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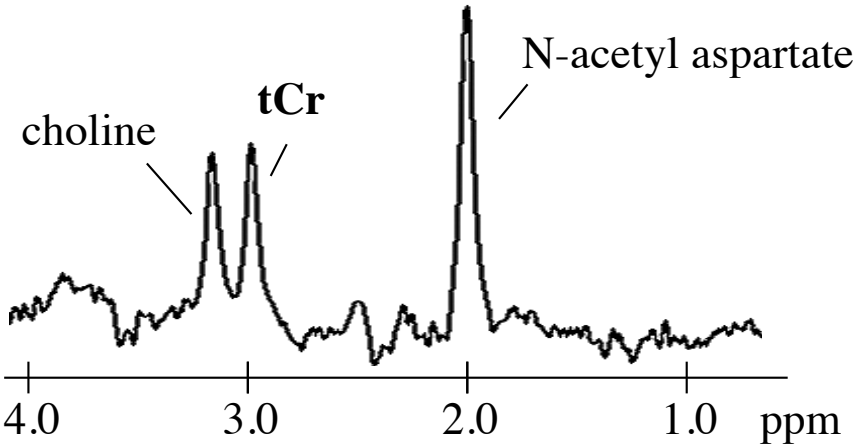
Problem Set #8

Rad 226a

1. **Creatine in skeletal muscle**.

The methyl group (-CH_3) of creatine, a metabolite involved in cellular energetics, gives rise to a single peak at 3.0 ppm in an *in vivo* ^{1}H-MRS brain spectrum (note, creatine is found in the body in the form of both creatine [Cr] and phosphocreatine [PCr], hence the peak is often labeled "total creatine" [tCr]).

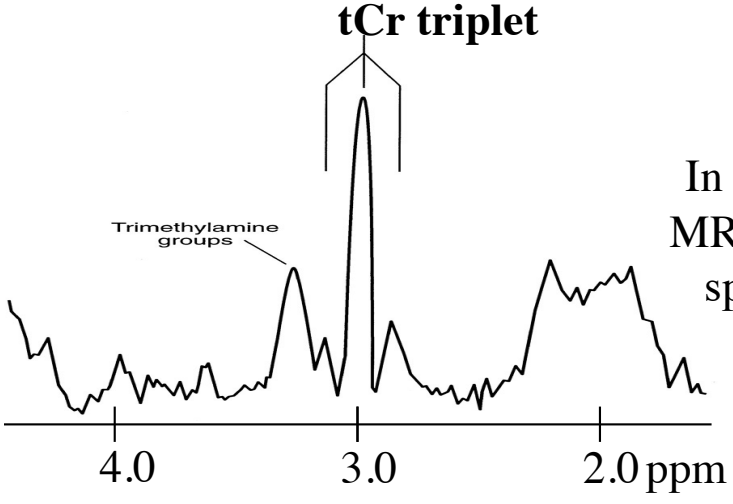


In vivo ^{1}H-MRS brain spectrum

However, the same compound, when measured in skeletal muscle, gives rise to a triplet.

a) Suggest an explanation for this effect (hint: the effect is *not* due to J-coupling)?

b) How might you test your hypothesis?



In vivo ^{1}H-MRS muscle spectrum

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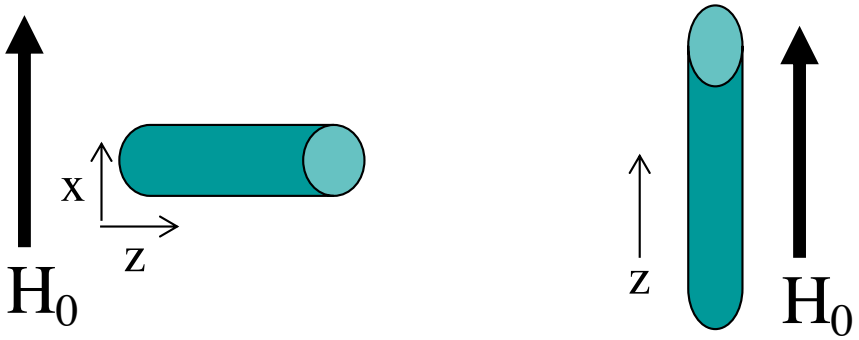
3. **Magnetic Susceptibility**

a) You are asked to scan a cylindrical water-filled phantom. Calculate the frequency shift of the water peak if the long axis of cylinder is aligned parallel to the main magnetic field (i.e. along the z axis) as compared to perpendicular to B_0 (e.g. along the x axis). For the purposes of this problem you may ignore end effects by assuming a infintely long cylinder.



