MRI Primer, Exercise #7

Due 19/Jan/2009

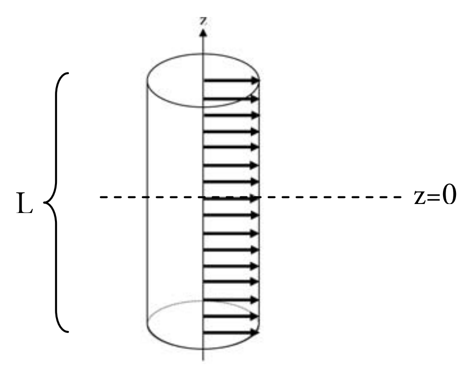
1. **Maximal T_1-Contrast in Spoiled-SE Imaging**. Given two types of tissue which differ only in their T_1 parameter (identical M_0, T_2), how would you choose TR to maximize the contrast between them in a spoiled spin-echo imaging sequence? That is, how would you maximize [Signal from tissue 1] – [Signal from tissue 2]? Derive an expression for TR.

2. **Ernst Angle**. The signal at echo-time in spoiled GRE imaging, as derived in class, depends on several parameters: T_1, T_2^*, the flip angle α, M_0, TR and TE. Assume we're "stuck" with a particular tissue (so T_1, T_2^* are given), and a particular TR, TE pair.
   a. How would you choose α to maximize the signal's magnitude? Prove that, for this angle,

$$\cos(\alpha) = e^{-TR/T_1}$$

   (Hint: differentiate ...) This angle is called the Ernst angle.
   b. Can you think of a reason why this α isn't always used in real-world experiments?

3. **Gradient Spoiling**. I've mentioned in class that gradients can be used to spoil the signal – that is, decrease its magnitude – by "dephasing" the spins. Let's try to see how this comes about analytically. Assume you have a uniform sample of size L, and that you excite the spins from thermal equilibrium to the x-axis, so $M_{xy}=M_0$ initially. Next, you apply a gradient $\mathbf{G} = G\hat{z}$ (i.e. along the z-direction).
   a. Write down M_{xy} as a function of *time and position*: $M_{xy}=M_{xy}(z,t)$.
   b. Compute s(t), the signal, as a function of time, using $s(t) \propto \int M_{xy}(z,t)dz$, where the integral is carried out all over the sample (neglect the constant of proportionality). Plot the result as a function of time. How long would you wait for the signal to become 0, for a 30 cm sample and for G=40 mT/m (for the first time; as you'll see, it oscillates and will cross 0 several times, while continuously decaying)?



The sample, right after exciting the spins (question 3)