EXTENDED STUDY OF HYDROGEN ATOM

ABSTRACT

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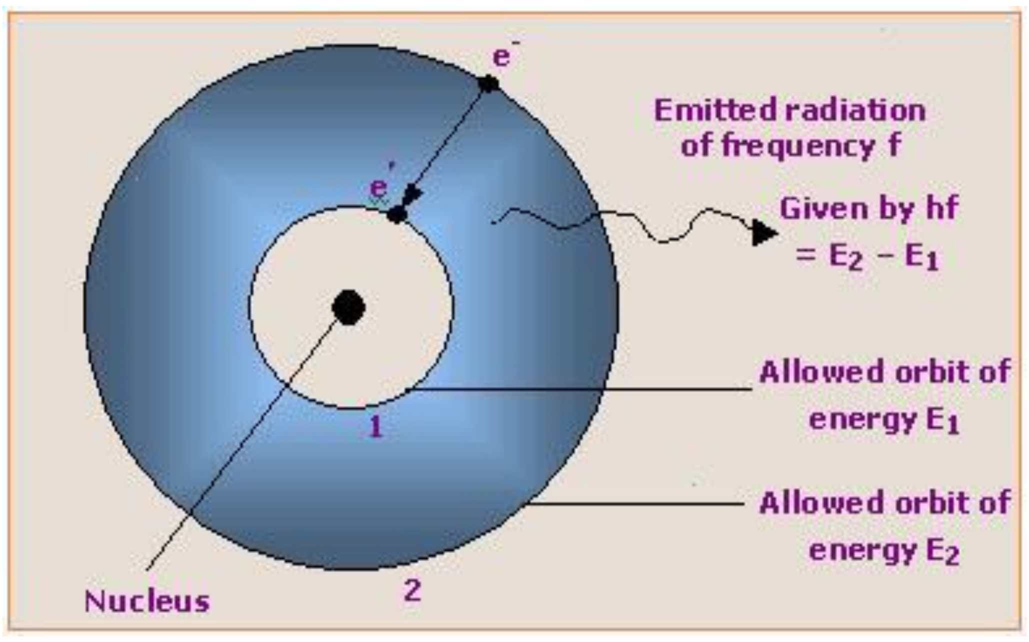
Hydrogen Atom is an atomic nucleus having one proton at the center and one electron revolving around a nucleus in a circular orbit. Bohr suggested “stationary states’ of atoms. These stationary states are states of definite Energy. The electron in any one stationary state does not radiate electromagnetic radiation continuously. The emission and absorption of electromagnetic radiation can be observed in transition between two stationary states. Frequency of the emitted or absorbed radiation is depending on difference in energy of two stationary states. Thus, emitted radiation has specific wavelength. Visible part of hydrogen spectrum, Balmer series was studied and calculated Rydberg constant.

BOHR’S MODEL OF AN ATOM

- Atom : Composed of small, heavily charged nucleus at centre & surrounded by electrons, which revolve in selected circular paths, called Orbits or Stationary States.
- They have a fixed value of radius & energy and thus, accounts for the stability of atom that was not explained by Rutherford’s model.
- Angular momentum of the atom is Quantized.

$$\text{i.e., } L = mvr = \frac{nh}{2\pi} \qquad \text{Where } n = 1, 2, 3 \ldots..$$



