Problem 1: Your first MR Quiz

Answer true or false (except for f) with one or two sentences of explanation:

a) Recovery of magnetization along the z axis after a 90° pulse does not necessary result in loss of magnetization from the xy plane.

b) A static magnetic field $B_0$ that is homogeneous results in a free induction decay that persists for a long time.

c) When the magnetization relaxes from the xy plane back to the z axis, it absorbs energy from the lattice.

d) A short tissue $T_1$ indicates a slow spin/lattice relaxation process.

e) $T_2$ is in some cases longer than $T_1$.

f) A sample you examine has a long $T_1$ and a very short $T_2$. What kind of sample is that presumably?

Problem 2: Precession

Suppose we are studying $^1$H nuclei at field strength of 5.87 T. Assume that the oscillating field $B_1$ is only $10^{-5}$ as strong as the $B_0$-field.

a) How fast will $M$ precess around $B_1$?

b) How much time is required for $M$ to precess one full revolution around $B_1$?

c) Calculate the flip angle $\alpha$ at the following times after irradiation with $B_1$ begins: 0, 0.10, and 0.20ms

d) Draw a rotating-frame diagram that shows $M$ at each of the above times.

e) Suppose $B_1$ is turned off 0.20ms after it was turned on. Describe what happens to $M$ in terms of $T_1$ and $T_2$ using a diagram in the rotating-frame.

Problem 3: Longitudinal Relaxation

In order to understand MR imaging and spectroscopy methods, it is essential to know the two principles of relaxation with their corresponding time constants. Here, we are going to investigate the spin-lattice (i.e. longitudinal) relaxation (time constant $T_1$).

a) Write an expression for the longitudinal magnetization as a function of time after a 180° pulse. After what time is the $M_z$ component zero?

b) Design an experiment to measure $T_1$ of a tissue or compound.

c) Suppose you were to conduct an imaging experiment searching for Multiple Sclerosis lesions in the brain (you do not need to know how MR imaging works yet). Looking at the images, you find that the cerebral spinal fluid (CSF, $T_{1,CSF}$=2800ms) is very bright. They outshine adjacent areas of white matter (WM, $T_{1,WM}$=800ms) where lesion growing usually starts, making it hard to spot the lesions.
How could you attenuate the signal from the CSF? (Hint: Note the different T₁ times!) Give also the timing of your experiment.

**Problem 4: Liver Tissue Experiment**

Liver tissue has a longitudinal relaxation time constant T₁ of 500ms and a transverse relaxation time constant T₂ of 40ms.

What will the MR signal be 40ms after an RF pulse? And 500 ms after?

**Problem 5: Excitation Pulses**

Hard pulses are RF excitation pulses which are used in various MR experiments.

The time course of a hard pulse is given by $B₁(t) = \begin{cases} 0, & t < 0 \\ A, & t \leq 2\tau \\ 0, & t > 2\tau \end{cases}$.

Calculate the excitation profile and bandwidth of this pulse.