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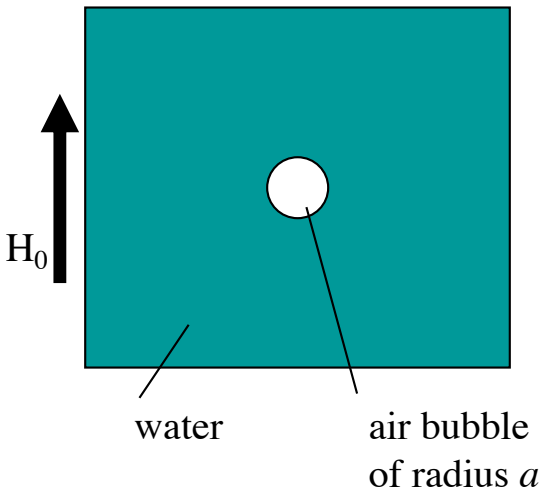
3. **Magnetic Susceptibility**

b) You are asked to scan a large water-filled phantom that has a spherical air bubble in the center. Calculate the magnetic field surrounding the air bubble. For the purposes of this problem you may ignore end effects by assuming a infintely large water phantom.



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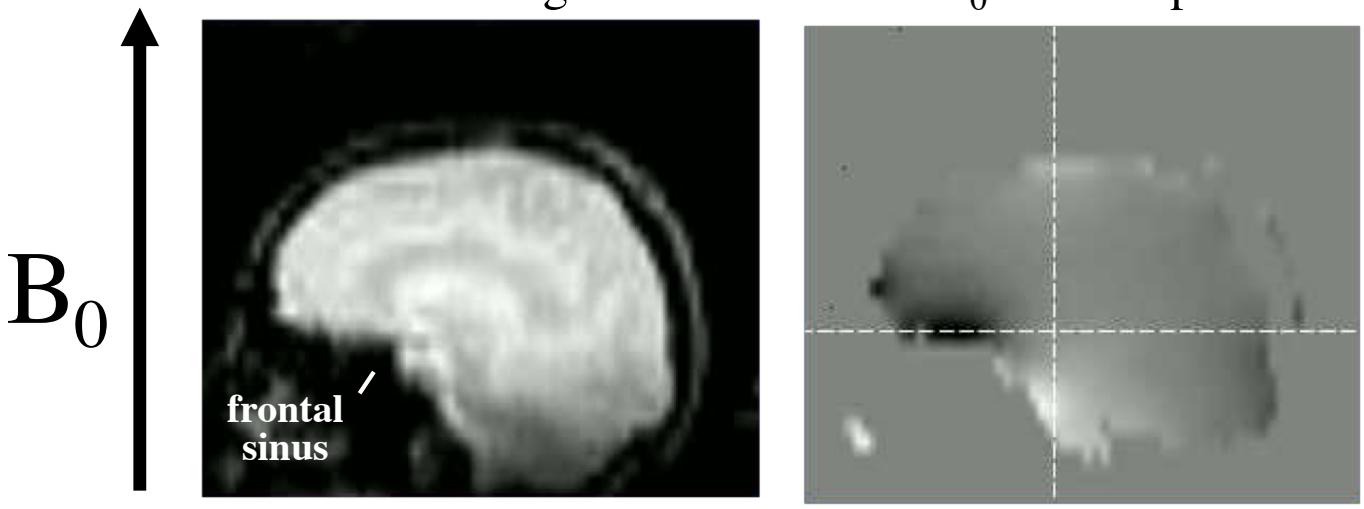
3. **Magnetic Susceptibility**

c) A sagital field map (i.e. image in which pixel intensity is proportional to the strength of the local magnetic field) of a human brain is shown below. Use the results from (a) and (b) to explain the observed B_0 inhomogeneity. Will the homogeneity in the frontal lobes change if the patient's head is positioned at a different angle with respect to the main magnetic field?

Water image

B_0 field map



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Problem Set #8

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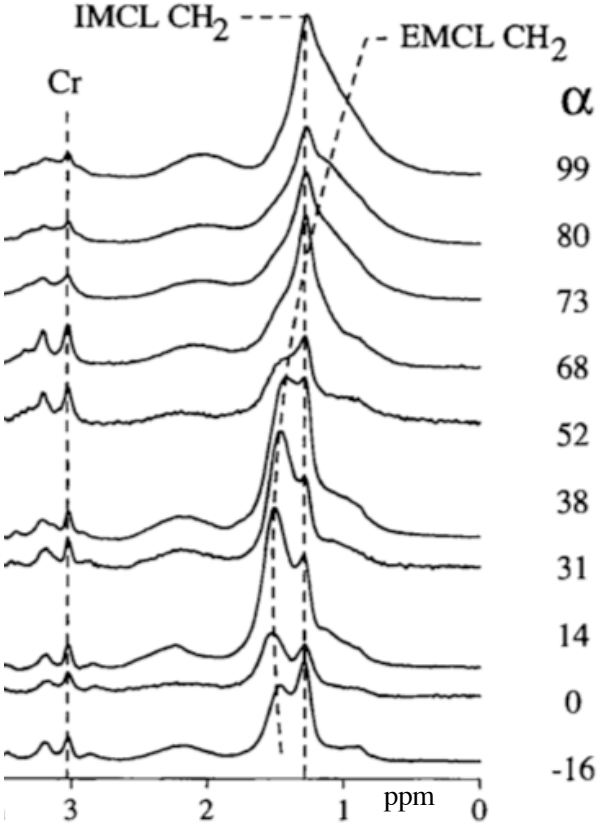
4. **Lipids and Skeletal Muscle**

