

Imaging Considerations

⊗ off resonance

1) B_0 inhomogeneity
"good" magnets 1 ppm over a 24 cm sphere
parts per million

es) 3T , 3 μ T variations
↓
 ~ 125 MHz , 125 Hz variations
(after 4ms, 180° at ref phase)

2) Susceptibility Differences (χ)

$\Delta\chi \sim 10^{-6}, 10^{-5}$
tissue property
1 to 10 ppm

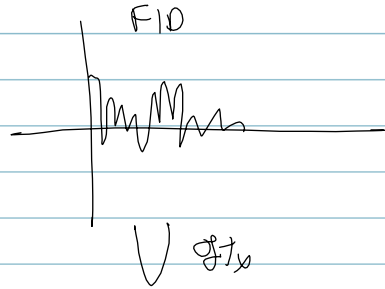
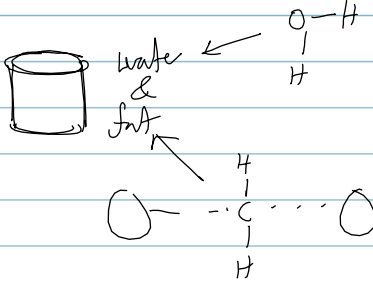
air - tissue

oxygenated - deoxygenated blood

3) Chemical shift (basis of NMR)

- small shift in resonant frequency
- depends on chemical environment

ex)



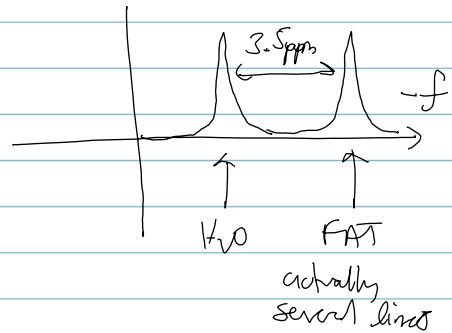
@ $B_0 = 3T$

-3.5 ppm



-440 Hz shift

"discrete inhomogeneity"



⊛ Effect on Imaging?

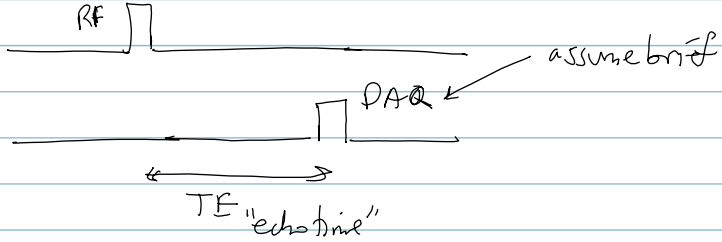
$$B_z = B_0 + E(\vec{r})$$

$$\omega = \omega_0 + \omega_E(\vec{r})$$

$$s(t) = \iint m(x,y) \underline{\underline{e^{-j\omega_E(\vec{r})t}}} e^{-i2\pi(k_x(t)x + k_y(t)y)} \text{dbody}$$


