**Important constants:**

| | |
|---|---|
| $h = 6.6260755 \cdot 10^{-34}$ J $s^{-1}$ | Planck's constant |
| $\hbar = h/(2\pi)$ | |
| $c = 2.99792458 \cdot 10^{8}$ m $s^{-1}$ | speed of light in vacuum |
| $k = 1.380658 \cdot 10^{-23}$ J $K^{-1}$ | Boltzmann constant |
| $N_A = 6.022 \cdot 10^{23}$ $mol^{-1}$ | Avogadro constant |
| $\gamma_H = 2.67522 \cdot 10^{8}$ rad $T^{-1}$ $s^{-1}$ | proton gyromagnetic ratio |
| $\gamma_C = 6.7283 \cdot 10^{7}$ rad $T^{-1}$ $s^{-1}$ | carbon gyromagnetic ratio |
| $\omega = 2\pi\ \nu$ | Relation between angular frequency and frequency |

**Important definitions and relations:**

| Symbol | description | Relationship to experiment |
|---|---|---|
| $B_0$ | main magnetic field (static along z axis) | Field of superconducting magnet |
| $B_1$ | rotating RF field, in rotating frame along x (or y) | pl1 (power level of pulse) |
| $\tau_P$ | length of RF pulse | p1, p2, ... |
| $\nu_0$, $\omega_0$ | precession frequency of spins in laboratory frame | signal that induces voltage in receiver coil |
| $\omega_{RF}$ | frequency of the RF field $B_1$. Normally $\omega \approx \omega_0$ | sfo1, set with o1p |
| $\omega_1$,$\nu_1$ | rotation rate of spins during pulse about rf field $B_1$ | determines length of pulse |
| $\Omega$ | free precession in rotating frame: $\Omega = \omega_0 - \omega$ | Observed NMR signal after mixing with reference frequency |

$\omega_0$ depends on main field (precession in laboratory frame)

$$\vec{\omega}_0 = -\gamma \vec{B}_0 \qquad or \qquad \nu_0 = \frac{\gamma B_0}{2\pi}$$

$\omega_1$ depends of strength of $B_1$ field (rotation during pulse)

$$\vec{\omega}_1 = -\gamma \vec{B}_1 \qquad or \qquad \nu_1 = \frac{\gamma B_1}{2\pi}$$

flip angle depends on strength and duration of $B_1$ field

$$\theta \quad = \quad \omega_1 \tau_P \quad = \gamma B_1 \tau_P$$

| | |
|---|---|
| Change in magnetization **during** pulse $B_1$ with length $\tau_p = p_1$ along x-axis: | $\boldsymbol{M_z} = M_0 I_z \cos(\omega_1 \tau_P)$<br>$\boldsymbol{M_y} = - M_0 I_y \sin(\omega_1 \tau_p)$<br>$\boldsymbol{M_x} = 0$ |
| Free precession and relaxation of a single signal **after** a 90° pulse along x-axis: | $\vec{M}_z(t) = M_0 \vec{I}_z [1 - e^{-\frac{t}{T_1}}]$<br>$\vec{M}_y(t) = - M_0 \vec{I}_y \cos(\Omega t) \; e^{-\frac{t}{T_2^*}}$<br>$\vec{M}_x(t) = M_0 \vec{I}_x \sin(\Omega t) \; e^{-\frac{t}{T_2^*}}$ |
| Energy of spin state: | $E_m = \gamma \hbar B_0 m_S$ |
| transition energy of $m_S = + ½$ to $m_S = - ½$ | $\Delta E = \gamma \hbar B_0 = \hbar \omega_0$ |
| excess magnetization for one spin in high temperature approximation | $\Delta N = N \dfrac{\gamma \hbar B_0}{2kT}$ |
| dwell time of receiver | $DW = 1/(2\ \nu_{max}) = 1/(2 \cdot SWH)$ |
| acquisition time | $AQ = TD \cdot DW = TD / (2 \cdot SWH)$ |
| width at half height | $\Delta \nu_{1/2} = \dfrac{1}{\pi T_2^*}$ |