Imaging Considerations

⊛ offresonance

1) B0 inhomogeneity — parts per million

"good" magnets 1 ppm over a 24 cm sphere

eg) 3T, 3 μT variation

↓ ↓

~125 MHz, 125 Hz variation

(after 4ms, 180° at refocuse)

2) Susceptibility Differences (χ) ← tissue property

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

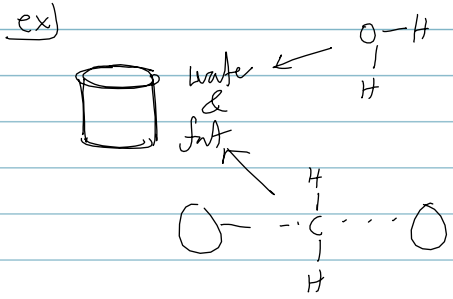
air - tissue

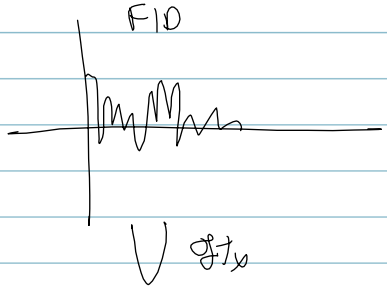
oxygenated - deoxygenated blood

3) Chemical shift (basis of NMR)

- small shift in resonant frequency
- depends on chemical environment

ex)



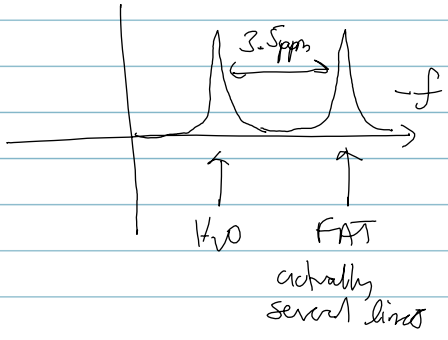


@ $B_0 = 3T$

-3.5 ppm

-440 Hz shift

"chemical shift"



(*) Effect on Imaging?

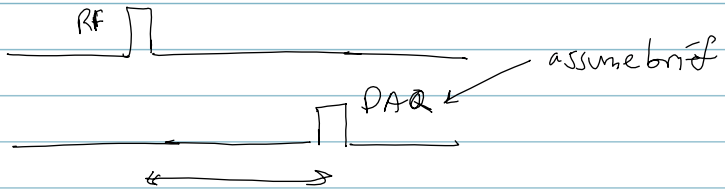
$B_z = B_0 + E(\vec{r})$

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

$$s(t) = \iint m(x,y)\, e^{-i\omega_E(\vec{r})t}\, e^{-i2\pi(k_x(t)x + k_y(t)y)}\, dx\, dy$$

effects

① signal loss

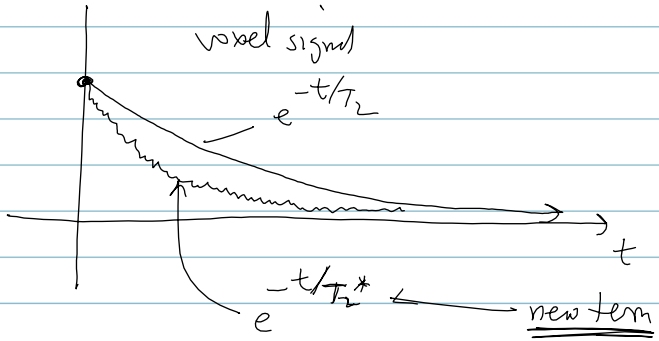


$$\text{object} = m(x,y)\, e^{-i\omega_E(x,y)TE}\, e^{-TE/T_2}$$

over a voxel

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

phase dispersion within the voxel



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 $n_0(x) = \delta(x - x_0)$ ← plug into sig eqn prs page use shifting property

const G_x

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

$$= e^{-i\gamma G_x \left(x_0 + \frac{\omega_E(x_0)}{\gamma G_x}\right) t}$$

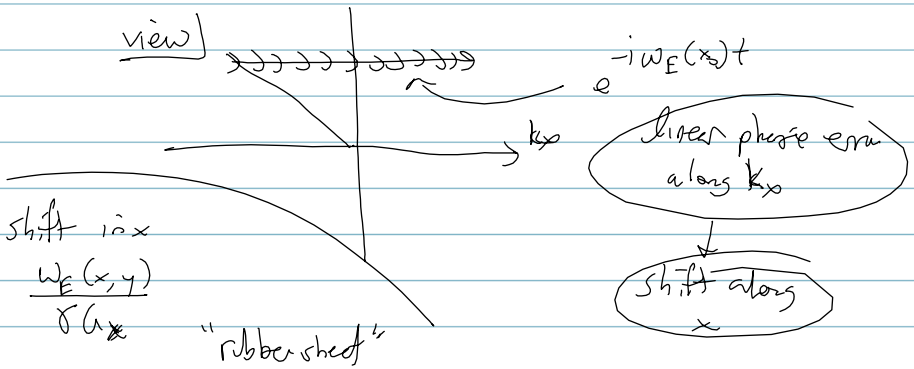
$$x_0' = x_0 + \frac{\omega_E(x_0)}{\gamma G_x}$$

view | const G_x creates mapping

x position ⟷ temporal frequency

shift ⟺ shift

view



chemical shift discrete offset ω_{cs}

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

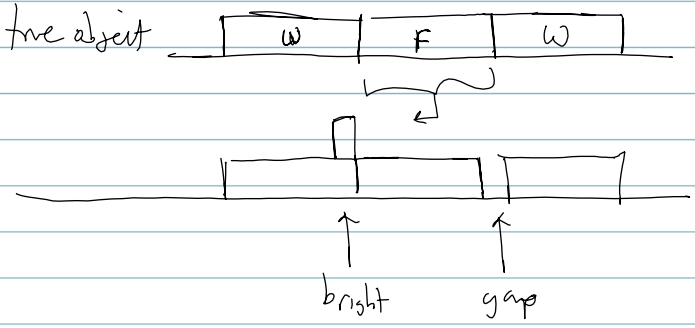
ex) water/fat @ 1T $\Delta\omega_{fat} = 2\pi(-150\ Hz)$

if $G_x = 0.1\ G/cm$

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

↖ could be 2-4 pixels

shifted fat leaves blank space



to minimize this

→ make G_x large