

①

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

$$\vec{B}_i(t) = B_i^e(t) [\cos(\omega_{\text{RF}} t + \theta) \hat{i} - \sin(\omega_{\text{RF}} t + \theta) \hat{j}]$$

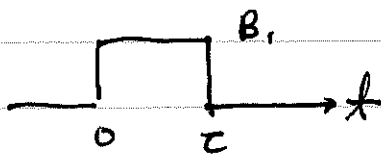
$$\vec{B}_{\text{eff}} = \vec{B}_{\text{rot}} + \frac{\vec{\omega}_{\text{rot}}}{\gamma}$$

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

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

Ex >

$$B_i(t) = B_i, \quad 0 \leq t \leq \tau$$



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

At on-resonance

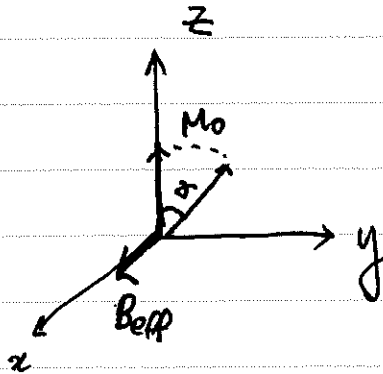
$$\frac{d\vec{M}_{\text{rot}}}{dt} = \vec{M}_{\text{rot}} \times \gamma \vec{B}_{\text{eff}}$$

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

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

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Graphically,



$$\text{Flip angle } \theta = \gamma B_1 \tau$$

- Numbers $\theta = 90^\circ = \frac{\pi}{2}$, $\tau = 1 \text{ ms}$

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