Pulsed NMR

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Abstract:

Introduction:

Theory:

Procedure:

Results:

Figure 1:

Discussion:

Appendix:

Pre-Lab:

1 **Setup**

2 **Free-Induction Decay (FID)**

A 90^o Pulse FID

i default oscilloscope settings: Time/Div 20 μs, CH1 1 V/cm, CH2 $2V/cm$, Trig: Ext, 1 V, POS.

ii tune the oscilloscope until the FID (detector out, channel 1) is maximized.

iii minimize the beat oscillations (mixer out, channel 2) by using the "Frequency Adjust".

iv adjust "A-width" for 90^o pulse, for maximimum FID.

v ensure optimum values by repeating steps (i), (ii), and (iii - this step).

vi record all settings

vii adjust the "Frequency Adjust" to see the beat oscillations in channel 2, sketch them, describe what causes them, and estimate T_2 - the time it takes for oscillation to reach 1/e of its original amplitude.

B Other Pulse Lengths

i start with the "A-width" and "Frequency Adjust" settings for 90^0 pulse and beat oscillations from part A.

ii increase "A-width" and describe what happens to the oscillation in channel 2.

iii how is a 360^o pulse width identified?

iv scetch oscillations from channel 2 with pulse lengths of 90^0, 180^o, and 360^0 and explain the behavior.

3 **Spin-Lattice Relaxation Time (T_1)**

A Single Pulse

i start with the 90^0 settings found in 2.A.v. Maximize "Detector Out" channel 1 by increasing "Repetition Time".

ii record the "Repetition Time" that gives max amplitude for 90^0 pulse.

iii decrease "Repetition Time" and explain reduction in amplitude.

iv get an estimate for T_1 by the "Repetition Time" that gives about $1/e \approx 1/3$ of the maximum value.

B Two Pulses, Zero Crossing

i Use the settings from 2.A.v for the in-tune 90^o and set the repetition rate to about 100 ms.

ii Turn the B pulses on (B pulses = 1) and start with a small delay - about 0.2 ms.

iii Adjust the settings on the oscilloscope until both A and B pulses can be observed.

iv Adjust the "A-width" to a 180^o pulse (minimized)

v Adjust the "B-width" to a 90^o pulse (maximized)

vi focus on the amplitude of the second pulse by switching "Sync" to B.

vii find T_1 by adjusting the "Delay Time" (τ). T_1 is the time that minimized the amplitude.

viii find a more statistically reliable value for T_1; measure the amplitude of the second pulse as a function of τ and fit the curve to a quadratic function and find the minimum if the curve.

4 **Spin-Spin Relaxation Time (T_2)**

A Two-Pulse Spin Echo

i start with A and B pulses set as in 3.B ii adjust the "A-width" to maximized 90^o pulse; the initial value of second amplitude should be minimized.

iii adjust the "B-width until it is maximized (180^o pulse).

iv get the second amplitude as a function of total delay time (2τ), using the cursor for Channel 1 to get the best values for the amplitude.

v fit data to an exponential decay to find T_2.

B Carr-Purcell Multiple Pule Spin Echo Sequences

i Start with same settings as 4.A, but start with 3 B pulses and make sure the CPMG switch is turned off.

ii lower the repetition rate to avoid overheating of the rf amplifier.

iii adjust the "Delay Time" and other possible oscilloscope settings until several time separated pulses can be observed.

iv Add more B pulses and tweak the settings until a decay in their amplitudes can be seen.

v obtain a function of the second amplitude as a function of "Delay Time" from the first 90^o pulse).

vi fit the data to an exponential decay to obtain a fitted value for T_2.

C Meiboom-Gill Sequence

i turn on the CPMG (Meiboom-Gill), repeat 4.B.iv - 4.B.vi, and obtain another value of T_2; why would the two numbers differ?

5 Find T_1 and T_2 using one of the experiments in a different medium (B glycerin or D petroleum jelly)