

SIMULATION

numerically
solve

fundamental
physics

elegant
relationships

k-space
small dip excitations

Bloch Equation

precession, relaxation

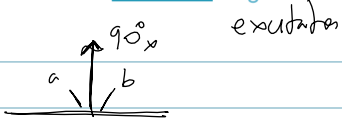
about a
transverse
axis

about
the z axis

Bloch Simulations in MATLAB

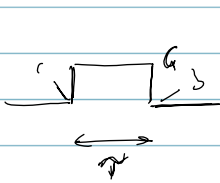
$$M = \begin{bmatrix} M_x \\ M_y \\ M_z \end{bmatrix} = [M_x \ M_y \ M_z]^T;$$

Jaynes, Physical Review
1954



left handed rotate about $x, \alpha \times 15$ (angle deg)

$$M_b = R_x(90^\circ) M_a$$



gradient, z axis

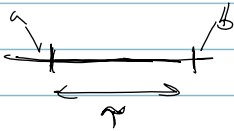
check units

$$M_b = R_z(\gamma G \tau) M_a$$

~~frequency~~ $\Delta f = \frac{\gamma}{2\pi} G_z \tau = \frac{\gamma}{2\pi} G_z \tau$

$$\Delta \theta = \Delta f \tau = \frac{\gamma}{2\pi} G_z \tau^2$$

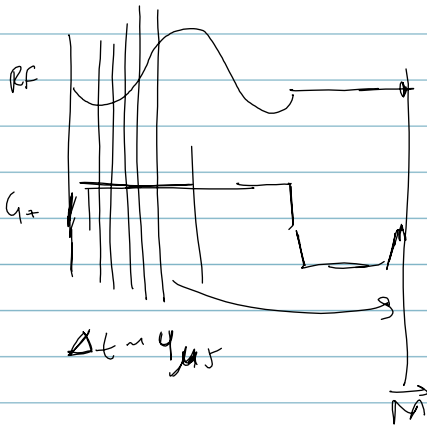
free precession



$$M_b = R_z(\Delta f \tau) A M_a + b$$

$$\begin{pmatrix} e^{-i\tau/T_2} & 0 & 0 \\ 0 & e^{-i\tau/T_2} & 0 \\ 0 & 0 & e^{-i\tau/T_1} \end{pmatrix} \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}$$

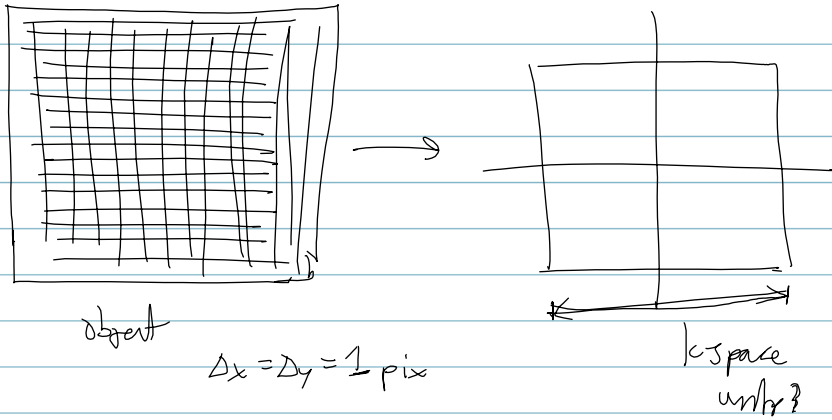
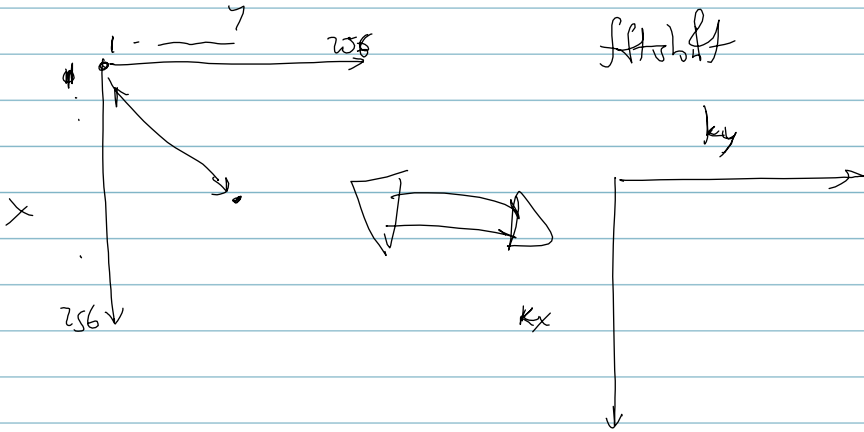
$M_0(1 - e^{-\tau/T_1})$



loop thru z -positions
loop thru time
consider each Δt separately
 \vec{M}_{end}

check units

Reconstruction in MATLAB



normalized coordinates

$$F_0^x = F_0^y = 256 \text{ pix}$$

$$k_x, k_y \in [-0.5, 0.5]$$

$$\Delta k_x = \Delta k_y = \frac{1}{256}$$