# Magnetic Resonance Spectroscopy

**Spectroscopy**: The interaction between matter and electromagnetic radiation such that energy is absorbed or emitted according to the Bohr frequency condition,

$$\Delta E = h\nu$$

$\Delta E$ is the energy difference (quantized) between the initial and final energy of matter,

$h$ = Planck's constant

$\nu$ = frequency of electromagnetic radiation

**Nuclear Magnetic resonance:**

NMR involves the magnetic energy of nuclei when they are placed in magnetic field. The transitions occur in radiowave region of the spectrum.

NMR depends upon

- → Shielding constants
- → Coupling constants of nuclei
- → Lifetime of energy levels.

★ We primarily study the NMR of liquid or solution systems. The NMR is uncommon in gas because of low sensitivity of NMR. This is due to the broader resonance lines are usually broader than for liquids.

## Quantization of Angular momentum:

The total angular momentum of an isolated particle cannot have any arbitrary magnitude but may only take certain discrete values.

Angular momentum is said to be quantized and its magnitude, P, can be specified in terms of a quantum number say R,

$$P = \hbar [R(R+1)]^{1/2} \quad \{R = l\}$$

$$\hbar = \frac{h}{2\pi} \quad (h = \text{Planck's constant})$$

R is either integral or half-integral.

- Quantization of angular momentum implies quantization of energy. Each energy state of particle may be specified by the suitable quantum numbers.
- Angular momentum is a vector property.

$$m_R = R, R-1, R-2 \ldots\ldots -R$$

There are $2R+1$ no. of allowed magnetic quantum numbers.

## Electron and nuclear ~~the~~ spin:

Transitions between nuclear spin energy levels give rise to the phenomenon of NMR corresponding property of electron spin leads to Electron spin resonance.

The proton has a spin quantum number, I of ½ as does the neutron.

For nuclei other than $^1H$, the spin angular momenta of the indivisual nucleons couple (together with their orbital-type angular momenta) to give the observed total.

- Nuclei with an odd mass number have half integral spin.
- Nuclei with an even mass number and an even charge numbers have zero spin ($^{12}C$, $^{16}O$, $^{32}S$)
- Nuclei with an even mass numbers but an odd charge number have integral spin.
- ~~Nuclei with an even mass no. but an~~

Nuclei with $I = 0$ do not show any direct effects.

The magnitude of the nuclear spin angular momentum is given by principle as

$$P = \hbar [R(R+1)]^{1/2}$$

Nuclei with spin quantum number greater than ½ also posses electric quadropole moment