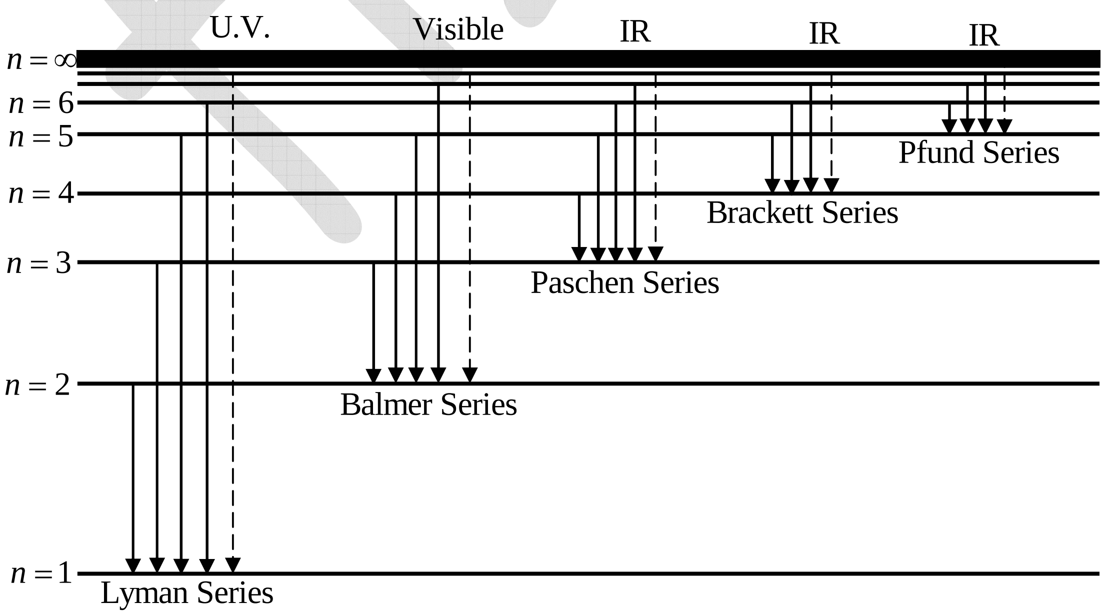
(b) Spectrum of Atomic Hydrogen

It has been discovered that when atoms exposed to white light can absorb light at certain discrete frequencies known as absorption lines or when atoms are excited by the passage of an electric current or by some another means produces discrete frequencies of light known as emission line. The spectrum of light absorbed or emitted by an element is carrying the signature of that element, e.g. Sodium burning in flame, produces two distinct yellow light of wavelength $5896\,\mathring{A}$ and $5890\,\mathring{A}$ which is observed after being dispersed by a suitable spectrometer. Each of the wavelength components is called a spectral line and whole family of lines is called a line spectrum. No two different elements can produce similar spectrum. The fact that each element produces its own characteristic spectrum, is of great importance as this information can be used for the chemical or element analysis, for example the elements present in Sun are analysed by this means. J. Balmer (1885) and J. Rydberg (1888) found that the spectral lines in hydrogen atom obey the following mathematical formula

$$\nu = \frac{1}{\lambda} = R\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

Where ν is the frequency of either an emission or absorption line, n_i and n_f are positive integer with $n_i > n_f$ and R is a constant, known as Rydberg's constant.



In atomic hydrogen, different line series are observed which are described below:

(*i*) *Lyman Series*: The series with $n_f = 1$ is known as the Lyman series and lies in the ultraviolet part of the spectrum.

$$\frac{1}{\lambda} = R\left(\frac{1}{1^2} - \frac{1}{n_i^2}\right) \qquad n_i = 2, 3, 4...$$

The lines are labeled as L_α, L_β, L_γ ……… in order of decreasing wavelengths.

L_α line: $n_f = 1$ and $n_i = 2$; $\lambda = 1216\,\mathring{A}$

L_β line: $n_f = 1$ and $n_i = 3$; $\lambda = 1026\,\mathring{A}$

L_γ line: $n_f = 1$ and $n_i = 4$; $\lambda = 973\,\mathring{A}$

While the Lyman series limit ($n_i \to \infty$) is $\lambda = 912\,\mathring{A}$.

(*ii*) *Balmer Series*: Balmer series ($n_f = 2$) was first to be discovered and it lies in the visible part of electromagnetic spectrum.

$$\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{n_i^2}\right) \qquad n_i = 3, 4, 5...$$

The lines are labeled as H_α, H_β, H_γ ……… in order of decreasing wavelengths.

H_α line: $n_f = 2$ and $n_i = 3$; $\lambda = 6563\,\mathring{A}$

H_β line: $n_f = 2$ and $n_i = 4$; $\lambda = 4861\,\mathring{A}$

H_γ line: $n_f = 2$ and $n_i = 5$; $\lambda = 4340\,\mathring{A}$

While the Balmer series limit ($n_i \to \infty$) is $\lambda = 3646\,\mathring{A}$. The H_α is an important line used in the detection of hydrogen presence.

(*iii*) *Paschen Series*: Paschen series was observed by Friedrich Paschen in 1908 corresponds to the transition between the states with ($n_f = 3$) and successive higher states and lies in the near Infrared region of the spectrum.

$$\frac{1}{\lambda} = R\left(\frac{1}{3^2} - \frac{1}{n_i^2}\right) \qquad n_i = 4, 5, 6...$$

The Paschen series starts with a line at 18751 $\overset{o}{A}$ and ends at 8204 $\overset{o}{A}$ (wavelength of Paschen series limit).

(*iv*) *Brackett Series*: In the Brackett series electron transition takes place from any higher principle quantum state to $n_f = 4$ and it is obtained in the far infrared region.

$$\frac{1}{\lambda} = R\left(\frac{1}{4^2} - \frac{1}{n_i^2}\right) \qquad n = 5, 6, 7.........$$

The Brackett series start at 40500 $\overset{o}{A}$ whereas the series limit lies at 14580 $\overset{o}{A}$. The shortest or high frequency lines of Brackett series overlap with the Paschen series lines.

(*v*) *Pfund Series*: This series was discovered by A.H. Pfund in 1924 which corresponds to transition between the states with ($n_f = 5$) and successive higher states and lies in Infrared region of the spectrum.

$$\frac{1}{\lambda} = R\left(\frac{1}{5^2} - \frac{1}{n_i^2}\right) \qquad n_i = 6, 7, 8.....$$

The Pfund series start at 74600 $\overset{o}{A}$ whereas the series limit lies at 22790 $\overset{o}{A}$.

(*vi*) *Humphreys Series*: The sixth series in the spectrum of hydrogen atom was observed by C.J. Humphreys in 1953 and lies in the infrared region of the spectrum. This series originates in transition to the sixth orbit from those of greater quantum numbers.

$$\frac{1}{\lambda} = R\left(\frac{1}{6^2} - \frac{1}{n_i^2}\right) \qquad n_i = 7, 8, 9.....$$

The series with higher orders is unnamed but it follows the same rule given by J. Rydberg formula.