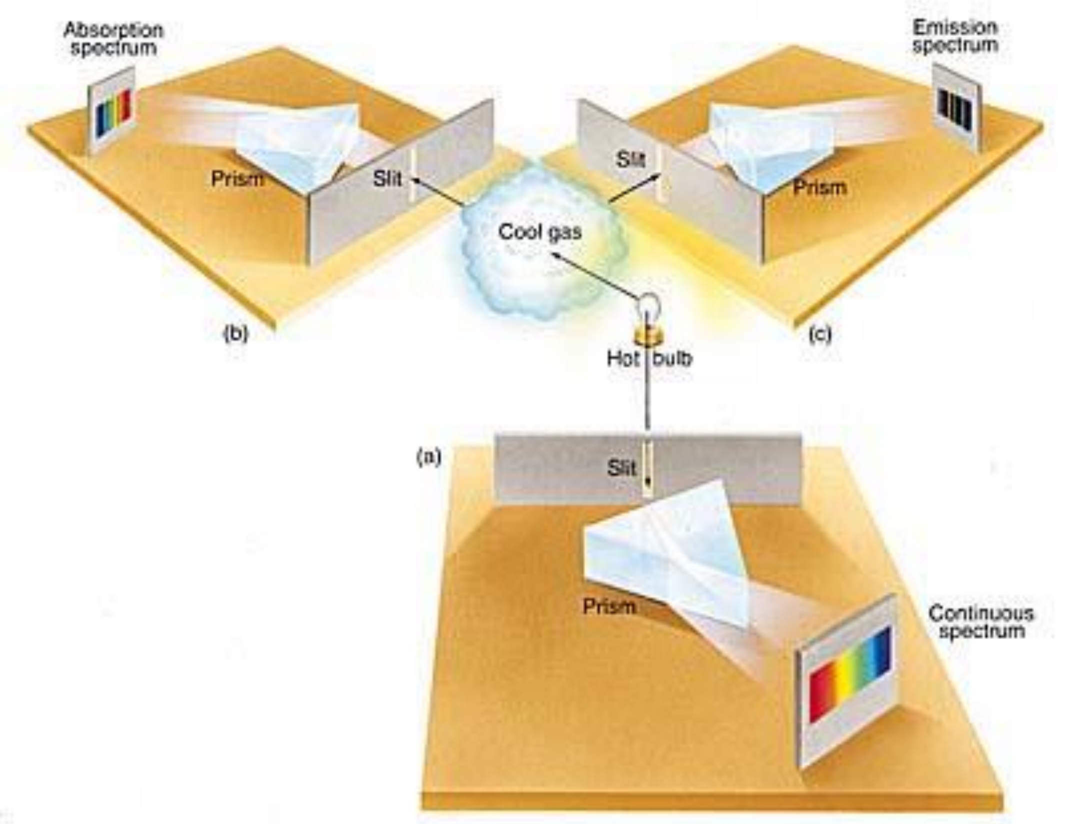
ATOMIC SPECTRA

Just as white light splits into seven colours on being passed through a prism, a similar spectrum is observed for atoms. For white light, spectrum is continuous in nature & for atoms,

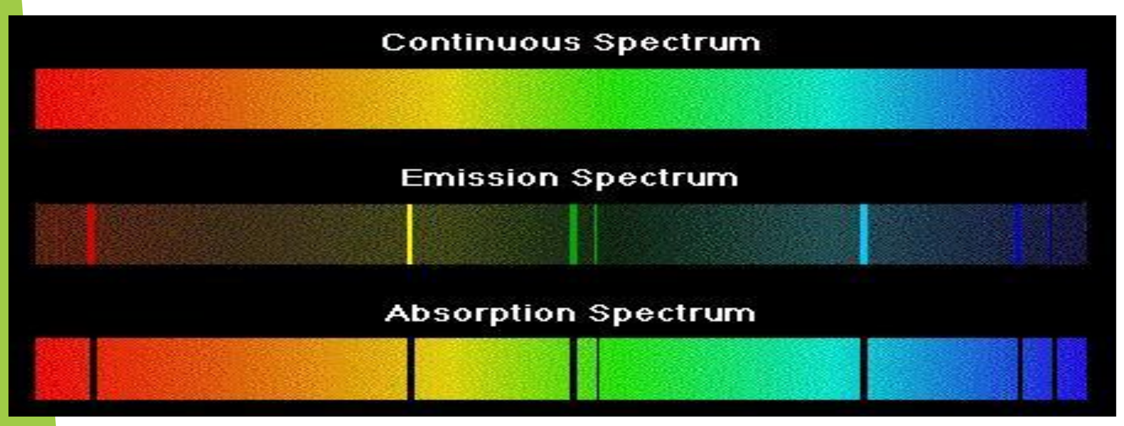
it is composed of sharp, well-defined lines/bands corresponding to definite frequencies.

