NUCLEAR MAGNETIC RESONANCE

EXPERIMENT PROCEDURE

- **Demonstrate nuclear magnetic resonance in glycerine, polystyrene and Teflon.**
- **Determine the resonant frequencies in a constant magnetic field.**
- **Make a comparison between the *g*-factors of ^{1}H and ^{19}F nuclei.**

OBJECTIVE

Demonstrate and compare nuclear magnetic resonance in glycerine, polystyrene and Teflon.

SUMMARY

Nuclear magnetic resonance (NMR) is based on the energy absorption by substances with nuclear magnetism, which are inside an external magnetic field produced by a DC source. The energy is absorbed from a high-frequency AC-generated field which is fed in perpendicular to the field from the DC source. If the frequency of the alternating field is equal to the resonant frequency, the impedance of the transmitting coil filled with the test material changes in accordance with a resonance curve and a peak will be visible on an oscilloscope screen. Suitable materials for this include glycerine, polystyrene and Teflon, whereby the magnetic moment of ^{1}H or ^{19}F nuclei is used..

REQUIRED APPARATUS

Quantity	Product	Number
1	ESR/NMR Basic Set (230 V, 50/60 Hz)	**1000638 or**
	ESR/NMR Basic Set (115 V, 50/60 Hz)	**1000637**
1	NMR Supplementary Set	**1000642**
1	Analogue Oscilloscope, 2x30 MHz	**1002727**
2	HF Patch Cord	**1002746**

GENERAL PRINCIPLE

Nuclear magnetic resonance (ESR) is based on the energy absorption by substances with nuclear magnetism, which are inside an external magnetic field produced by a DC source. The energy is absorbed from a high-frequency AC-generated field which is fed in perpendicular to the field from the DC source. If the frequency of the alternating field is equal to the resonant frequency, the impedance of the transmitting coil filled with the test material changes in accordance with a resonance curve and a peak will be visible on an oscilloscope screen. The cause of resonance absorption is a transition between energy states of the nucleus' magnetic moment inside a magnetic field. The resonant frequency depends on the strength of the DC-generated field and the width of the resonance signal is related to the uniformity of the field.

The magnetic moment of a nucleus with nuclear spin *I* assumes discrete values in a magnetic field *B*:

(1) $$E_m = -g_I \cdot \mu_K \cdot m \cdot B, \quad m = -I, -I+1, \ldots, I$$

$$\mu_K = 5{,}051 \cdot 10^{-27}\ \frac{\text{J}}{\text{T}} \quad : \text{Nuclear magneton}$$

g_I: *g*-factor of atomic nucleus

The interval between the two levels is therefore

(2) $$\Delta E = g_I \cdot \mu_K \cdot B$$

When the energy levels meet the condition for resonance, another magnetic field of frequency *f* applied perpendicular to the uniform field excites the transition between energy states. Resonance occurs when the frequency *f* precisely fulfils the following condition:

(3) $$h \cdot f = \Delta E\ ,$$

h = 6.626 · 10^{-34} Js: Planck's constant

In this experiment nuclear magnetic resonance will be demonstrated in glycerine, polystyrene and Teflon, whereby the ^{1}H isotope contributes to the resonance in glycerine and polystyrene while the ^{19}F isotope is the contributor in Teflon. The uniform magnetic field is largely generated by permanent magnets. Added to this is a magnetic field which varies in a saw-tooth pattern between zero and a maximum value generated inside a pair of Helmholtz coils. Now a frequency *f* can be found where resonance absorption takes place in a pre-selected magnetic field, which, for simplicity, we will take to be in the middle of the saw-tooth wave.

EVALUATION

The *g*-factors for the nuclei involved are quoted in literature to be as follows: $g_I(^{1}\text{H}) = 5.5869$ und $g_I(^{19}\text{F}) = 5.255$.

From (2) und (3) the following applies for the resonant frequency *f* in a magnetic field *B*.

$$f = g_I \cdot \frac{\mu_K}{h} \cdot B$$

The resonant frequencies for various nuclei in the same magnetic field therefore have the same ratios as the *g*-factors:

$$\frac{f(^{19}\text{F})}{f(^{1}\text{H})} = \frac{g_I(^{19}\text{F})}{g_I(^{1}\text{H})} = 94\%$$

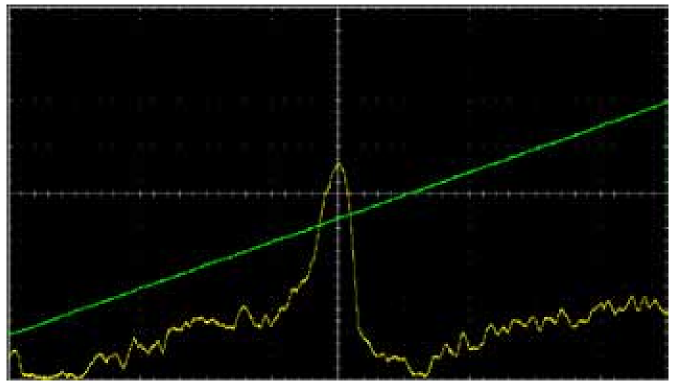

Fig. 1: Nuclear magnetic resonance in glycerine (*f* = 12.854 MHz))

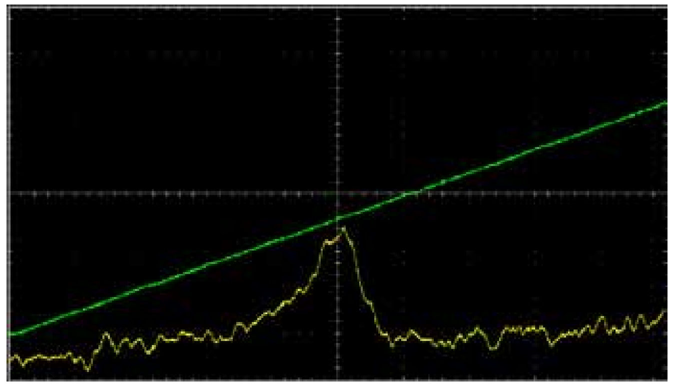

Fig. 2: Nuclear magnetic resonance in polystyrene (*f* = 12.854 MHz)

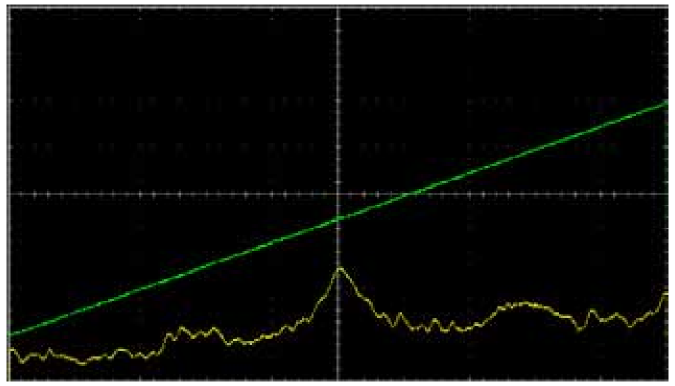

Fig. 3: Nuclear magnetic resonance in Teflon (*f* = 12.1 MHz)