Zeemann Effect

Now m_l can have $(2l+1)$ values from $+l$ to $-l$. Therefore an external magnetic field will split a single energy level into $(2l+1)$ levels. The d-state $(l=2)$ is split into 5 sub-levels and the p-state $(l=1)$ is split into 3 sub-levels as shown in fig (2)

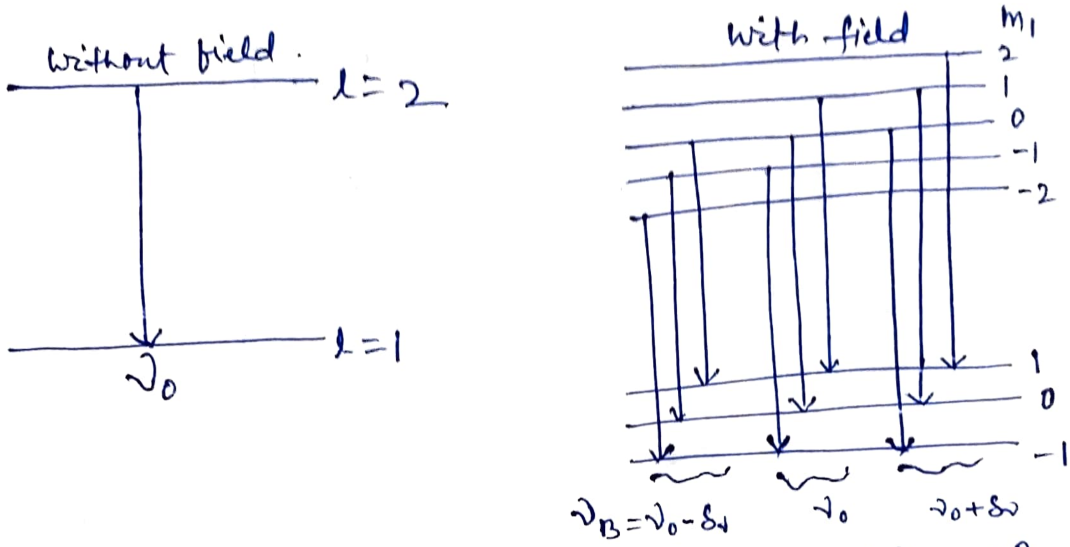

Fig (2)

Let E_0 represents the energy of the level $l=1$ in the absence of the magnetic field and E_B represent the energy of this level in the presence of magnetic field. Then

$$E_B = E_0 + \Delta E$$

$$= E_0 + m_{l0} \frac{eh}{4\pi m} \cdot B \quad \text{--- (5)}$$

Similarly, if E_{01} and E_{B01} represent the energies of the level $l=2$ without and with the magnetic field respectively, then

$$E_{B01} = E_{01} + M_{l01} \frac{eh}{4\pi m} B \quad \text{--- (6)}$$

The quantity of energy radiated in the presence of magnetic field is

$$E_{B01} - E_{B0} = E_{01} + E_0 = (m_{l01} - m_{01}) \frac{eh}{4\pi m} \cdot B$$

or, $h\nu = h\nu_0 + \Delta m_l \frac{ehB}{4\pi m}$

or, $\nu = \nu_0 + \Delta m_l \frac{eB}{4\pi m}$ ——— (7)

Where ν = frequency of the radiation emitted with the magnetic field and ν_0 = frequency of the radiation in the absence of the magnetic field. The selection rule for m_l is $\Delta m_l = 0$ or ± 1.

Hence, we have three possible lines,

$\nu_1 = \nu_0$ for $\Delta m_l = 0$ ——— (8)

$\nu_2 = \nu_0 + \frac{eB}{4\pi m}$ for $m_l = +1$ ——— (9)

and, $\nu_3 = \nu_0 - \frac{eB}{4\pi m}$ for $m_l = -1$ ——— (10)

Fig. (2) represents the normal zeeman effect. Though there are nine possible transitions, they are grouped, into only three different frequency components as indicated by eqns (8), (9) and (10). For three transitions in a bracket, change in the value Δm_l is the same and hence they represent the same energy and single line.

Anomalous Zeeman Effect :