	13.4	441
2.	Green	1st order	17.8	19.0	18.4	537
3.	Yellow	1st order	19.1	20.3	19.7	567
4.	Red	1st order	22.2	23.7	22.95	652
5.	Violet	2ndorder				
6.	Green	2ndorder				
7.	Yellow	2ndorder				
8.	Red	2ndorder				

CALCUATIONS:

Calculate wavelength for each spectral line as

$$\lambda = \frac{1}{n}\frac{k.l}{\sqrt{d^2 + l^2}}$$ for first order diffraction.

Where, k = 2.54/15000 = 1.693×10^{-4}
d = 55 cm (as adjusted for this set of readings
l = $l_1 + l_2$ / 2 for each spectral line
n = order of spectrum

Putting all proper values for each line of spectrum we can calculate the wavelength of each line as

(i) For Voilet line λ_V (For 1st order n = 1

$$\lambda_R = \frac{1.693x\,10^{-4}\,x\,13.4}{\sqrt{55^2 + 13.4^2}} = 4008\ A^\circ$$

(ii) For Red line λ_G

$$\lambda_y = \frac{1.693x\,10^{-4}x18.4}{\sqrt{55^2+18.4^2}} = 5371\ A^o$$

Similarly λ_Y = 5667 A° and λ_R = 6519 A°

RESULTS:

Table shows the Practical and standard values of wavelength for each spectral line. The results obtained with this experiment are always with in 10% of the standard value.

(b) Measured and Experimental spectral lines of Mercury

S.No.	Colors	Standard λ nm	Measured Experimentally λ nm
1.	Violet	440	441
2.	Green	540	537
3.	Yellow	580	567
4.	Red	660	652