$$\frac{d\vec{M}}{dt} = \vec{M} \times \gamma\vec{B} \quad \Longrightarrow \quad \frac{d\vec{M}_{rot}}{dt} = \vec{M}_{rot} \times \gamma\vec{B}_{eff}$$

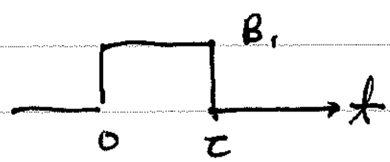
$$\vec{B}_1(t) = B_1^e(t)\left[\cos(\omega_{RF}t+\theta)\hat{i} - \sin(\omega_{RF}t+\theta)\hat{j}\right]$$

$$\vec{B}_{eff} = \vec{B}_{rot} + \frac{\vec{\omega}_{rot}}{\gamma}$$

$$\vec{\omega}_{rot} = \begin{pmatrix} 0 \\ 0 \\ -\omega_{RF} \end{pmatrix}$$

$$\vec{B}_{eff} = \begin{pmatrix} B_1^e \cos\theta \\ B_1^e \sin\theta \\ B_0 - \dfrac{\omega_{RF}}{\gamma} \end{pmatrix}$$

Ex) $\quad B_1(t) = B_1 \,, \quad 0 \le t \le \tau$



$$\vec{B}_{eff} = \begin{pmatrix} B_1 \\ 0 \\ 0 \end{pmatrix}$$

~~At~~ on-resonance

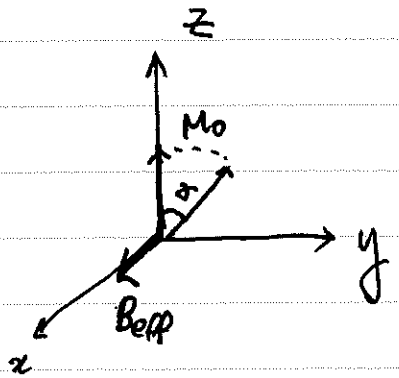
$$\frac{d\vec{M}_{rot}}{dt} = \vec{M}_{rot} \times \gamma\vec{B}_{eff}$$

$$\Rightarrow \vec{M}_{rot}(t) = R_x(\gamma B_1 t)\begin{bmatrix} 0 \\ 0 \\ M_0 \end{bmatrix}$$

$$= \begin{bmatrix} 0 \\ M_0 \sin(\gamma B_1 t) \\ M_0 \cos(\gamma B_1 t) \end{bmatrix}$$

②

Graphically,



flip angle $\alpha = \gamma B_1 \tau$

- Numbers $\alpha = 90° = \frac{\pi}{2}$, $\tau = 1\,ms$

$\frac{\pi}{2} = \gamma B_1 \; 1\,ms \Rightarrow B_1 \approx 0.06G = 6\mu T$