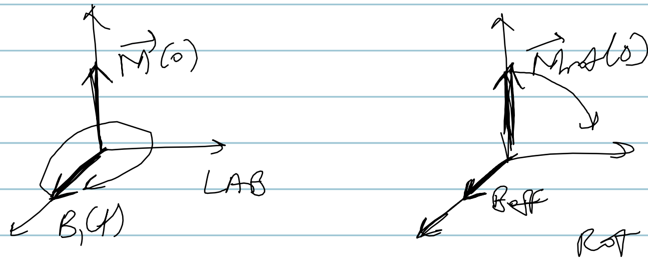
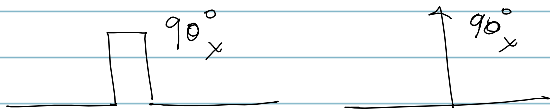
Review



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

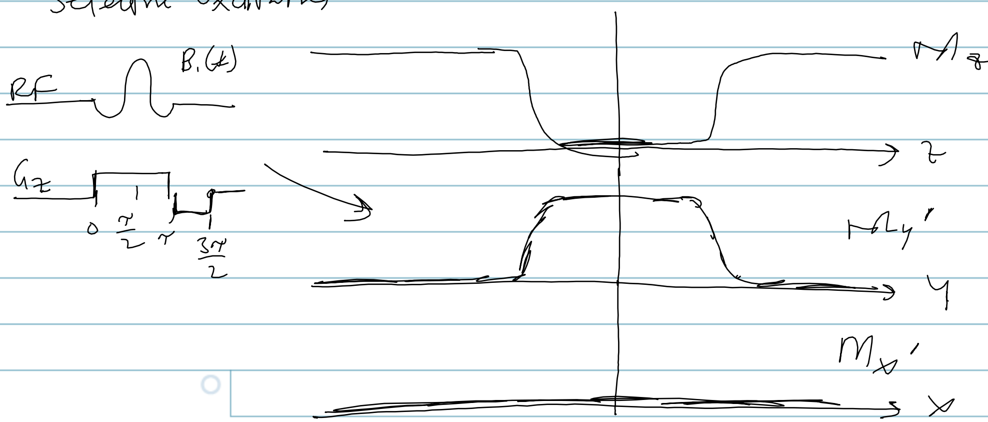
- rotation $\theta = \int_0^{\tau} \omega_1(t)\, dt = \int_0^{\tau} \gamma B_1(t)\, dt$

- specify θ (tip/flip angle) and axis



remember: left handed rotations!

selective excitation



Small tip approximation, θ small, $M_z \approx M_0$

$$M_r\left(\frac{3\tau}{2}, z\right) = i M_0 \mathcal{F}\left\{ \underline{\omega_1\left(t+\frac{\tau}{2}\right)} \right\}$$

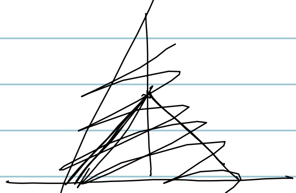
equilibrium magnetization

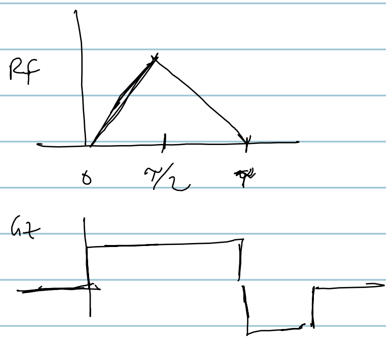
centered $\gamma B_1(t)$

$$f = -\frac{\gamma}{2\pi} G_z z$$

Nish 6.11

$$B_1(t) = B_1 \Lambda\left(\frac{t-\frac{\tau}{2}}{\tau/2}\right)$$



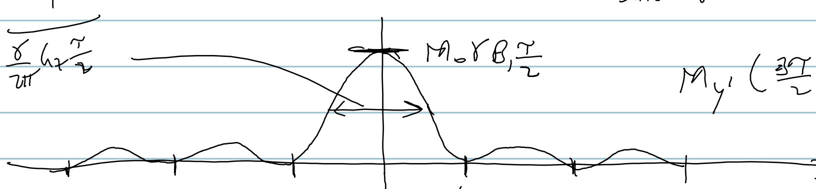


$$m_r\left(\frac{3\tau}{2}, z\right) = i M_0 \mathcal{F}\left\{ \gamma B_1 \Lambda\left(\frac{t}{\frac{\tau}{2}}\right) \right\}$$

$$f = -\frac{\gamma}{2\pi} G_z z$$

$$= i M_0 \gamma B_1 \frac{\tau}{2} \operatorname{sinc}^2\left(\frac{\tau}{2}\left(+\frac{\gamma}{2\pi} G_z z\right)\right)$$

sinc^2 is even



thinner slices:

$\uparrow G_z \longrightarrow$ OK, but amplitude limited

$\uparrow T \longrightarrow$ reduce BW of $B_1(t)$,
but off resonance is an issue

$\longrightarrow$ consider T_2

$G_z \approx 1$ G/cm

$T \approx 1$ ms

$\Delta z \approx 0.4$ cm

Fourier Interpretation:

"kspace"

Signal reception $\quad s(t) \xrightarrow{\mathcal{F}t_x} g_\theta(\omega)$ projection

