possibility of resonant transfer of excitation between the translationally nonequivalent ions which enter in either one or in different magnetic sublattices. As shown by Allen et al. [6], the results obtained with Cr_2O_3 show that the DS observed in it is due to exchange interaction of the nonequivalent Cr^{3+} ions that enter in one sublattice. On the other hand, it is impossible to obtain unambiguous estimates of the resonant interaction between the sublattices from the available experimental data. The same pertains also to observations of DS in $YCrO_3$, since the identification given in [5] for the exciton spectrum is evidently not the only one.

We note in this connection that DS in $RbMnF_3$, which has two nonequivalent Mn^{2+} ions per unit cell, is due exclusively to excitation transfer between the sublattices, and the data obtained by us yield direct information on this phenomenon for the case of optical excitation. It is interesting that, unlike Cr_2O_3 and $YCrO_3$, the DS in $RbMnF_3$ has no field-independent component, and is induced completely by the external magnetic field, increasing in proportion to the square of the field intensity:

$$\Delta\nu_D\,(\text{cm}^{-1}) = 12{,}7 \cdot 10^{-10} \cdot H^2\,(\text{Oe}).$$

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OBSERVATION OF A SINGLE NUCLEAR SPIN-SPIN RESERVOIR IN A CRYSTAL WITH TWO NUCLEAR SPIN TYPES

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The question of the existence of a single reservoir of spin-spin interactions (the SS reservoir) in a crystal with several spin types is still unclear. Theoretical considerations were advanced [1 - 7], but the existence of such a reservoir has been proved experimentally only under special cross-relaxation conditions [3, 6] (when the resonant frequencies of the spins are practically equal or practically multiples of one another). Our experiments were undertaken for the purpose of clarifying this question. If a single SS reservoir does indeed exist, then saturation of one of the NMR lines on the wing should lead to a strong shift of the spin-spin temperature T_{SS} [8 - 10] of all the spins, and this should result in a new effect, namely a characteristic distortion of other NMR lines that are not saturated directly.

The experiments were performed on the spins of F^{19} and Li^7 in single-crystal LiF in a field H = 3500 Oe at T_0 = 4.2°K and at an orientation [111] || $\vec{H}$. The NMR lines of F and Li were detected at the frequencies 14 and 5.8 MHz, respectively, with the aid of two Q-meters with crossed coils. The field H was modulated harmonically at a frequency 2 Hz and an amplitude 20 Oe. Both NMR absorption lines were induced by a nonsaturating HF field and were observed continuously on the screen of a two-beam oscilloscope, with a sweep synchronized with the modulation of the field H. To obtain a strong increase of $T_0/|T_{SS}|$ we saturated the line with the higher frequency - the line of the F spins; this was done most effectively by adiabatic demagnetization in a rotating coordinate frame (ADRF), namely a rapid passage of the line under saturation conditions (isentropically) from the wing to its center [5]. To this end, a saturating pulse with amplitude H_1 = 0.3 Oe was turned on at the time of passage of the indication frequency. Figures 1a and 1b show the NMR signals of F and Li after passage through the low-frequency (a) and high-frequency (b) wings of the NMR line of F, prior to the appearance of the spin-lattice relaxation. The NMR line of F becomes antisymmetrical as the result of ADRF, as it should [5, 10]. A new factor in our experiment is that the NMR line of Li does not remain at equilibrium, but acquires a strongly pronounced asymmetry that persists for about 10 sec after the ADRF. On one of its wings there is observed a section of induced radiation (on the same wing as for F), and on the other the absorption exceeds the equilibrium value; its maximum shifts to the side, and the value of the signal at the exact center remains unchanged.

