1(d). Angular Momentum of Nucleus

The hydrogen nucleus $_1^1\text{H}$ consists of a single proton and its total angular momentum is given by $\left|\vec{S}\right| = \frac{\sqrt{3}}{2}\hbar$. A nucleon in a more complex nucleus may have orbital angular momentum due to motion inside the nucleus as well as spin angular momentum. The total angular momentum of such a nucleus is the vector sum of the spin and orbital angular momenta of its nucleons, as in the analogous case of the electrons of an atom.

When a nucleus whose magnetic moment has z component μ_z is in a constant magnetic field $\vec{B}$**,** the magnetic potential energy of the nucleus is

Magnetic energy $\qquad U_m = -\mu_z B$

The energy is negative when $\vec{\mu}_z$ is in the same direction as $\vec{B}$ and positive when $\vec{\mu}_z$ is opposite to $\vec{B}$. In a magnetic field, each angular momentum state of the nucleus is therefore split into components, just as in the Zeeman Effect in atomic electron states. Figure below shows the splitting when the angular momentum of the nucleus is due to the spin of a single proton.

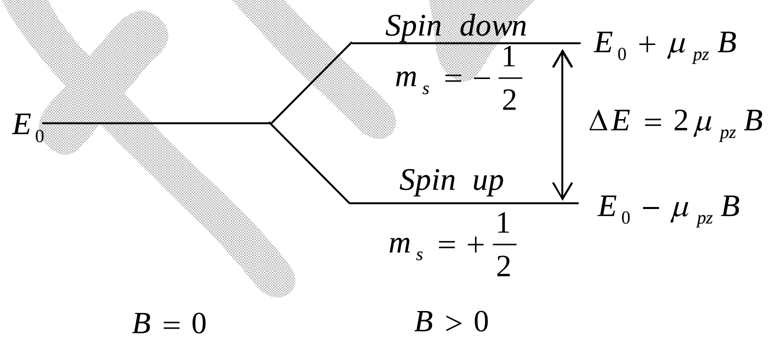

Figure: The energy levels of a proton in a magnetic field are split into spin-up and spin-down sublevels.

The energy difference between the sublevels is

$$\Delta E = 2\mu_{pz} B$$

A photon with this energy will be emitted when a proton in the upper state flips its spin to fall to the lower state. A proton in the lower state can be raised to upper one by absorbing a photon of this energy. The photon frequency ν_L that corresponds to ΔE is

Larmor frequency for photons $$\nu_L = \frac{\Delta E}{h} = \frac{2\mu_{pz} B}{h}$$

This is equal to the frequency with which a magnetic dipole precesses around a magnetic field.