ZEEMAN EFFECT FOR ONE ELECTRON:-

Paschen-Back effect Strong ... weak magnetic field

(1) Normal Zeeman effect (2) Anomalous Zeeman Effect

The effect of magnetic field on the spectrum was first of all discovered by Zeeman in year 1896 and is called Zeeman effect. It was observed that a single spectral line split up into three components such that one line has got a larger frequency, other a lower frequency than that the frequency of original line and third one has the frequency of original line. This was named as normal Zeeman effect.

But later on much more complicated splitting was observed and was called anomalous Zeeman effect.

Vector model of the atom:-

(1) Normal Zeeman effect is produced in the case of a singlet line.

(2) Orbital motion of the electron is sufficient to explain this normal Zeeman effect.

(3) Anomalous Zeeman effect is produced by doublet, triplet lines such as (Na, Ca etc.) This effect can be explained by considering the spin motion besides orbital motion.

When an atom is placed in a magnetic field the electron ~~orbit~~ orbit begins to execute a precessional motion round the direction of the applied magnetic field.

$(\omega = 2\pi\nu)$

The precessional frequency of (Larmor) is given by the formula $\omega_L = \frac{e}{\cancel{4\pi} mc} H \;|\; \omega_L = \frac{e}{2mc} H$

On account of this precessional motion the energy of the electron changes. The change of the magnetic energy

$$\Delta E = \omega_L \, l \frac{h}{2\pi} \cos(l, H)$$

[Projection of the precession vector in the direction of the field]

$$\nu = \frac{\omega}{2\pi}$$

$$= \frac{e}{2mc} H \, l \frac{h}{2\pi} \cos(l, H)$$

$$= \frac{eh}{2mc\,2\pi} H \, l\cos(l H)$$

$$\Delta E = \frac{eh}{4\pi mc} H \, l \cos(l, H)$$

$$\Delta E = \frac{eh}{4\pi mc} H m_l$$ where m_l = magnetic quantum

Let E_0' and E_0'' be the Energy of final and Initial level in the absence of magnetic field. ① A

Let E_H' and E_H'' be the corresponding energy in the presence of the field. So

$$E_H' = E_0' + \frac{eh}{4\pi mc} H m_l' \quad \text{— (2)}$$

where m_l' is the magnetic quantum No of the final level and m_l'' of the Initial level.

$$E_H'' = E_0'' + \frac{e \cdot h}{4\pi mc} H \cdot m_l'' \quad \text{— (3)}$$

When Transition occurs from higher Energy levels to lower Energy levels then

$$h\nu = E_H'' - E_H' \qquad (3-2)$$

$$= (E_0'' - E_0') + \frac{eh}{4\pi mc} H (m_l'' - m_l')$$

$$\frac{\nu}{c} = \lambda = \bar{\nu} = \text{wave No}$$

$$h\nu = h\nu_0 + \frac{eh}{4\pi mc} H \cdot \Delta m_l$$

$$\nu = \nu_0 + \frac{e}{4\pi mc} H \cdot \Delta m_l \quad \text{— (4)}$$

where $\frac{eH}{4\pi mc} = L$ called the Lorentz unit and represent the Normal zeeman effect.

① then $\nu = \nu_0$

② when $\Delta m_l = -1$

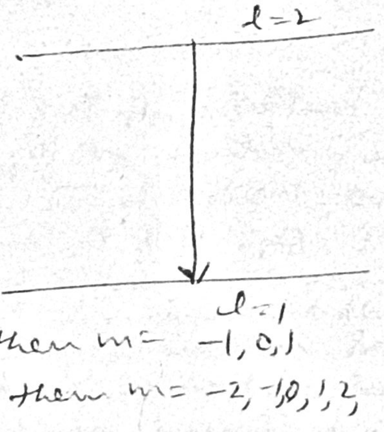
$$\nu = \nu_0 - \frac{eH}{4\pi mc}$$

③ when $\Delta m_l = +1$

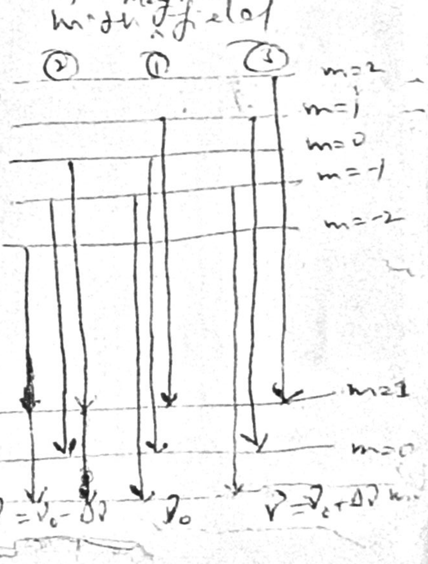
$$\nu_H = \nu_0 + \frac{eH}{4\pi mc}$$

Now we consider the Normal zeeman effect for $l = 2$ & $l = 1$ level.

without field



with magnetic field



If $l = 1$ then $m = -1, 0, 1$

If $l = 2$ then $m = -2, -1, 0, 1, 2$