Nuclear Magnetic Moments

Any motion of a charged has an associated magnetic field. This on a combined scale an electrical current which is due to motion of $e^{\ominus}$ along the conductor, produces such a field.

- Electrons or nuclear posses angular momentum there is a magnetic moment.

Suppose an electron is travelling in an orbital at an angular velocity ω.

$$i = \frac{e\omega}{2\pi}$$

$e \rightarrow$ magnitude of charge in electron

$$\text{or} \quad i = \frac{e\omega}{2\pi} = \frac{eP}{2\pi m_e r^2}$$

$P \rightarrow$ orbital angular momentum

$m_e \rightarrow$ mass of electron

$r \rightarrow$ distance from nucleus

The magnetic moment μ generated by such motion is given in electromagnetic theory

$$\cancel{\mu = Ae\ Ai} \quad \mu = Ai$$

$A \rightarrow$ Area marked out by the orbital

if $e^{\ominus}$ moves in a circular orbit

$$A = \pi r^2$$

$$\mu = -\left(\frac{e}{2m_e}\right) P$$

As per the above equation the angular momentum is quantized in unit of $\hbar$. Electronic magnetic moments are quantized in units of $\frac{e\hbar}{2m_e}$ $\left(\hbar = \frac{h}{2\pi}\right)$. $= \mu_B$

$\mu_B \rightarrow$ Bohr's magneton $= 9.27410 \times 10^{-24}\ JT^{-1}$.

Due to spin motion involved we introduced magnetic moment and angular momentum.

Hence we introduce a new factor g (Lande's splitting factor)

Thus we rewrite

$$\mu = -g\left(\frac{e}{2m_e}\right)P = -g\mu_B\frac{P}{\hbar}$$

↳ Coupled spin-orbital motion.

The constant of proportionality relating μ & P depends on the mass of the particle and charge.

$$\mu \propto \left(\frac{ze}{2m_N}\right)P$$

$m_N \rightarrow$ mass of nucleus

and $z \rightarrow$ charge number

$$\mu_N = \frac{e\hbar}{2m_p}$$

$m_p \rightarrow$ mass of proton

$$\mu_N = 5.05095 \times 10^{-27}\ JT^{-1}$$

$$\mu_N = \frac{g_N \mu_N P}{\hbar}$$

$g_N \rightarrow$ nuclear g-factor

↳ $g \rightarrow$ positive for electron

Negative nuclear g-factors imply that spin magnetic moment is antiparallel to the angular momentum positive values indicate that μ & P are parallel.

- Nuclear magnetic moments are expressed as magnetogyric ratio γ.

$$\gamma = \frac{\text{magnetic moment}}{\text{angular momentum}} = \frac{\mu}{P}$$

or $\quad \mu = \gamma P$

$$\gamma \hbar = g_N \mu_N$$

$$\mu = g_N \mu_N [I(I+1)]^{1/2}$$

$$\boxed{\mu = \gamma \hbar [I(I+1)]^{1/2}}$$