Atomic Spectra is of two types :

- *Emission Spectra*
- *Absorption Spectra*



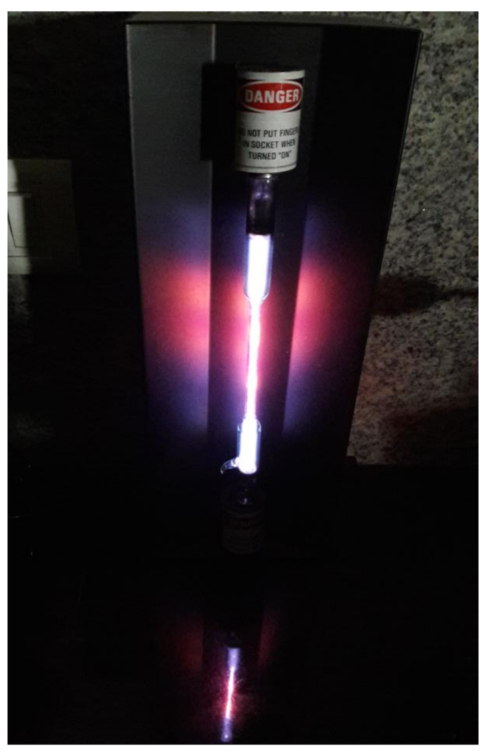
Emission spectrum is the photographic negative of the absorption spectrum.