G_x only

excitation $\quad B_1(t) \xrightarrow{\mathcal{F}t_x} M_r(z)$

G_z only

$s(t) \Leftrightarrow M(k_x(t), 0)$

control kspace points using time varying G

speculate

$B_1(t) \longleftrightarrow M_r(k_z)$

time varying G_z

excitation k-space

return to small tip approx

$$M_r(T,z) = i M_0 \int_0^T \omega_1(s)\, e^{+i\omega(z)(s-t)}\, ds$$

G_z constant
$\omega(z) = \gamma G_z z$

consider $B_1(t)$
& $G_z(t)$ ← can be time varying

$$M_r(T,z) = i M_0 \int_0^T \omega_1(s)\, e^{-i\left(\gamma \int_s^T G_z(t')\,dt'\right) z}\, ds$$

Define $k_z(s) = \dfrac{\gamma}{2\pi} \displaystyle\int_s^T G_z(t')\,dt'$

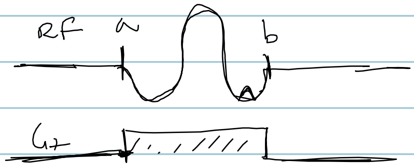
$$= i M_0 \int_0^T \omega_1(s)\, e^{-i 2\pi k_z(s) z}\, ds$$

* $\omega_1(s)$ "depositing" weight in excitation k-space $\quad [\gamma B_1(s)]$

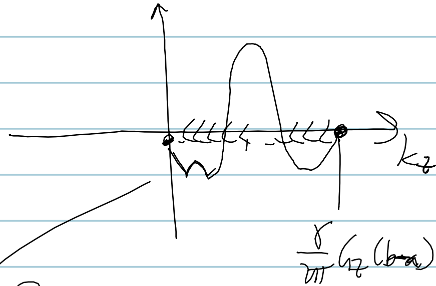
* trajectory in excitation k-space is controlled by gradients
  Note: always end at origin

* $M_r(z)$ is the Fourier transform of the weighting

ex)



not refocused



$$M_r(z) = \mathcal{F}T_x \{ \quad \}$$

$$= \sqcap \cdot \text{phase factor } e^{-i\,\omega(z)\,\tau/2}$$

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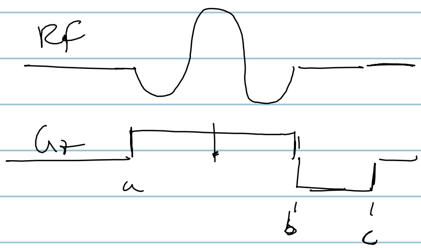
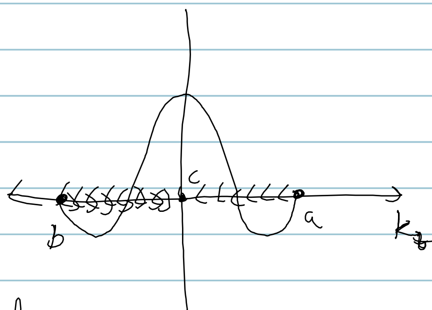
ex)



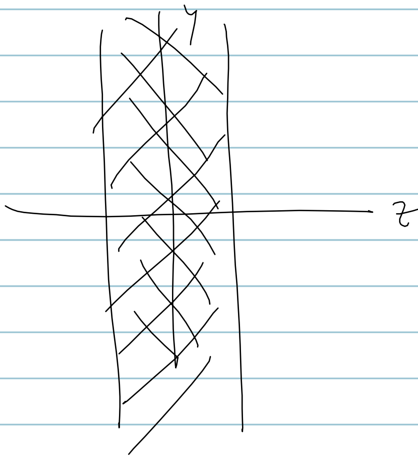


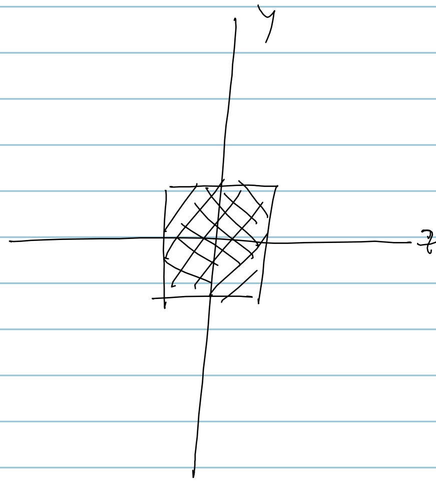
centered sinc

no phase in the slice profile!

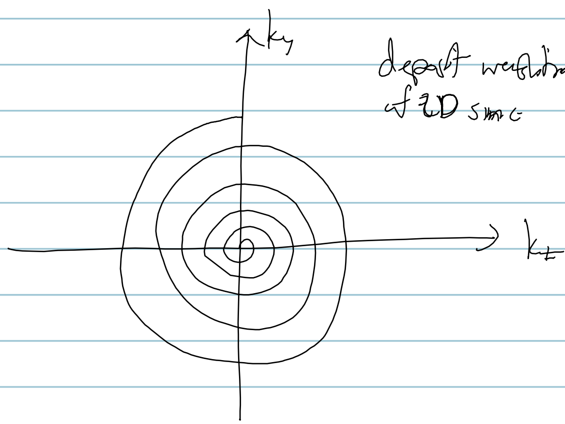
framework applies to 2D & 3D selective excitation

$$\vec{k}(s) = \frac{\gamma}{2\pi}\int_{s}^{T} \vec{G}(t')\,dt'$$





see Past Projects for examples



deposit waveform of 2D sinc