CogSci 260: Introduction to Diffusion Tensor Imaging
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Week 3 Problem Set

Problem 1

Consider a block of a single tissue type placed in the a 3T human MRI scanner.

Problem 1a A time $t = 0$ an initial magnetization $M_0\hat{z}$ points along the direction ($\hat{z}$) of the main magnetic field $\mathbf{B}_0 = B_0\hat{\mathbf{z}}$.

1. What is the Larmor frequencey ω in terms of the main field B_0?
2. What is the longitudinal magnetization $m_{\parallel}$ at $t = 0$?
3. What is the transverse magnetization $m_{\perp}$ at $t = 0$?

Problem 1b An excitation pulse of 90° is applied along the x-axis at time $t = 0$. Assuming that this pulse happens instantly. Ignore T_1 relaxation.

1. What is the transverse magnetization $m_{\perp}$ at a time $t = \tau$ shortly (a few ms) after the pulse?
2. A series of refocussing (180°) pulses are applied. Assume an echo occurs at the time τ_E. What is the amplitude of this echo?
3. Why is T_2^* refocussed but T_2 isn't?

Problem 2

Consider a normal human brain in the a 3T human MRI scanner.

Problem 2a The MRI signal is

$$s(\mathbf{k}) = \int m_{\perp}(\mathbf{x}, t)e^{-i\mathbf{k}\cdot\mathbf{x}}d\mathbf{x} \tag{1}$$

1. What is i?
2. What is $\mathbf{k}$?
3. What is $\mathbf{x}$?
4. What is the "$\cdot$" between $\mathbf{k}$ and $\mathbf{x}$?

Problem 2b

We apply gradients G_x, G_y and G_z along each of the three axes x, y, and z, respectively, for a time τ.

1. Write the gradients in vector form
2. Write the spatial coordinates in vector form
3. What is $\mathbf{k} \cdot \mathbf{x}$?

Problem 2c

The applied gradients are $G_x = 1G/cm$, $G_y = 1G/cm$ and $G_z = 0G/cm$.

1. What is the angle of phase generated in the xy plane by these gradients?

2. What is the angle of phase generated in the xy plane if we double the strength of G_x?
3. What is the angle of phase generated in the xy plane if we half the strength of G_y?