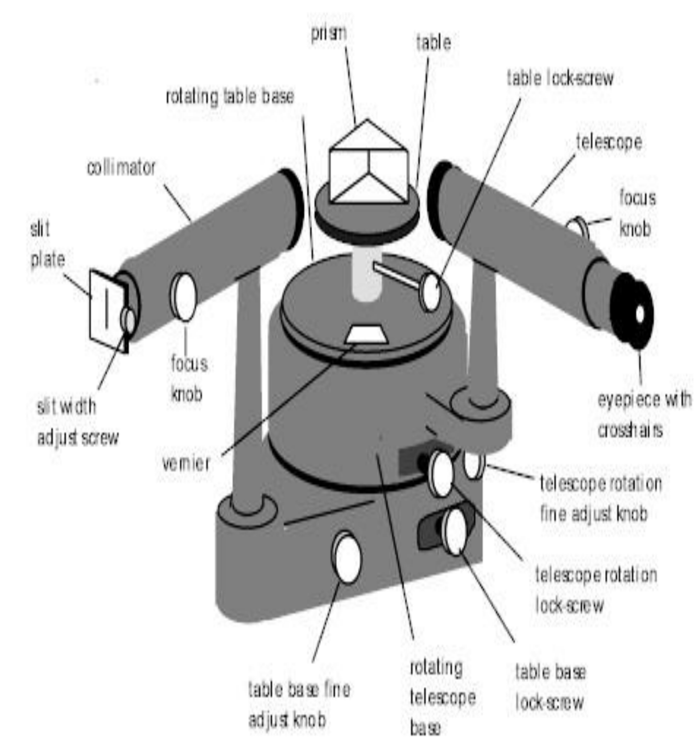


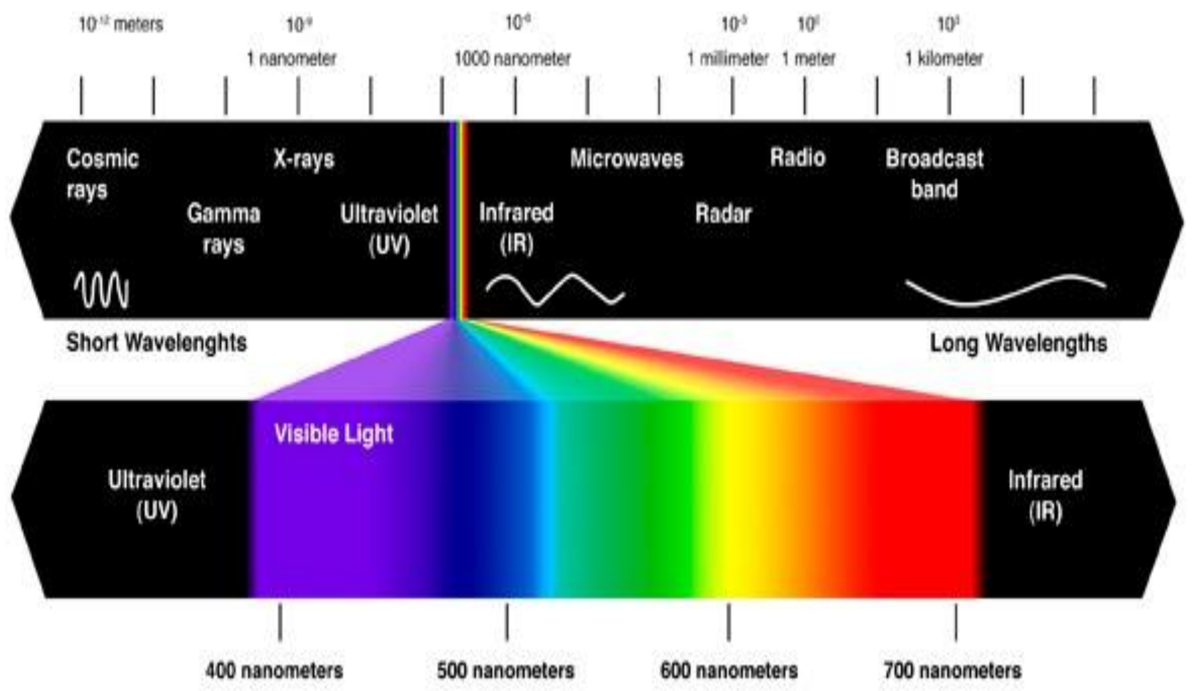
EMISSION SPECTRUM OF H-ATOM

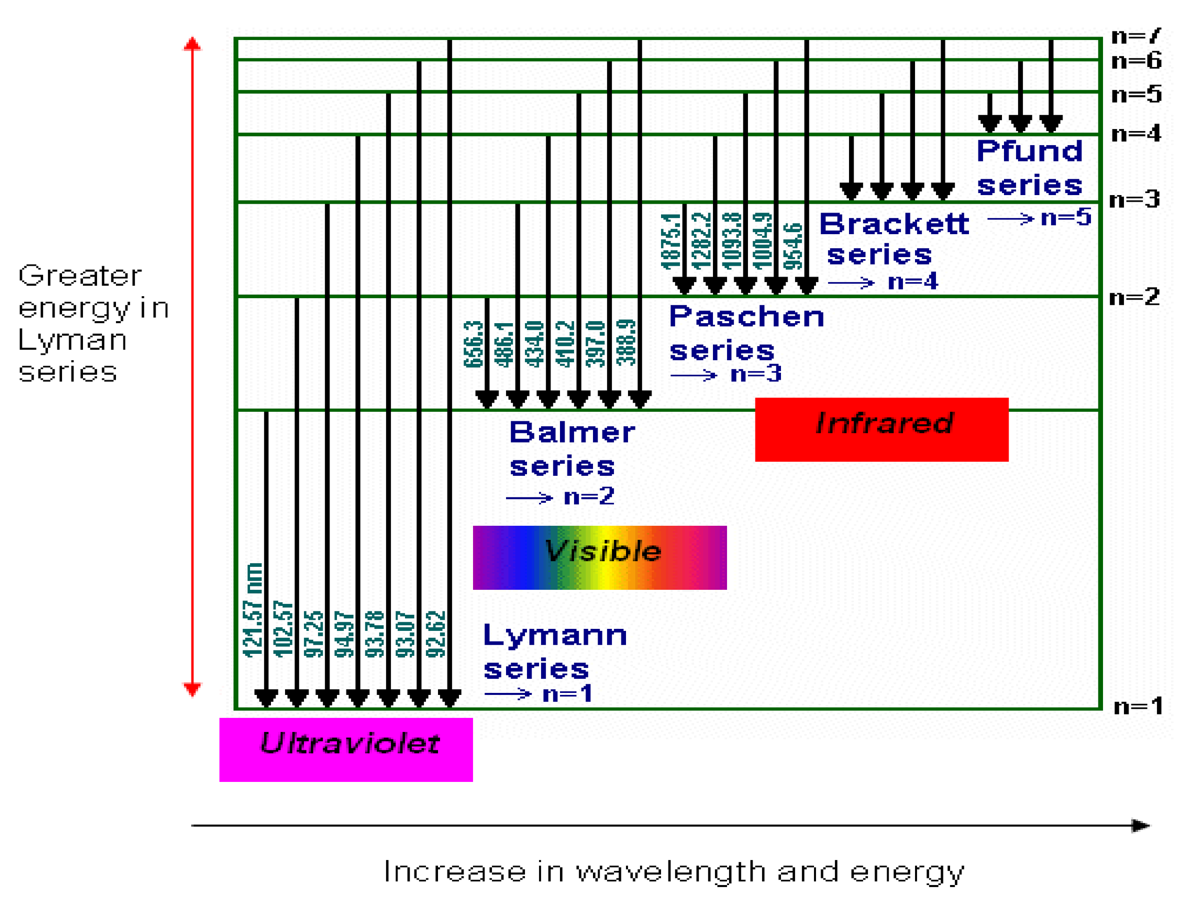
- Spectrum of hydrogen atom is obtained by passing an electric discharge via the hydrogen gas taken in the discharge tube under low pressure.
- Electrical energy transmitted to the gas causes the hydrogen molecules to dissociate into atoms: $H_2 \rightarrow H + H$

- Lifetime of an electron in the excited level is of magnitude 10^{-8} sec. They loose energy by emitting a photon which carries off the excess energy.





