Nuclear Magnetic Resonance: relaxation times

Physics 480
(Dated: 2020-Note Covid Response Alteration of Deliverables in the Procedure Section)

I. OBJECTIVE

This experiment explores nuclear spin resonance of protons within complex molecules in the liquid state, and permits the determination of γ, the gyromagnetic ratio, and with it, g_p, the nuclear 'g-factor' for the proton. The experiment also is designed to measure two fundamental decay times associated with an ensemble of nuclear spin states, one having to do with so-called 'spin-lattice' interactions and the other, 'spin-spin' interactions. In order to measure γ, we will also need a Gauss meter. Electromagnetic RF fields, along with strong, permanent magnets are used to create the resonance condition, and to manipulate nuclear spins within liquid samples. The student will measure the fundamental relaxation times indicated above, T_1, and T_2, along with a third one, T_2^* the relaxation time of free induction decay (FID). We will perform measurements in two samples using the pulsed NMR techniques (PNMR) described in the manual,[2] and will permit comparison of results and values inferred with literature values.

Why is the value of g_p weird or surprising? What is the relationship between the gyromagnetic ratio of the proton, and g_p, and the spin of the proton? **Sorry for being cryptic, we will pursue this and many other important aspects of the experiment explicitly in tutorial hours).** Please come to the first tutorial session with this sorted out, and with written solutions to the first several questions of the PNMR section of the tutorial questions. Consult with your instructor regarding which questions to prepare for first. After the first tutorial session, all of the questions are fair game.

II. REFERENCES

1. TEXT[1]
   (a) Section 7.1-7.5 Magnetic resonance experiments
   (b) Section 3.3 Help with DAQ and DSO's, (data acquisition, digital storage oscilloscopes, respectively)
   (c) Section 10.3,10.4 Data fitting, and experimental uncertainty (help with, though we will adopt different conventions), and error propagation
   (d) Appendix B Brief Matlab introduction, somewhat dated, but still useful
   (e) view "Introduction to Fitteia" video
2. Manuals[2]
   (a) NMR Spin Echo Laboratory Manual (TeachSpin PS2). Read before the first lab meeting! This can be found on the Blackboard course website. Much of this can be found on-line at TeachSpin's website, `http://www.teachspin.com`, and follow the links to the pulsed NMR apparatus. Be sure to find there (and read) the 'Conceptual Tour of TeachSpin's Pulsed NMR'.
   (b) Gaussmeter manual.
   (c) TEKTRONIX tds2XX manual.
   (d) 480WDataAcquisition, version 3 (find this too on our public course site).
3. From the research literature
4. W. Klein, *Nuclear Magnetic Resonance: Free-induction decay and spin echoes in a 0.05T magnetic field*, Am. J. Phys. **58** 143 (1990). Find this and the following papers on Inspec and read before the first lab meeting.
5. Paper C.2.H (PS2 manual, page 17)

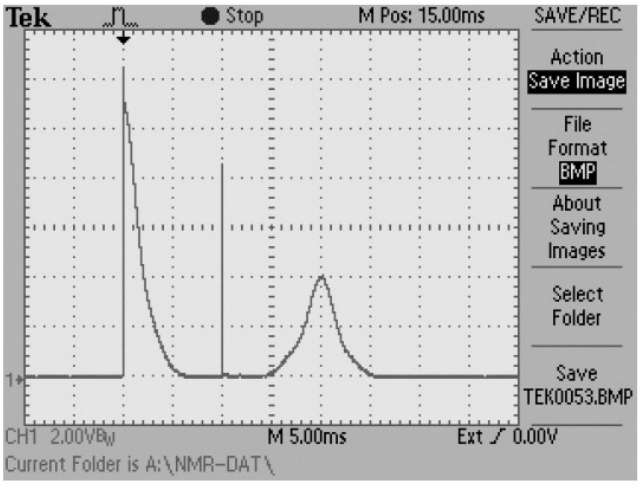

FIG. 1. In this figure we see a 'spin-echo' signal. How can one achieve such a signal with the apparatus, and what does the signal mean? What can one measure with it? What is the first troubling thing about this figure? The second? Why is it unacceptable for inclusion in a submitted paper for PHYS 480?

6. Paper C.2.N

III. PROCEDURE AND DELIVERABLES

Conduct experiments described in section III of the PS2 manual. For these experiments, we will analyze two samples, Light Mineral Oil and Distilled Water. For each, Measure

1. FID's (to assess T_2^*)

2. both relaxation times

3. γ (for each substance), and infer g_p for the proton (from each substance). Most importantly, compare them. Do we expect the gyromagnetic ratios to be the same for each molecule? Note, this measurement assumes that the magnitude of the magnetic field is measured. And also note: the ratio between the $\gamma's$ is known to much greater accuracy than $\gamma's$ themselves.

Compare all results with accepted, and literature values (you'll have to search for these).

IV. TUTORIAL QUESTIONS

Find these on our public course website and prepare for all of them.

[1] A.C. Melissinos Jim Napolitano, *Experiments in Modern Physics*, 2nd. Ed., (Elsevier Science USA, 2003); see Chapter 6, sections 1-4.

[2] Pulsed/CW NMR Spectrometer manual, also known as the PS2 Manual. See our BB course site, folder "Some Manuals and Guides".