Nuclear Zeeman Splitting

A nuclear state with spin I is $(2I+1)$-fold degenerate. Degeneracies are an outcome of symmetries in the Hamiltonian (here, space isotropy). If an external magnetic field is applied, this degeneracy is broken.

$$\hat{H}_z = -\hat{\vec{\mu}} \cdot \vec{B}_0$$

$$\left.\begin{aligned} \hat{H}_z &= -\gamma \hat{\vec{I}} \cdot \vec{B}_0 \\ \text{let} \quad \vec{B} &= \hat{z}\, B_0 \end{aligned}\right\} \quad \hat{H}_z = -\gamma B_0 \hat{I}_z$$

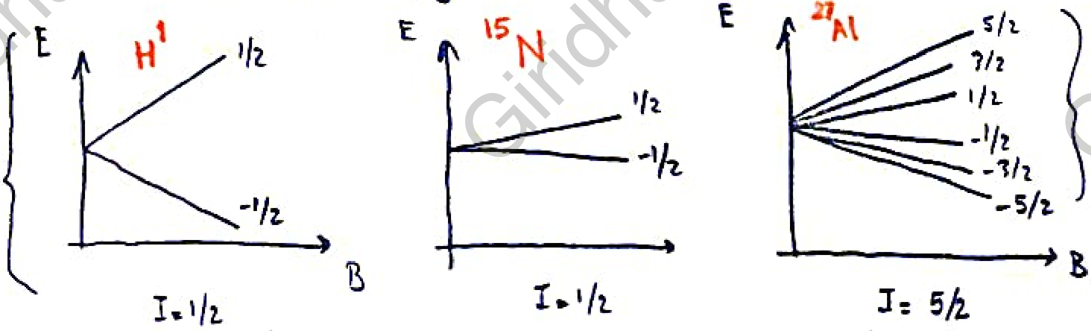
ω_0: Larmor Frequency

$$\langle m | \hat{H}_z | m \rangle = m\hbar\omega_0 \quad ; \quad m = -I, \dots, I \qquad (2I+1) \text{ states}$$

with $\Delta E_z = \hbar|\omega_0|$ ← Level splitting

The splitting bet. the nuclear spin levels is called the nuclear Zeeman splitting. NMR is the spectroscopy of the nuclear Zeeman sublevels.

H is 10 times more magnetic than N



6 levels $= 2 \cdot \frac{5}{2} + 1$

The Zeeman splitting <u>within</u> the nuclear ground state must not be confused with the enormously large splitting bet. nuclear spin ground state and the nuclear spin excited states. The Zeeman splittings are far smaller than thermal energies (unless at ultracold T's).

As an example consider the deuteron $^{2}_{1}H$, having $p+n$. Its "spin", meaning ground state total angular momentum is $I=1$ (i.e, triplet).

If the "spin" of say the neutron flips to make it a singlet state, i.e., $I=0$, due to associated spin-dependent nuclear forces, this configuration has an energy 10^{11} kJ/mol higher $\xrightarrow{\text{compare}}$ $E_{\text{thermal}}(300\text{K}) = 2.5$ kJ/mo