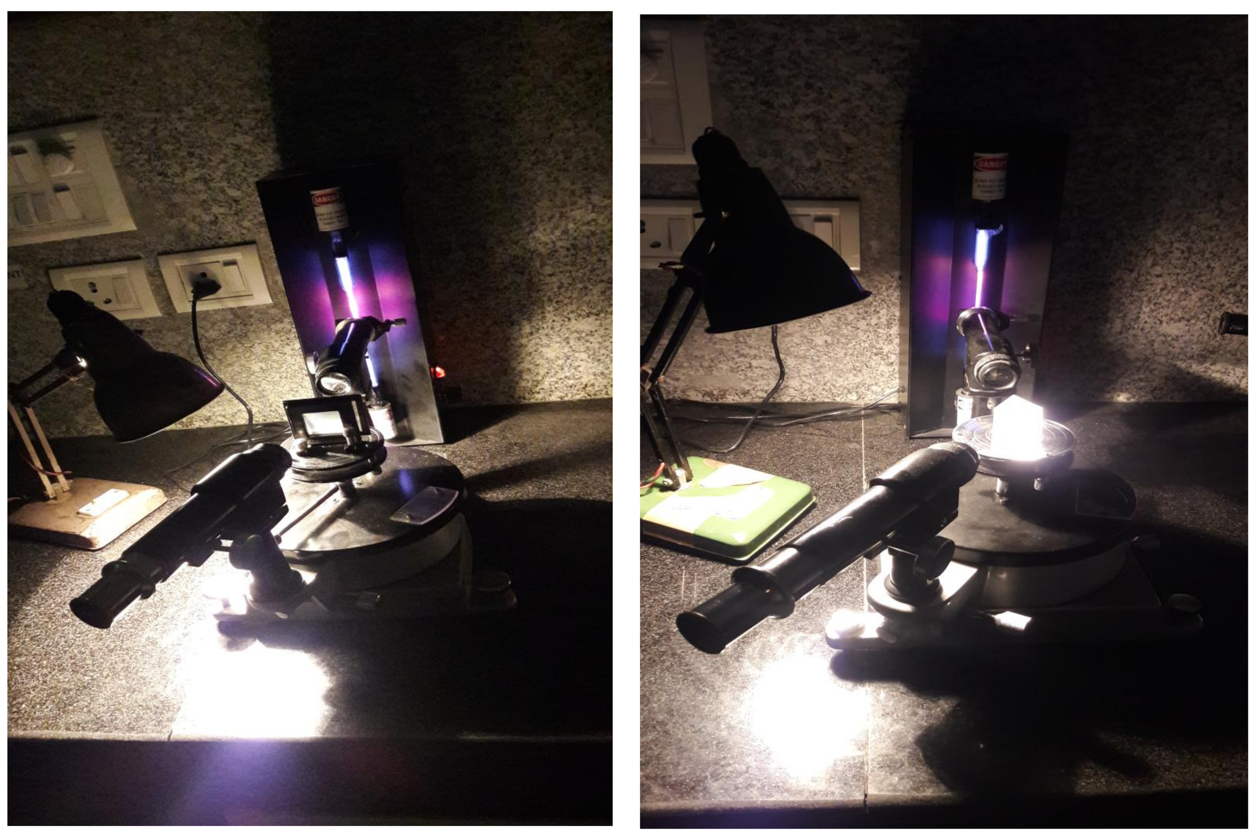




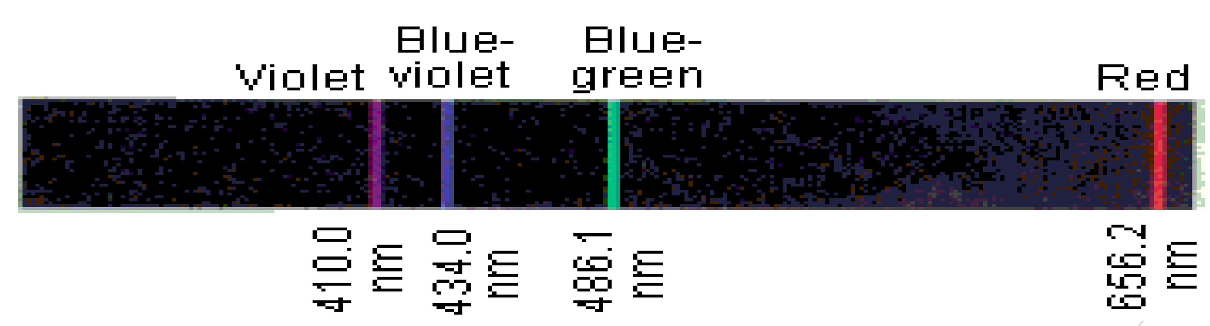
Rydberg Equation:

