Harvard-MIT Division of Health Sciences and Technology
HST.584J: Magnetic Resonance Analytic, Biochemical, and Imaging Techniques, Spring 2006
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<u>HST.584 / 22.561 – Problem Set 1</u>

Due: Feb. 22 / 2006 in class

1. a) In typical proton NMR imaging experiments, RF pulse lengths (ϕ_{tip} = 90°) are 1000 μsec. How big is B_1? How does this compare to typical values for B_0?

b) For a 4 turn solenoid of radius 20cm, what current would need to be applied to generate this field? Estimate the power needed to apply this current.

c) If B_0 = 1.5T, and the RF pulse is applied 5 kHz off resonance at the strength given in part (a), what is B_{eff}? Where would the magnetization vector point after the 1000 μsec '90°' RF pulse? Is this a true 90° pulse?

2. a) If you were to perform an equivalent of the basic NMR experiment on a free electron (a.k.a. an ESR or electron spin resonance experiment), what would be the resonance frequency at 1.5T? Is this a practical experiment? What limitations might there be for doing this in humans?

b) What field strength would you need to produce the same electron resonance frequency as you get from a proton NMR experiment?

c) What B_1 field strength would you need to apply to obtain a 90° RF pulse in 10 μsec?

3. a) The Martinos Center has built and now operates a human-sized 7.0T MR imaging system. If B_0 = 7.0T and the nuclei of interest are protons, what is the ratio of parallel to anti-parallel spins at room temperature? How does this compare to our current 1.5T and 3.0T imaging systems? How do these values change if the nuclei of interest are carbon-13 instead?

b) Not convinced that this is enough of a difference in the spin states, you set out to explore two possibilities for improving the net magnetization available. You have two options: temperature or a further increase in field strength.

i) For protons, at what temperature can you get a 2-1 ratio of low to high energy spins at this field strength? For ^{13}C?

ii) For protons, what field strength would you need to achieve this differential at room temperature? For ^{13}C?