NUCLEAR MAGNETIC RESONANCE ON SOME ORIENTED NUCLEI[1]

ЯДЕРНЫЙ МАГНИТНЫЙ РЕЗОНАНС НЕКОТОРЫХ ОРИЕНТИРОВАННЫХ ЯДЕР

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The technique of nuclear magnetic resonance on oriented nuclei NMR/ON has been developed in the programme SPIN. The $^3He - ^4He$ dilution refrigerator adapted for an easy and quick exchange of the sample was used for these measurements. The NMR/ON study of $^{60}CoFe$, $^{57}CoFe$ and $^{54}MnNi$ has been carried out using the frequency modulated continuous wave method and the adiabatic fast passage method. Resonance techniques as well as the eddy current heating technique were utilized for spin-lattice relaxation measurements.

The purpose of this contribution is to present some experimental results of nuclear magnetic resonance on oriented nuclei (NMR/ON) ^{57}Co, ^{60}Co in iron ($^{57}CoFe$, $^{60}CoFe$) and ^{54}Mn in nickel ($^{54}MnNi$). The equipment for the nuclear orientation technique developed in the framework of the programme SPIN has been utilized for these experiments. It is based on the $^3He - ^4He$ dilution refrigerator [1], which gives the possibility for an easy and quick exchange of the sample. A special exchangeable insert has been constructed for the sake of the resonance experiments. It makes possible to place the sample (soldered by an indium — tin solder to the heat exchanger) together with the rf exciting coils inside the dilution chamber without interrupting the dilution process. The necessary rf power is conveyed to the dilution chamber by a special coaxial cable with low thermal conductivity. A static polarizing magnetic field is produced by superconducting coils of the Helmholtz type.

Our samples were prepared by the conventional diffusion technique. The activity of the measured isotope was prepared in the form of its chloride solution and an appropriate amount of this solution was dried on the surface of the iron or nickel thin foil (~ 1 μm), or on the surface of the iron signle crystal disc ~ 4 mm in diameter and 0.38 mm in thickness[1]). The chloride was reduced for a few minutes at the temperature of 550 °C in an hydrogen atmosphere and then the samples were heated at a temperature 800—900 °C to achieve the diffusion of the radioactive isotope into the crystal lattice. Finally the samples were etched to remove the excess of the surface activity.

The γ-ray anisotropy was measured at the angle of 0° and 180° with respect to the direction of the polarizing field using two Ge(Li) detectors in connection with the conventional γ-ray spectroscopy

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[1]) Iron single crystals were prepared in the Department of Metal Physics of the Institute of Physics, Czechoslovak Academy of Sciences.

technique. An example of the obtained resonant γ-ray anisotropy destruction of the ^{57}Co 127 keV line for ^{57}CoFe is given in Fig. 1. These lines were measured by the continuous wave method with the frequency modulated rf field. A triangle-wave modulation was used with the modulation frequency of 10 Hz and a sweep width of 0.5 MHz and 0.2 MHz for a polycrystal (curve 1) and a single crystal (curve 2), respectively. The obtained resonance signal S defined by the formula

$$S = \frac{W_{mod} - W_{rf}}{1 - W_{rf}} 100\ \% \tag{1}$$

(in which W_{mod} and W_{rf} are γ-ray anisotropies with and without a resonance effect) was 35 % for the polycrystalline sample and 15 % for the single crystal.

The dependence of the resonance frequency on the external magnetic field B_{ex} is shown in Fig. 2. In the case of thin foil polycrystalline samples we may neglect the demagnetizing field. Moreover,

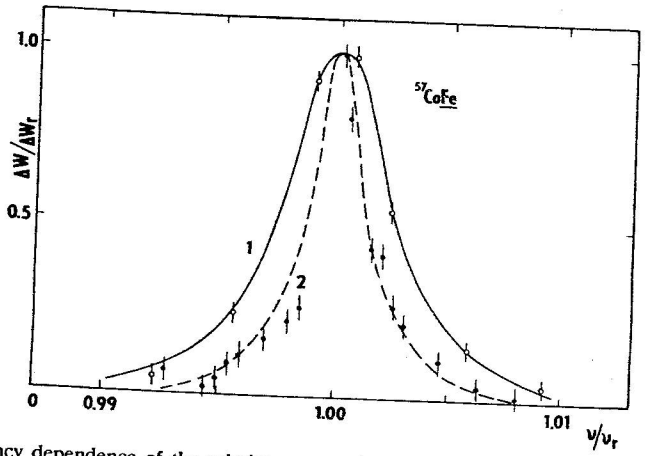

Fig. 1. Frequency dependence of the relative γ-ray anisotropy destruction for a ^{57}CoFe polycrystal (curve 1) and a single crystal (curve 2).

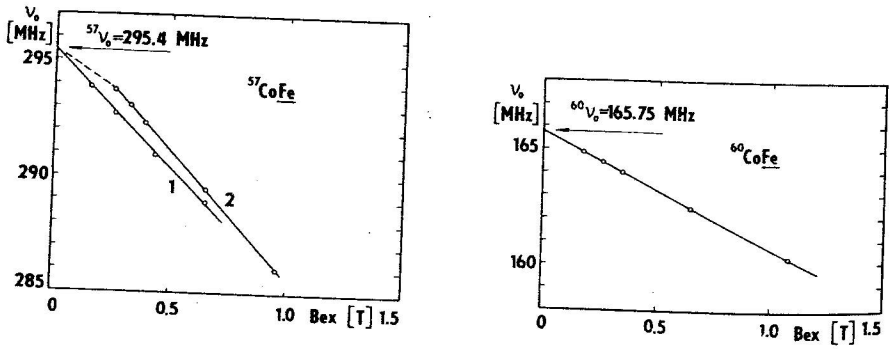

Fig. 2. Resonance frequency dependence on the external magnetic field for ^{57}CoFe (a) polycrystalline (curve 1) and single crystal (curve 2) samples and a ^{60}CoFe (b) polycrystalline sample.

neglecting the influence of the domain structure in the nonsaturated sample, we may take this dependence for a straigth line. The best fit of the experimental data is given by the zero field resonance frequencies $^{57}\nu_0 = 295.40\ (25)$ MHz and $^{60}\nu_0 = 165.75\ (25)$ MHz. Using these results we get for the nuclear moment ratio the value

$$\frac{^{57}\mu}{^{60}\mu} = 1.24\ (3), \tag{2}$$

which is in very good agreement with the recent values given in literature [2, 3].

Besides the cw technique also the adiabatic fast passage method (AFP) has been used for ^{57}CoFe NMR/ON measurements. The signal showed the dependence on the passage direction, which is characteristic for the weak quadrupole interaction $\gamma\hbar B_1 \gg |P|$ with the negative sign of the parameter P [4]. The preliminary evaluation of the spin-lattice relaxation rate gives the Korringa constant $T_1 T \sim 0.2$ sK.

In addition to the ^{57}CoFe and ^{60}CoFe studies the first NMR/ON measurements on ^{54}MnNi have also been performed. Here we may present some of their results. We got the zero field resonance frequency $^{54}\nu_0 = 273.1$ (1) MHz. With a ^{54}Mn magnetic moment of $^{54}\mu = 3.302(5)\ \mu_N$ [5] this value leads to the hyperfine field $B_{hf} = -32.55$ (6) T. The AFP measurements showed the NMR/ON signal nearly independent of the passage direction. Therefore it can be concluded that only a very weak electric quadrupole interaction takes place in this system. In agreement with [5] we have also found a rather fast spin-lattice relaxation leading to the Korringa constant $T_1 T \sim 0.1$ sK.

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