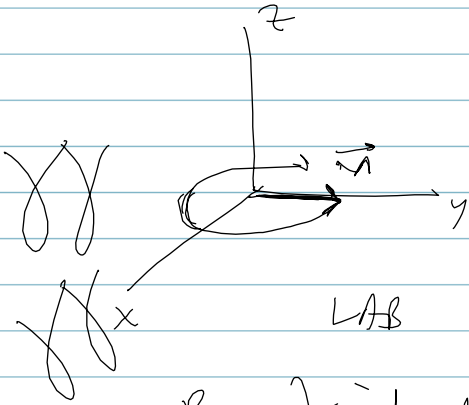


B.

detection of signals

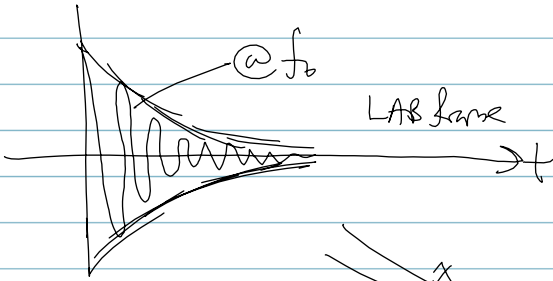


processing \vec{m}

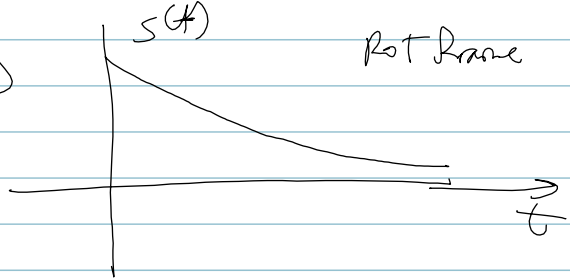
induce EMP in color

$$EMP = -\frac{d\phi}{dt} \leftarrow \text{flux}$$

Received signal called "free induction decay" FID



demod



\vec{M} returns to equilibrium $M_0 \hat{k}$

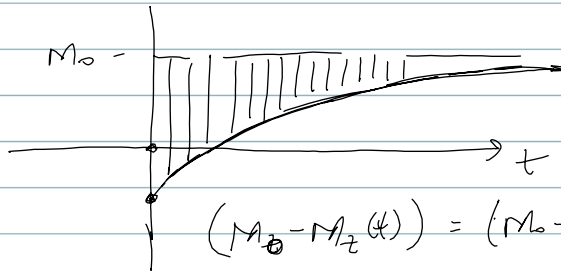
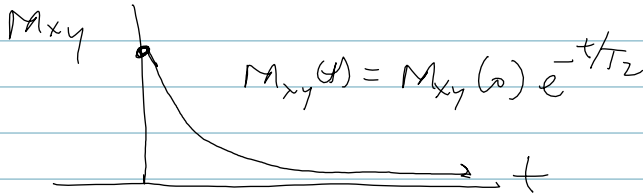
transverse $M_{xy} \rightarrow 0$

longitudinal $M_z \rightarrow M_0$

both are exponential
 T_2

T_1

time dependent
time constants



$$M_z(t) = M_z(0) e^{-t/T_1} + M_0 (1 - e^{-t/T_1})$$

Relaxation Why?

T_1 - spin-lattice

fluctuating fields, movement of dipoles
exchange @ f_0

100 ms to 5 sec

paramagnetic agents can shorten T_1

Gold chelates often used

T_2 - all of above + spin spin
dephasing phenomenon



after 90° flip (→ → → → → → →)
↙ field of neighboring spins
↘ off resonant condition

↪ spread in freq and phase at microscopic level

↪ dephasing (→ ↗ ↘ ↗ ↘ ↗ ↘)
→

$T_1 \sim$ dependent on B_0 (longer at higher B_0)

$T_2 \sim$ largely indep of B_0

solids $T_2 < 1 \text{ ms}$

liquids $T_2 \approx T_1 \approx 3 \text{ s}$

\rightarrow tissue

Basic NMR experiment

- ① RF - excite sample
- ② receive signal
- ③ wait for relaxation

Problem: How do we make an image??

RF sensitive to entire volume

G gradient fields G_x, G_y, G_z

$$B = (G_x \hat{x} + G_y \hat{y} + G_z \hat{z}) \hat{k}$$

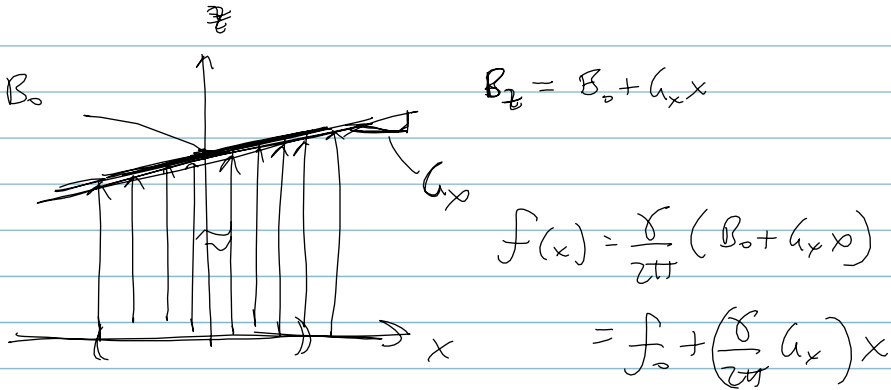
\uparrow

$$G_x = \frac{dB_z}{dx}$$

$$|G| \ll 4 \text{ G/cm}$$

hardware limit

40 mT/m



RCV signal - temporal frequency maps to spatial position

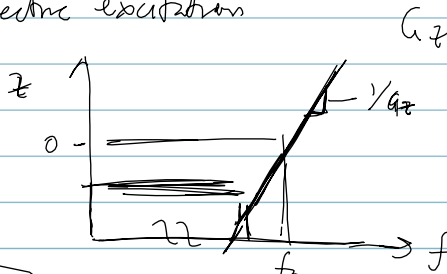
ex) object $\Delta x = 20 \text{ cm}$
 $G_x = 0.5 \text{ G/cm}$

$$\Delta f = \frac{\gamma}{2\pi} G_x \Delta x = 412.57 \text{ kHz}$$

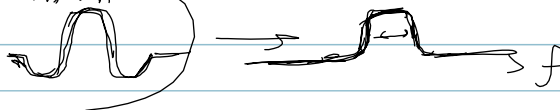
↑
 $(4257 \text{ Hz/G}) (0.5 \text{ G/cm}) (20 \text{ cm})$

G_x enable selective excitation

enables slice/slab excitations



apply B_1 with an envelope



2D imaging

- ① selectively excite a slice B_{11} G_z
- ② record signals, encode x, y G_x G_y
- ③ wait for relaxation

