Z7 - Studding Magnetic Relaxation of Protons by Spin Echo Method

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The goal of the exercise is an investigation of pulse methods of nuclear magnetic resonance (NMR). Student learns how NMR spectroscope works, plans and makes measurements (also prepares chemical solutions) and this way gets competences in laboratory work. The measuring of relaxation times T_1 and T_2 of protons in water solutions of organic and inorganic compounds is a basic result of exercise. Additionally there are also measurements of temperature and concentration dependence of T_1 and T_2.

Preparatory questions

1. NMR – classical description [1]
   - Magnetic moment in magnetic field – equation of motion in laboratory and in rotating frame
   - Effective field
   - Bloch equation
2. NMR – quantum description [1]
3. Pulse methods for investigation of NMR [1]
   - Resonance pulses of radio frequency π and $\pi/2$
   - Free Induction Decay
   - Spin echo
   - Different pulse sequences
4. Nuclear magnetic relaxation phenomenon [1]
   - Spin–net relaxation T_1
   - Spin–spin relaxation T_2
5. Investigation of temperature dependence – activation energy [1]

Computational assignments

Calculate magnetic nuclear resonance of hydrogen, deuterium and helium in a field of induction 2T

Apparatus and materials

The set-up (Figure 1) consists of:

- Pulse spectrometer PS15 (2) controlled by PC (1)
- Electromagnet (7) with electrical supplier (5) and cooling system
- Nuclear stabilizer of magnetic field JTM83 (6)
- Heating-cooling system (4, 8) with a temperature controller (3)

Experiment

- Principle of operation and maintenance of PS15 spectrometer with external electromagnet creating B_0, stabilized by JTM83
- Measuring of T_1 and T_2 for protons in vicinity of Cu ions in water solution of $CuSO_4$ in different temperatures using appropriate pulse technique
- Measuring of T_1 and T_2 for protons in water solutions of proteins in different temperatures using appropriate pulse technique (especially for biophysics)
- Measuring of T_1 and T_2 for protons in distilled water in different temperatures using appropriate pulse technique

Exploration of the set-up:

1. Switching on the water cooling of electromagnet. It is recommended to wait a quarter of an hour.
2. Switching on: PC, electromagnet electrical supplier, spectrometer PS15, JTM83 stabilizer
3. Launching SPI program (lock-off function)
4. Changing a current of electromagnet to achieve a resonance value of B0 (FID signal on a display)
5. Activation of stabilization of magnetic field
6. Finding time duration of pulses π and $\pi/2$
7. Applying appropriate pulse sequences establish T_1 and T_2 for a sample in a room temperature and below (with a help of electrical cooling system)

Data analysis

The experimental data should fit the appropriate theoretical dependencies:

- Finding T_1 and T_2 of protons in CuSO4 in different temperatures
- Finding T_1 and T_2 of protons in distilled water solution in different temperatures
- Finding activation energy for water

Figure 1: Apparatus

Safety rules

Be careful with strong magnetic field and liquid nitrogen. Student with peacemakers should avoid the exercise. Keep watches, phones, memory sticks etc. away from magnetic field.

References

[1] J.P.Hornak, The Basics of NMR