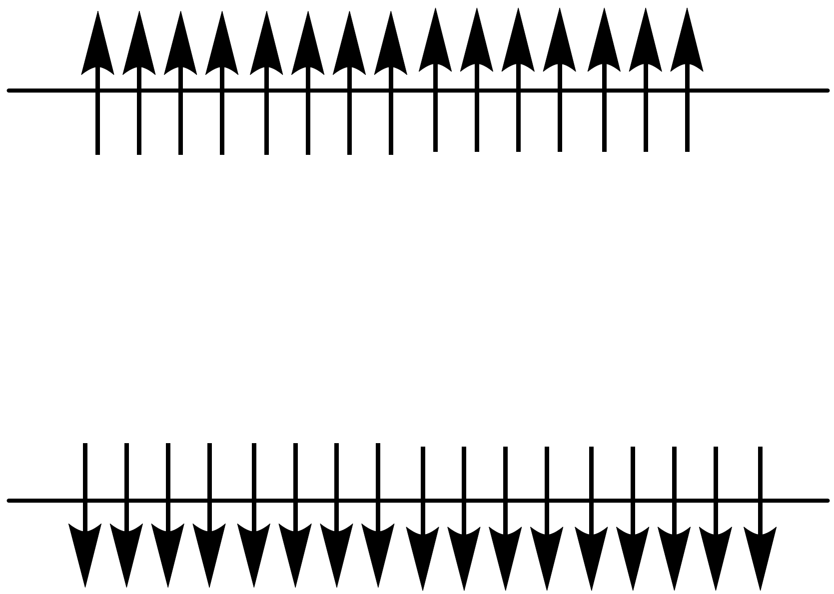
The classical vs. quantum view

- According to a classical picture the nuclei precess around the axis of the applied magnetic field B_z or B_0.
- In the quantum view a sample is composed of many nuclei of spin I = 1/2. The angular momentum is a vector of length $\{I(I+1)\}^{1/2}$ and a component of length m_I along the z-axis.
- The uncertainty principle does not allow us to specify the x- and y- components
- In either case the energy difference between the two states is very small and therefore the population difference is also small.

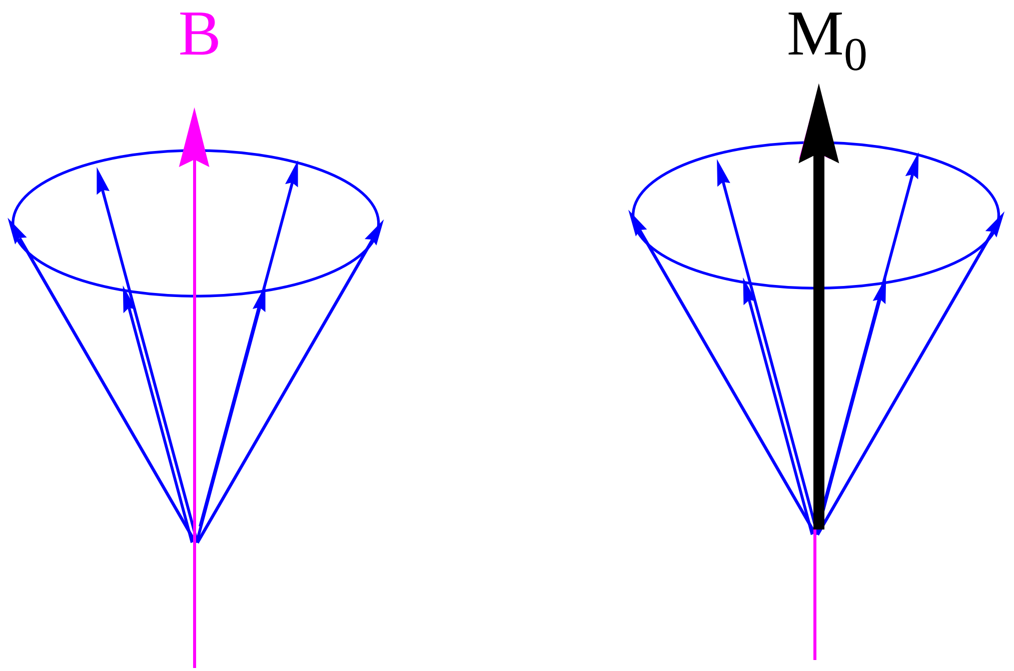
The population difference and sensitivity of the NMR experiment



$$\frac{N_\beta}{N_\alpha} = e^{-h\nu_L / kT}$$

Given the fact that ν_L is in the radiofrequency range $h\,\nu_L \ll k_B T$. This small population difference gives rise to the measured magnetization in a NMR experiment.