effects

① signal loss

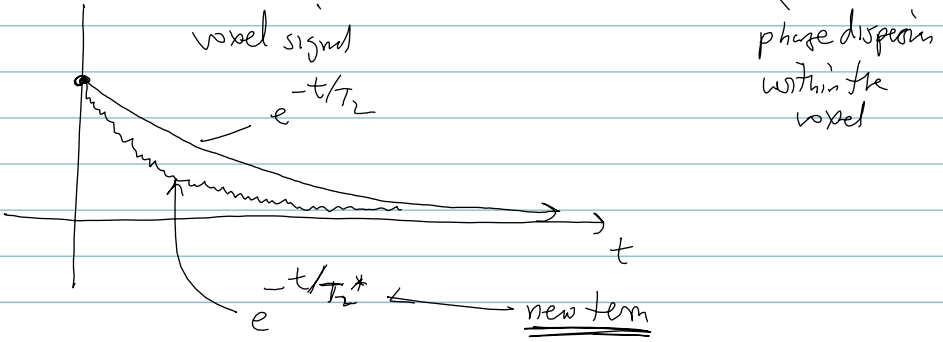


$$\text{object} = m(x,y) e^{-j\omega_E(x,y)TE} e^{-TE/T_2}$$

over a voxel



$$\left\{ \int e^{-j\omega_E(x,y)TE} \right\}$$



- T_2^* - includes effects of
- 1) T_2 decay
 - 2) intravoxel off resonance
- ★ $T_2^* \leq T_2$
 - ★ T_2^* space variant

(2) distorted impulse response (distorted image)

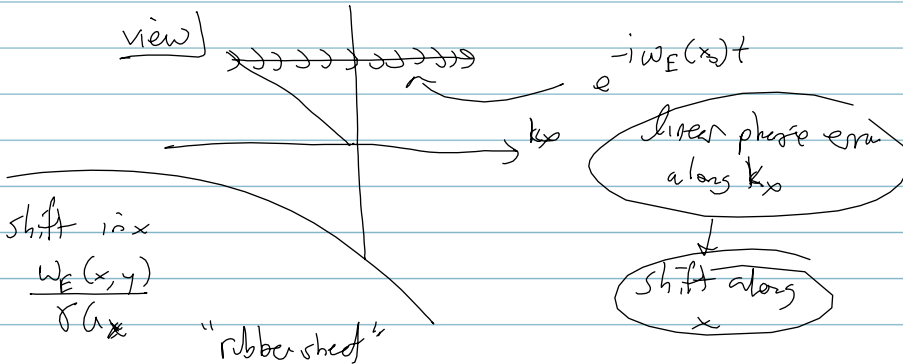
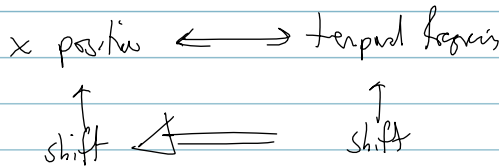
1D case $n(x) = \int (x-x_0) \leftarrow \text{phys info}$
 const γ_x sig eqn prs page
use shifting property

$$s(t) = e^{\underbrace{-i\omega_E(x_0)t}_{\text{phase error}}} e^{\underline{-i\gamma_G x_0 t}}$$

$$= e^{-i\gamma_G(x_0 + \frac{\omega_E(x_0)}{\gamma_G})t}$$

$$x'_0 = x_0 + \frac{\omega_E(x_0)}{\gamma_G}$$

view | const γ_x creates mapping



chemical shift discrete shift ω_{cs}

$$(x_0, y_0) \rightarrow \left(x_0 + \frac{\omega_{cs}}{\gamma G_x}, y_0 \right)$$

ex) water/fat @ 1T

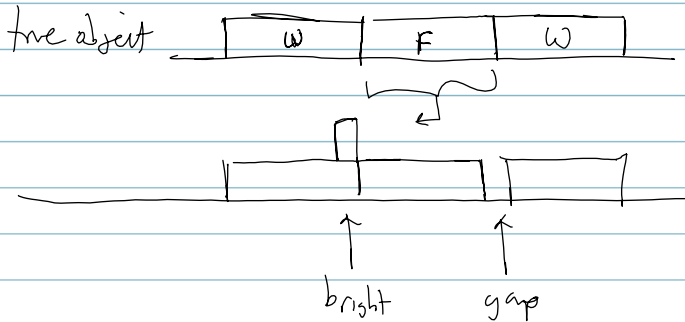
$$\Delta\omega_{fat} = 2\pi(-150 \text{ Hz})$$

$$\text{if } G_x = 0.1 \text{ G/cm}$$

$$\Delta x = \frac{2\pi(-150)}{\gamma(0.1)} = -0.35 \text{ cm}$$

↑ could be 2-4 pixels

shifted fat leaves blank space



to minimize this

→ make G_x large