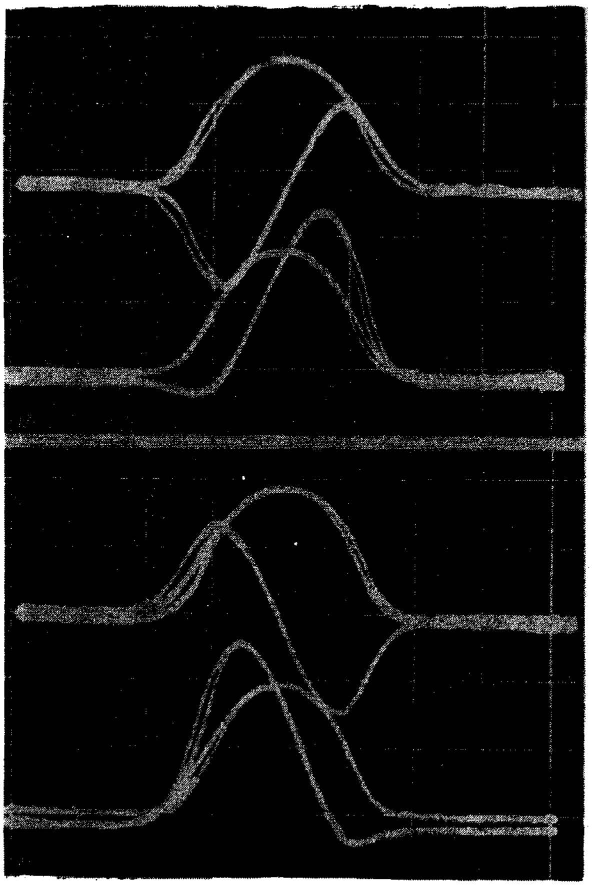

Fig. 1. Oscillograms of NMR absorption signals P(Δ) of F^{19} and Li^7 following ADRF of the spins of F^{19}. The upper lnd lower traces of a and b are for F and Li, respectively. The antisymmetrical signals (F) and the asymmetrical ones (Li) are the results of ADRF; the symmetrical signals are for equilibrium. One major division in the horizontal direction is equal to 4.8 Oe.

This result can be explained by admitting the existence of a single temperature T_{SS} for both spin types. Indeed, let us consider the general expression for the magnetic-resonance absorption signal obtained on the basis of the SS reservoir concept [8]:

$$P(\Delta) = P_Z(\Delta) + P_{SS}(\Delta) = P_0(\Delta)\left(\frac{T_0}{T_Z} + \frac{\Delta}{\nu_0}\frac{T_0}{T_{SS}}\right) \quad (1)$$

Here T_Z is the Zeeman temperature, $\Delta = \nu - \nu_0$ is the deviation of the frequency ν of the HF field from the resonant frequency ν_0 of the spins, $P_Z(\Delta)$ and $P_{SS}(\Delta)$ denote the symmetrical Zeeman and antisymmetrical spin-spin components of the signal P(Δ), respectively, and $P_0(\Delta)$ is the equilibrium absorption signal.

Let us take into account the fact that the ADRF is completed by a maximum increase of $|T_{SS}^{-1}|$ for the spins of

F and by an annihilation of their Zeeman energy ($T_Z^{-1} = 0$) [5]; for the Li spins we have in this case $T_Z = T_0$. Then, after the ADRF, we get from (1):

$$P(\Delta) = P_{SS}(\Delta) = P_0(\Delta)\,\frac{\Delta}{\nu_0^F}\,\frac{T_0}{T_{SS}}\quad , \tag{2}$$

and for the NMR indication signal of Li

$$P(\Delta) = P_0(\Delta)\left(1 + \frac{\Delta}{\nu_0^{\mathrm{Li}}}\,\frac{T_0}{T_{SS}}\right). \tag{3}$$

Since $T_0/|T_{SS}|$ increases strongly as a result of the ADRF of the F spins, we get from (3) all the signularities of the obtain NMR signals of Li, as well as their correspondence with the form of the NMR signals of F. For a quantitative estimate of the results, we have compared the values of T_{SS} determined independently for the spins of F and Li from their NMR signals (Fig. 1). Reduction of the results using different values of Δ and using formulas (2) and (3) yielded

$$\left(\frac{T_0}{T_{SS}}\right)^F = 810 \pm 70,\quad \left(\frac{T_0}{T_{SS}}\right)^{\mathrm{Li}} = 830 \pm 60$$

for Fig. 1a and

$$\left(\frac{T_0}{T_{SS}}\right)^F = -840 \pm 50,\quad \left(\frac{T_0}{T_{SS}}\right)^{\mathrm{Li}} = -860 \pm 60$$

for Fig. 1b. Thus, the values of T_{SS} for the spins of F and Li turned out to be the same within the limits of measurement accuracy.

