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Hydrogen Atom Spectroscope.

I. Experiment purpose:

1. We use the theory of multi-slit interference splitting light in grating to know spectroscope.
2. We use the grating to observe the Balmer series lines when Hydrogen atom is lighting in the spectrum.
3. We study the quantization phenomenon of electronic energy level and the electron energy in the hydrogen atom.
4. According to measuring the line spectrum, we can calculate Planck's constant.

II. Experiment theory:

According to N,bohr's model of hydrogen atom, it is quantization when electron circles to atomic nucleus so the energy of hydrogen atom is quantization. If the electrostatic force is from electron being circular motion to hydrogen atom, then the centripetal force on electron is:

$$F = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{r^2} = m\frac{v^2}{r} \qquad (2\text{-}1)$$

Bohr assumes that the condition of quantization track is that the value of angular momentum L is h/2π integer multiple. Then,

$$L = pr = n\frac{h}{2\pi} \qquad (2\text{-}2)$$

v and p are velocity and momentum when electronic is in circular motion. r is the radius of the track.

e: charge quantity of electronic = $1.60\times10^{-19}C$. m: mass of electronic = $9.11\times10^{-31}kg$. ε_0 :

permittivity of vacuum = $8.85\times10^{-12}F/m$, h: Planck constant = $6.63\times10^{-34}j-\sec$, n: principal quantum number with integer.

From (2-1) and (2-2), we can get the amount of hydrogen atom that is also quantization, and the relation formula is:

$$E_n = -\frac{me^4}{8\varepsilon_0^2h^2}\frac{1}{n^2} \qquad (2\text{-}3)$$

When n=1 and E_1=-13.6eV, the energy is the lowest that is called ground state energy. When n=∞ and E_∞=0, it is the amount of the energy without momentum since electronic of hydrogen atom takes off from proton totally. The binding energy or ionization energy of the atom is making the status of the electronic from baseline state ionization to free without momentum that energy is needed to supply. Therefore, the ionization energy of hydrogen atom is 13.6eV. (Note: the energy unit, 1 Ev=$1.6\times10^{-19} j$)

When atom is in high energy, the electronic will move rapidly from the higher energy track n_1 to the lower energy track n_2, and release photon. The energy of the released photon is the energy difference of the previous status and the later status:

$$\Delta E = hv = \frac{hc}{\lambda} = E_{n1} - E_{n2} \tag{2-4}$$

From the up formula, c is light speed = 2.997924590×10^{8} m/sec, λ is the wavelength of the Photon. We bring (2-3) into (2-4) and get:

$$\frac{1}{\lambda} = \frac{me^4}{8\varepsilon_0^2 h^3 c}\left(\frac{1}{n_2^2} - \frac{1}{n_1^2}\right) = R_H\left(\frac{1}{n_2^2} - \frac{1}{n_1^2}\right) \tag{2-5}$$

the constant is $R_H \equiv \frac{me^4}{8\varepsilon_0^2 h^3 c}$ that we call Rydberg constant (Rydberg constant=1.09678×10^{7} m^{-1})。

Spectroscope：

Image 2-1 is an optical path of diffraction grating. The light goes through slits S where is located on lens L of focus point and project parallel light. Then the light shoots to diffraction grating (d is the gap of the slit) and diffracting injection. We can observe the stripes of diffraction by using lens L' to focus on the screen.

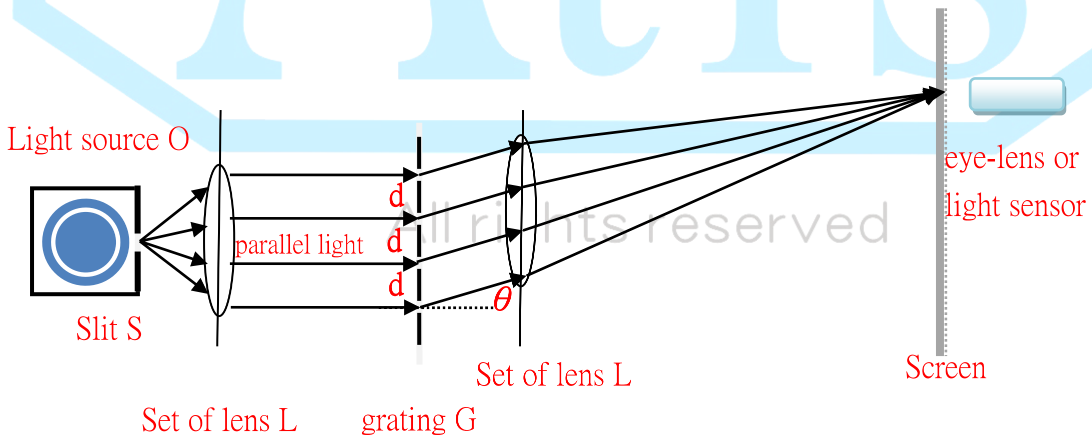

Image 2-1

According to wave's addition of phasor, we can infer to the condition when diffraction appears main bright rays (or main maximum).

$$d \sin\theta = m\lambda \tag{2-6}$$

Upper formula, we call Grating Relation. d is the distance between two slits. If the specification of the grating is 500 lines/mm, then $d = \frac{1}{500} cm$, θ is diffraction angle.