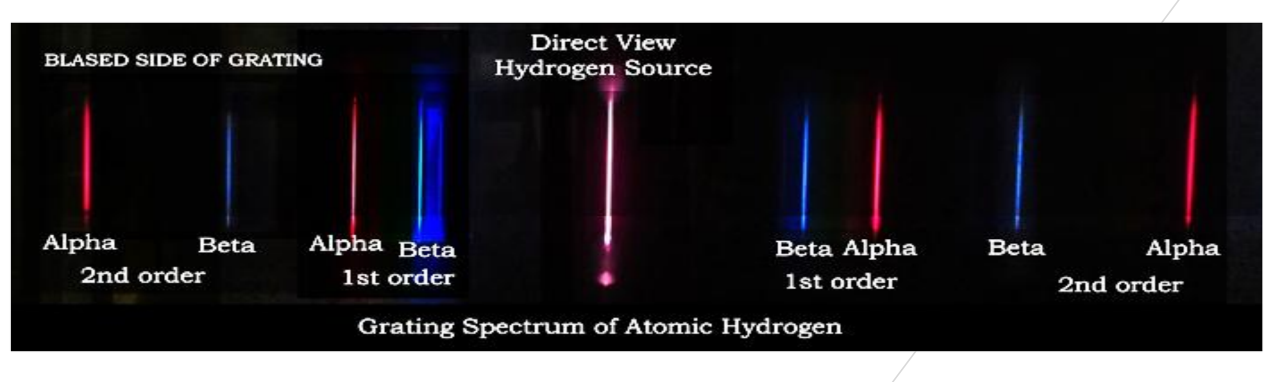
$$\frac{1}{\lambda} = R_H\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] \quad \text{where } R_H = \frac{2\pi^2 me^4}{h^2} \text{ is called the Rydberg constant.}$$

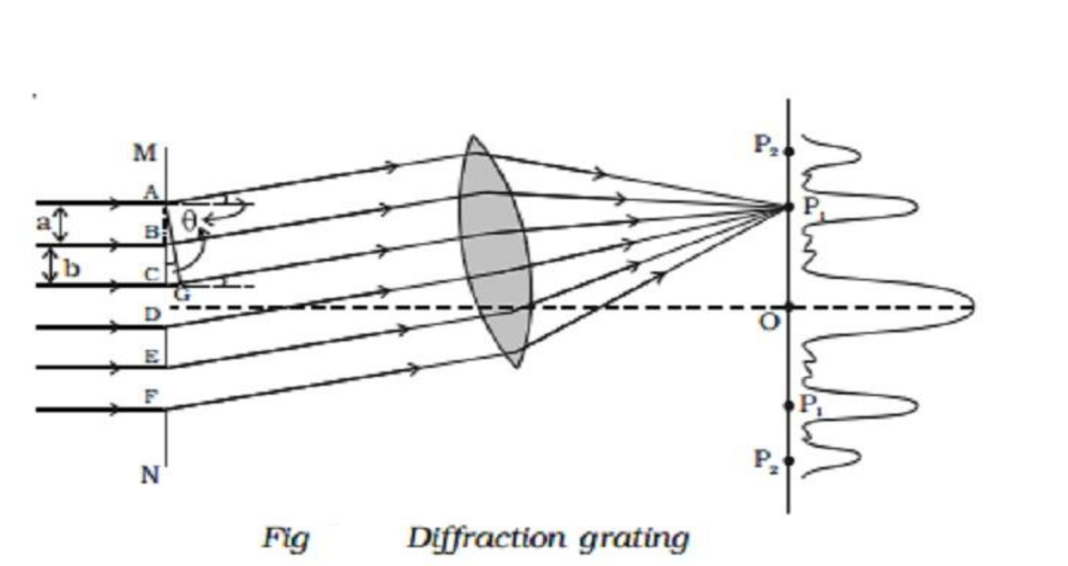
$$R_H = 1.0973731 x 10^7 m^{-1}$$



- The emission spectrum of hydrogen atom for Balmer Series as obtained by prism & diffracting grating were reverse of each other.







BY DIFFRACTION GRATING:

$$\lambda = \frac{d \sin\theta}{n}$$

d = grating element i.e. (2.54/N), N= no. of lines per inch.

$E_\infty \rightarrow E_2$

$E_6 \rightarrow E_2$

$E_5 \rightarrow E_2$

$E_4 \rightarrow E_2$

$E_3 \rightarrow E_2$

The formula for Balmer Series is

$$\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{n^2}\right),$$

where n = 3, 4, 5, ..., and

R is the Rydberg Constant.