Skeletel muscle contains lipids both within the muscle cells (intramyocellular lipids [IMCL]) and in the extra cellular space (extramyocellular lipids. [ECML]). As shown in the figure below, the IMCL peaks have a different chemical shift from those arising from EMCL. However, this chemical shift difference is a function of the angle between the muscle fibers and the applied magnetic field B_0. In the case shown below, an angle of $\alpha = 0^o$ represents muscle fibers parallel to B_0, and $\alpha = 90^o$ corresponds to fibers perpendicular to the B_0. The best separation between the IMCL and EMCL lipid peaks is achieved when the muscle fibers are approximately parallel to the static magnetic field. How do you explain this effect?



Series of ^{1}H-MR spectra of *M. tibidis* anterior in a 32 y old female volunteer with her calf at different angles with respect to the static magnetic field.

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Problem Set #8

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5. **Chemical Shift Localization Error**

Conventional slice selective excitation assumes that all spins have the same Larmor frequence. For spins with different resonant frequencies, the selected slice is spatially shifte. Cho and NAA are separated by 1.2 ppm (154 Hz at 3T and 360 Hz at 7T) and the relative shift in space between the selected slices for these two metabolites is given by:

$$\delta_x = \frac{\delta \cdot \gamma \cdot B_0 \cdot S_{th}}{BW}$$

where δ_x is the spatial shift caused by chemical shift, δ is the relative resonance frequency difference between spins (in ppm), B_0 is the main magnetic field strength, S_{th} is the slice thickness, γ is the gyromagnetic ratio in Hz/T, and BW is the spatial bandwidth in Hz.

a) Given that there is an RF peak amplitude limit on the scanner, determine whether the PRESS or the STEAM sequence is more susceptible to chemical shift localization error.

b) What are some ways to eliminate or reduce the chemical shift localization error?

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Problem Set #8

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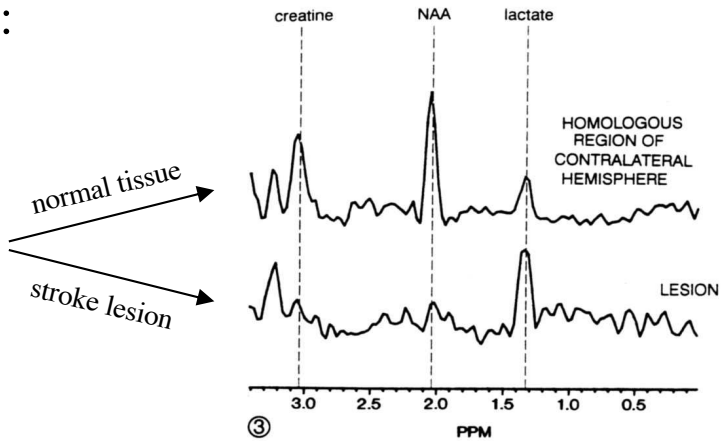
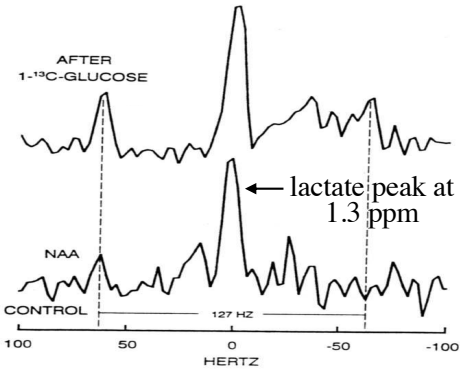
6. **Lactate, Stroke, and ^{13}C-glucose**

An investigator studying the ^{1}H-MRS spectra from a stroke victim obtains the following data:

2.1 T in vivo ^{1}H-MRS brain spectra
TR/TE=4000/270 ms



The investigator wants to know if the observed lactate signal in the lesion is being actively metabolically produced (hence possibly coming from viable but poorly-oxygenated tissue) or from a pool of metabolically inactive lactate. To answer this question, he performs a second experiment in which a ^{1}H-MRS spectrum is acquired after the infusion of ^{13}C-labeled glucose into the patient's bloodstream. He observes the data shown below and identifies the two new resonances at ± 63.5 Hz around the original lactate signal as coming from lactate associated with the glucose infusion.



a) What is the basis for this claim?

b) What new information can be obtained from the second experiment that was unavailable without the glucose infusion?

c) Design an editing scheme that **only** detects the satellite peaks and suppresses all other resonances.