From (2-6) we know, when m=0 so $\theta = 0^0$, we call zero rank maximum. There is nothing with λ, so all the color lights at this angle are overlapping without separating. We see the white bright ray as light source from incandescent lamp. When m=1, we call the first rank maximum. θ and λ are related so the different color light with different wavelengths will create different diffraction angle. Therefore, we can see the different bright rays in various color light. When m=2, we call the second rank maximum and when m=3, we call the third rank maximum etc.

From (2-6) formula we know, when m is bigger, angle θ is bigger that will start gradually from zero rank bright rays, and we can see the blending light in diffraction spectrum from rank by rank. From the value of m and θ ,we can calculate the wavelength of each single light in the spectrum according to (2-6).

Experiment accessory (For reference only, subject to the actual sample)

No.	**Name**	Qty.	No.	**Name**	Qty.
1.	adjustable feet optical slide	1	**2.**	zoom collimating tube	1
3.	moveable angle disc	1	**4.**	observing eye lens	1
5.	support	1	**6.**	grating piece	1
7.	grating piece holder	1	**8.**	hydrogen spectrum tube	1
9.	safety power supply of spectrum tube	1			

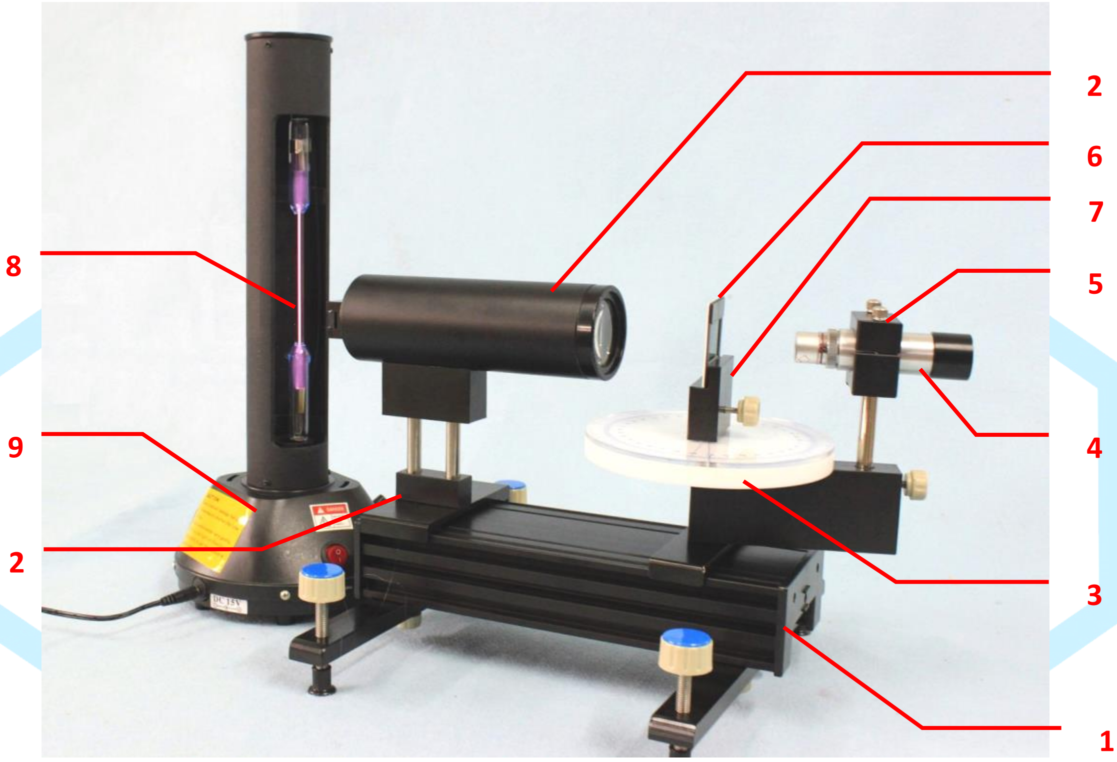

Image 3-1 Installation image of hydrogen spectrum grating analytic device

Attention:

(1) Grating piece is delicate. Do not touch by hand in the middle screen. Or it can not be cleaned by any material. Once after wiping, the grating piece will be broken.

(2) The wide of the slit may not be too wide. Otherwise, the spectrum will not be sharp and create overlapping that will observe with difficulty.

(3) To wear gloves changes lamp is advised to avoid oil sticking on the surface of the lamp.

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