a simple superheating of the sample.

The results make it possible, first, to state that the Mossbauer effect on Sn^{119} nuclei in an iron matrix can serve as a perfectly suitable method for measuring temperatures at least to 6×10^{-3} °K; second, they indicate that the level population of the hyperfine splitting of the spins of the Fe^{57} nuclei in the same sample, at temperatures below 0.015°K, remains almost unchanged and does not correspond to thermal equilibrium with the lattice.

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[1] A.Ya. Parshin, V.P. Peshkov, B.G. Egiazarov, A.I. Shamov, and V.P. Romashko, ZhETF Pis. Red. 15, 44 (1972) [JETP Lett. 15, 30 (1972)].

NMR IN PARAMAGNETIC TERBIUM ETHYL SULFATE AND IN ANTIFERROMAGNETIC TERBIUM TRIFLUORIDE

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Great interest attaches to investigations of NMR of diamagnetic atoms in magnetically-concentrated crystals at temperatures so low that the degree of electron polarization is large and the energy of the magnetic dipole-dipole interaction of the paramagnetic ions is comparable with kT.

We have chosen as the object of such an investigation single crystals of terbium ethyl sulfate (TbES) and terbium trifluoride (TbF_3). The splitting of the two lower levels of the Tb^{3+} ion in TbES in a magnetic field is described by a spin Hamiltonian (S = 1/2)

$$\mathcal{H} = g_{\parallel}\beta H_z S_z + \Delta_x S_x + \Delta_y S_y$$

with parameters $g_{\parallel} = 18$ and $\Delta = (\Delta_x^2 + \Delta_y^2)^{1/2} \simeq 0.4$ cm^{-1} [1]. Owing to the large value of $g_{\parallel}$ only the lower level is actually populated at 0.35°K already in a field $H \sim 3000$ Oe, and

$$\{\exp[-(g_{\parallel}\beta H + \Delta)/kT]\sim 5\cdot 10^{-6}\}.$$

Since the inter-ion distances in rare-earth ethyl sulfates are large (the smallest distance in a chain along the C axis is 7 Å), there is practically no exchange interaction [2]. At the same time, the Tb^{3+} ions are coupled by a strong dipole-dipole interaction. For example, the energy of this interaction for the closest ions is of the order of 1°K. We have therefore assumed the possibility of magnetic ordering in TbES in the region of the temperature of liquid He^3. A study of the proton magnetic resonance (PMR) spectrum has shown, however, that there is no long-range order all the way to the T = 0.33°K. This is probably due to the low interaction energy of the ions of the neighboring change, owing to singularities in the crystal structure.

To observe the PMR we used a pulsed NMR spectrometer with operating frequency $\nu = 13.4$ MHz. Figure 1 shows a plot of the spin-echo signal amplitude against the magnetic field ($H_0 \parallel C$), obtained at a fixed interval between two pulses. The positions of the line in the specturm are confirmed also by a calculation performed under the assumption that the crystal is paramagnetic.

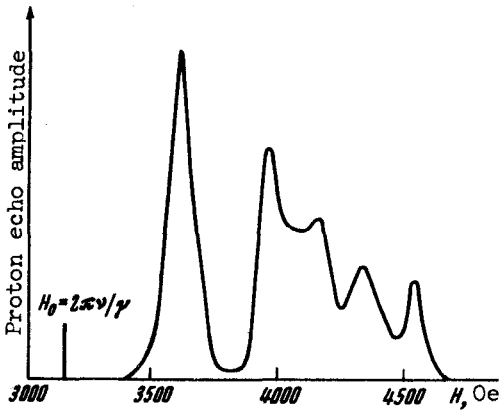

Fig. 1

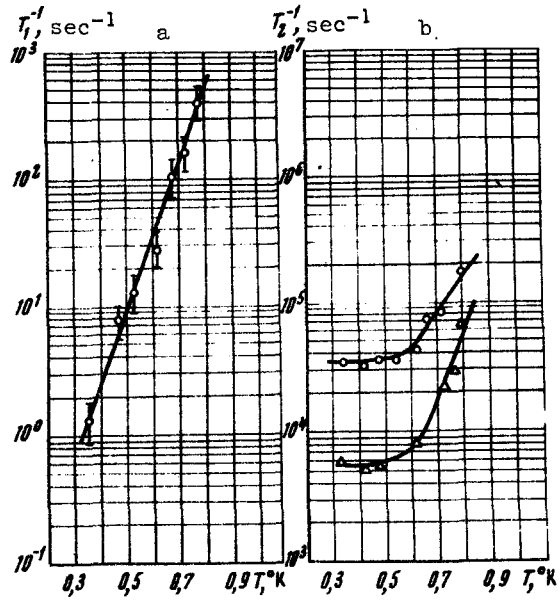

Fig. 2

Fig. 1. Amplitude of the proton echo in TbES vs. the magnetic field $H_0 \parallel C$.

Fig. 2. Measured values of the rates of proton longitudinal (a) and transverse (b) relaxation in a TbES crystal vs. the temperature: o) H = 3000 Oe, Δ) H = 4550 Oe, H ∥ C.

According to estimates, the local fields at certain protons exceed the value $H = 2\pi\nu/\gamma = 3150$ Oe, as a result of which the lines due to such protons were not observed.