We note that when the increase of $|T_{SS}^{-1}|$ is the result not of ADRF but of saturation of the NMR line of F on the wing, and the spins are insulated from the lattice, then the NMR signal of Li also acquires an asymmtrical form, but less pronounced, in agreement with the lower value of $|T_{SS}^{-1}|$ [8 - 10]. On the other hand, when the equilibrium NMR line of F was saturated exactly at the center, or was traversed isentropically from the center to the wing, which did not increase $|T_{SS}^{-1}|$ in either case, then the NMR signal of Li remained at equilibrium, in full agreement with our interpretation. This fact confirms also the absence of cross relaxation between F and Li.

We have also observed the approach of the P(Δ, t) signals of F and Li to the equilibrium value $P_0(\Delta)$ under the influence of spin-lattice relaxation following the ADRF. Their analysis has shown that the decay of the components of the $P_{SS}(\Delta, t)$ extracted from the signals P(Δ, t) with the aid of formulas (2) and (3) is exponential for all Δ, with a time constant $T_1' = 7.5 \pm 0.9$ sec which is the same in both cases; this is in fact the spin-lattice relaxation time of a single SS reservoir. The recovery of the $P_Z(\Delta, t)$ components of both lines after their saturation was also exponential, but with different time constants, $T_1 = 5.5$ and 14.5 min for F and Li respectively. These are the spin-lattice relaxation times of the Zeeman reservoirs of F and Li.

It follows therefore from the experiments that the temperature T_{SS} is the same for the spins of F and Li not only at the first instant after the ADRF, but also during the course of the entire process of establishment of equilibrium with the lattice. By the same token, this demonstrates convincingly that a single SS reservoir exists for all the nuclear spin in the crystal also without cross relaxation.

We note that in stationary saturation of the NMR line of F on the wing, its indication signal P(Δ) vanishes for all values of Δ, and the NMR signal of Li remains at equilibrium. This is understandable, for in this case, owing to the relatively strong coupling between the SS reservoir and the lattice ($T_1/T_1' \gg 1$), the value of T_0/T_{SS} changes little [8 - 10], and its influence on the NMR signal of Li is negligible.

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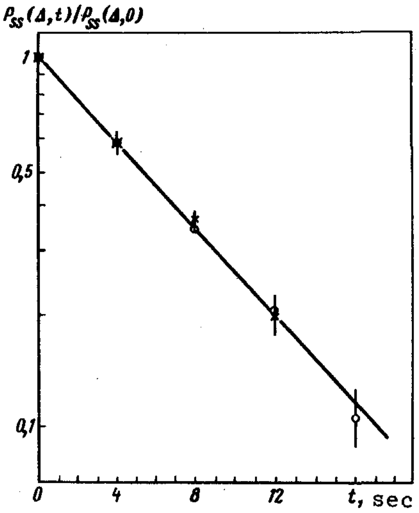

Fig. 2. Decay of spin-spin components $P_{SS}(\Delta, t)$ of the NMR absorption signals $P(\Delta, t)$ of F^{19} and Li^7 after ADRF of the F^{19} spins. o - experimental values of $P_{SS}(\Delta, t)/P_{SS}(\Delta, 0)$ for F; × - the same for Li.

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HYPERSOUND ABSORPTION IN DIAMOND

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An investigation of the absorption of hypersound waves in dielectric single crystals yields information on the mechanism of elastic losses at ultrahigh frequencies. There are many published reports of experimental studies of the absorption of hypersound in various single crystals in a wide range of