The bulk magnetization vector



Precessing nuclear spins

The bulk magnetization

The applied magnetic field B causes spins to precess at the Larmor frequency resulting in a bulk magnetization M_0.

The Bloch Equations

The magnetization vector M obeys a classical torque equation:

$$\frac{dM}{dt} = M \times B$$

where B is the magnetic field vector. M precesses about the direction of an applied field B with an angular frequency γB radians/second.

The Vector Components of the Bloch Equations

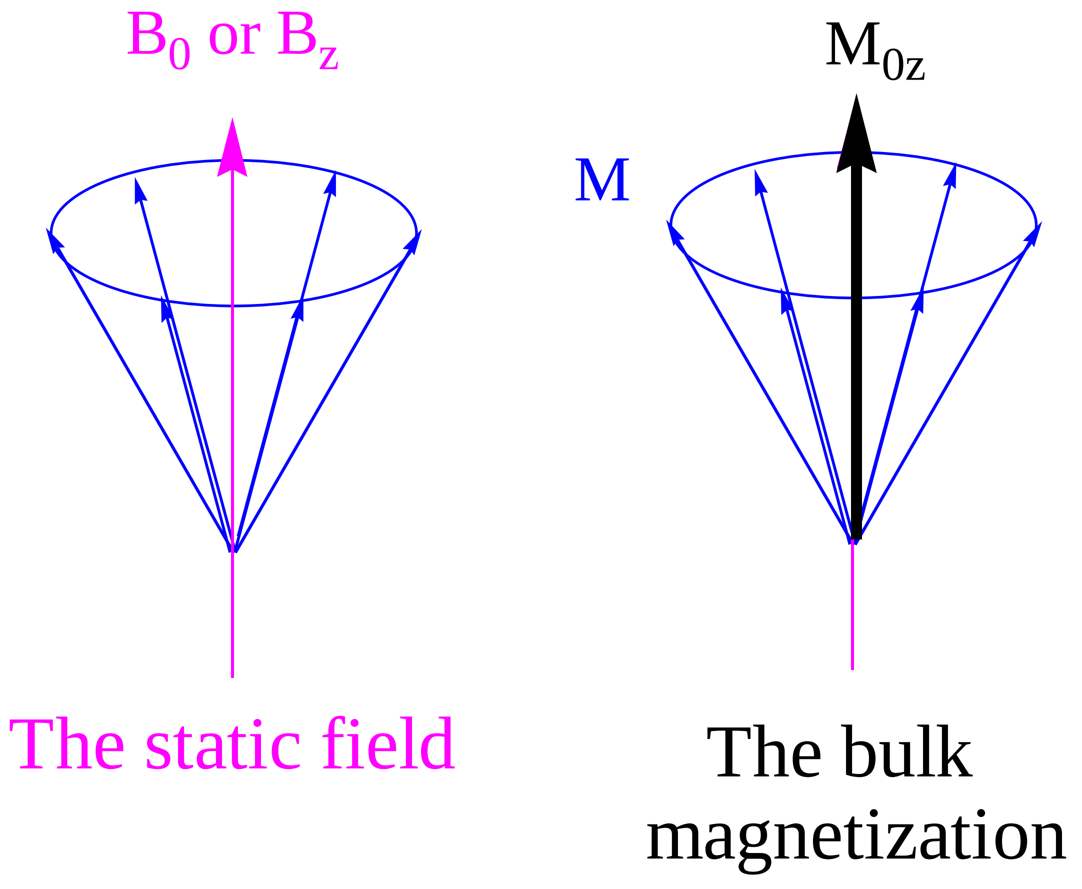
$$\frac{dM_x}{dt} = \gamma\left(M_y B_z - M_z B_y\right)$$

$$\frac{dM_y}{dt} = \gamma\left(M_z B_x - M_x B_z\right)$$

$$\frac{dM_z}{dt} = \gamma\left(M_x B_y - M_y B_x\right)$$

If no radiofrequency fields are present then $dM_x/dt = 0$ and $dM_y/dt = 0$ and we simplyhave rotation about the static field B_z. We will also call this B_0.

The static field causes precession of nuclear spins



The magnetic field vector M precesses about B_0.
The spins precess at the Larmor frequency $\omega = -\gamma B_0$.