The presence of a coupled system of large magnetic moments exerts a strong influence also on the proton magnetic relaxation processes. The reservoir of the dipole-dipole interactions of the Tb^{3+} ions has a specific heat much larger than that of the nuclear spin system. Therefore, although the rate of the electron spin-spin relaxation at such low temperatures is low, the relaxation of the longitudinal component of the nuclear magnetization turns out to be effective. The transfer of energy from the nuclear spin system to the reservoir of the dipole-dipole interactions of the Tb^{3+} ions is apparently the result of mutual reorientation of the electron and nuclear spins, leaving the total energy of both spin systems unchanged. When the temperature is lowered, the probability of such processes should decrease as a result of the "alignment" of the electron spins and narrowing of the electron resonance line.

Figure 2a shows the measured rates of the longitudinal relaxation T_1^{-1} on the weak-field line of the spectrum (see Fig. 1). Measurements on other lines of the spectrum have shown that the temperature dependence is similar throughout, but the absolute values of T_1^{-1} and T_2^{-2} decrease with increasing magnetic field. The rate of relaxation of the transverse nuclear-magnetization component (Fig. 2b) was estimated from the envelope of the spin-echo signal when the interval between pulses was varied.

The lack of a theory that describes adequately the nuclear relaxation mechanisms in concentrated paramagnets, at temperatures on the order of the dipole-dipole interactions of the magnetic ions, does not make it possible to make numerical estimates that might be compared with the experimental data.

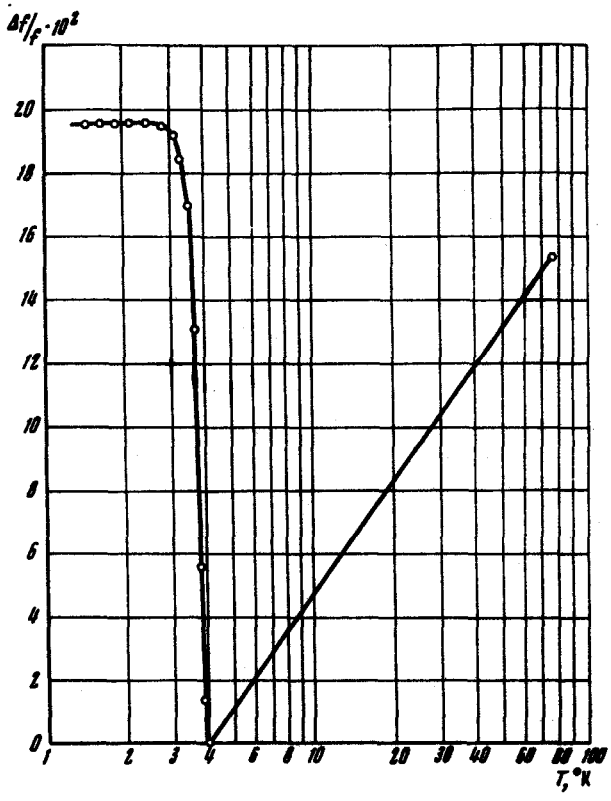

Fig. 3. Measured temperature dependence of the relative change of the autodyne frequency for single-crystal TbF_3.

Unlike in the ethyl sulfate, we did observe in the terbium trifluoride single crystal a magnetic ordering at 3.9°K. We plotted the temperature dependence of the frequency of the autodyne generator used as the NMR pickup (Fig. 3). The high-temperature region is described by a Curie law with a constant $C_0 = 1.9$. Near 4°C, a sharp change in the frequency takes place and corresponds to the transition to the antiferromagnetic state, after which the frequency ceases to change. Similar changes are described in the papers by the Leiden Group [3]. An additional confirmation of the magnetic ordering is the study of the NMR of F^{19} in TbF_3. A single line with a recorded signal/noise ratio equal to 3 is observed at 4.2°K. When the temperature is lowered at 1.5°K, this ratio increases by several orders of magnitude.

More detailed results of the research will be published later.

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[1] A.A. Abragam and B. Bleaney, Electron Paramagnetic Resonance of Transition Ions, Oxford University Press, 1970.
[2] J.M. Baker, J. Phys. C. Solid State Phys. 4, 1631 (1971).
[3] K.W. Mess, E. Lagendijk, D.A. Curtis, and W.J. Huiskamp, Physica 34, 126 (1967).

INFLUENCE OF SPECTRAL LINE WIDTH OF EXCITING RADIATION ON THE GAIN IN STIMULATED SCATTERING

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1. The amplification of the light in stimulated scattering in a pump field of intensity I_p (W/cm^2) in an active medium of length L (cm) is proportional to $\exp(gI_pL)$. The gain g (cm/W) is given by $g = A/\Delta\omega$, where $\Delta\omega = 2\pi(\Delta\nu_p + \Delta\nu_{sp})$, while $\Delta\nu_p$ (cm^{-1}) and $\Delta\nu_{sp}$ (cm^{-1}) are respectively the widths of the spectral lines of the exciting radiation and of the spontaneous scattering. For stimulated Raman scattering (SRS) we have $A = \lambda_S^2\sigma N/Y$, where λ_S is the wavelength of the first Stokes component, σ is the SRS cross section, and N is the concentration of the molecules. For stimulated Mandel'shtam-Brillouin scattering $A = \gamma^2k^2/(n^3c\rho v)$, where γ is the photoelastic constant of the medium, ρ is its den-