These transitions emit visible photons.

BY PRISM:

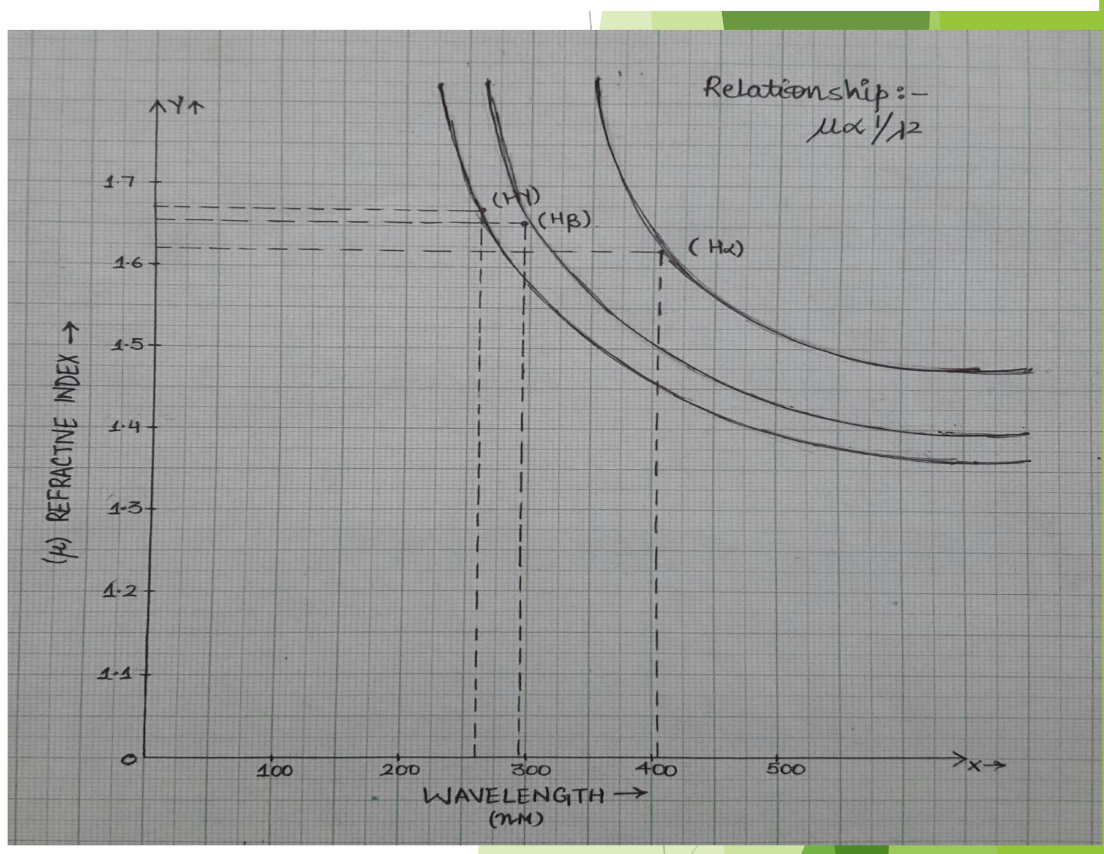
$$n = \frac{\sin(A + \delta m/2)}{\sin(A/2)}$$

$$n = \frac{c}{v}$$

v= velocity of the spectral lines in the medium.

Cauchy’s Dispersion Formula :

$$n(\lambda) \approx A + {}^{B}/_{\lambda^2} + {}^{C}/_{\lambda^4} + \cdots$$



RESULT

- The calculated value of Rydberg Constant within the limits of experimental error was R=1.15*10^7 m-1.
- The values of wavelength as calculated were:

  H(alpha) = 626 nm

  H(beta) = 463.7 nm

  H(gamma) = 414 nm

REFERENCES

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