nitude in the differential cross section of elastic π^+p backward scattering at 3.15 GeV/c. From the data in the table we see that a narrow peak exists near 180° for 4.0 GeV/c. Indeed, the value of $(d\sigma/d\Omega)^{4.1}_{180^\circ}$ exceeds by one order of magnitude the average cross section for scattering into the back hemisphere, and is almost 4 times as large as the cross section for the $\cos\theta_{\rm cms}$ interval from -0.8 to -1.0 at 4.0 GeV/c. There is a peak in the backward π^+ scattering also for 4.85 GeV/c, with $(d\sigma/d\Omega)^{4.85}_{180^\circ}$ exceeding by several times the value of $(d\sigma/d\Omega)^{4.00}_{90+180^\circ}$, which in turn should be larger than $(d\sigma/d\Omega)^{4.85}_{90+180^\circ}$.

The existence of a peak in elastic π^+p backward scattering in a rather broad energy interval above 3 GeV shows that this peak is not connected with the appearance of any resonance, but is characteristic of the process of elastic scattering at high energies. [1)]

The differential backward-scattering cross section at 4.0 GeV/c, obtained in [2], together with the value of $(d\sigma/d\Omega)^{4.1}_{180^\circ}$ from that reference, is well described by a relation of the type

$$d\sigma/d\Omega = A\ \exp\{p_\perp/0.32\},$$

where $p_\perp$ is the perpendicular momentum transfer in GeV/c.

The value of $(d\sigma/d\Omega)_{180^\circ}$ decreases rapidly in the energy interval measured by us. However, since measurements at different energies were made at different values of the square of the momentum transfer u, this decrease in the cross section is accompanied by a simultaneous change in two parameters, the energy and the square of the momentum transfer u.

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CONCENTRATION AND TEMPERATURE DEPENDENCES OF THE SPIN-LATTICE RELAXATION TIMES IN RUBY AT HELIUM TEMPERATURES. RELAXATION IN ZERO MAGNETIC FIELD.

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A rather strong dependence of the spin-lattice relaxation time T_1 in ruby on the concentration of the Cr^{3+} ions was noticed by several investigators [1-5]. In a recent communication [6], however, the authors deduced the independence of T_1 in ruby crystals grown by a special method from the gas phase. In addition, an anomalous temperature dependence of the relaxation time in the 1.6 - 4.2°K region at high Cr^{3+} concentrations was observed by some [3,5,7], although not by other investigators.

In view of the contradictions between the foregoing facts, and bearing in mind the great importance of the concentration dependence of the spin-lattice relaxation time in the theory of paramagnetic relaxation in crystals and the great practical value of ruby crystals for use in quantum amplifiers and lasers, we undertook to measure precisely the relaxation time in ruby at helium temperatures in a broad range of Cr^{3+} ion concentrations, from 0.05 to 0.7%.

We investigated samples grown by the Verneuil method in a strongly reducing medium with $H_2:O_2$ gas ratio $\approx 5:1$. The values of T_1 were measured by pulsed saturation of the paramagnetic resonance lines at frequencies $\nu_1 = 11{,}472$ and $\nu_2 = 9400$ Mc. The frequency ν_1 corresponds exactly to the start of the splitting of the ±1/2 and ±3/2 levels of the ground state by the electric crystalline field ($\delta = 0.3824$ cm^{-1}). Measurements at this frequency in zero magnetic field are therefore of particular interest in the explanation of the nature of the concentration dependence of the relaxation time. In this case we are dealing with a two-level system, and consequently there are no spin-spin cross correlation processes, which depend on the concentration of the paramagnetic ions and greatly influence the restoration of the populations in many-level systems.

Investigations of the transition $\pm 1/2 \leftrightarrow \pm 3/2$ in zero magnetic field at the frequency ν_1 have shown that the relaxation curves are singly-exponential at all the investigated concentrations and do not depend on the duration of the saturating pulses. This confirms (see [2]) the assumption that there are no cross relaxation processes in this transition, and the observed relaxation curves corresponded to spin-lattice relaxation.

At the frequency ν_2 we investigated the transition $1/2 \longleftrightarrow -1/2$ for parallel orientation of the c axes of the ruby crystals relative to the external magnetic field (intensity H = 3360 Oe). The doubly-exponential relaxation curves observed at this frequency for certain Cr^{3+} concentrations corresponded to both spin-lattice and cross relaxations. These two processes were separated by investigating the dependence of the form of the relaxation curves on the duration of the saturating pulses [2].

The values of T_1 in ruby, measured at T = 4.2°K for the transitions $\pm 1/2 \longleftrightarrow \pm 3/2$ in zero magnetic field and $1/2 \longleftrightarrow -1/2$ in a field H = 3360 Oe at different Cr^{3+} concentrations f, are shown in Figs. 1 and 2, respectively (f is the ratio of the number of Cr^{3+} ions to the number of Al^{3+} ions). These values fit well the relation

$$T_1^{-1}(f) = T_1^{-1}(0) + T_1^{-1}(1)\cdot f^n \qquad (1)$$

with parameters $T_1^{-1}(0) = 9$ sec^{-1}, $T_1^{-1}(1) = 2 \times 10^6$ sec^{-1}, and n = 2 for the $\pm 1/2 \longleftrightarrow \pm 3/2$ transition and $T_1^{-1}(0) = 9.6$ sec^{-1}, $T_1^{-1}(1) = 10^6$ sec^{-1}, and n = 1.9 for the $1/2 \longleftrightarrow -1/2$ transition. Here $T_1^{-1}(0)$ is the rate of spin-lattice relaxation for infinite magnetic dilution of the crystal (i.e., for f = 0), and $T_1^{-1}(1)$ corresponds to the relaxation rate at f = 1. The value of

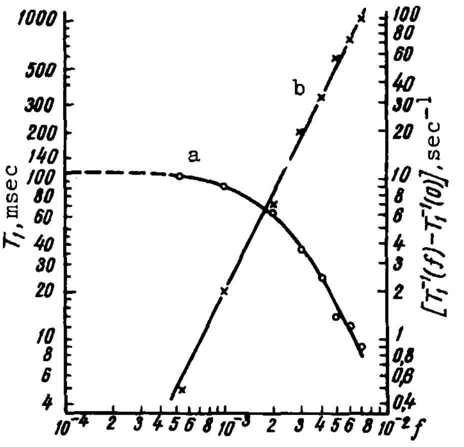

Fig. 1. Relaxation time T_1 vs. the concentration f (a) and value of $T_1^1(f) - T_1^1$ (b) in ruby for the ±1/2 ↔ ±3/2 transition in a zero magnetic field at T = 4.2°K. o - experimental points, x - points recalculated from the experimental values.

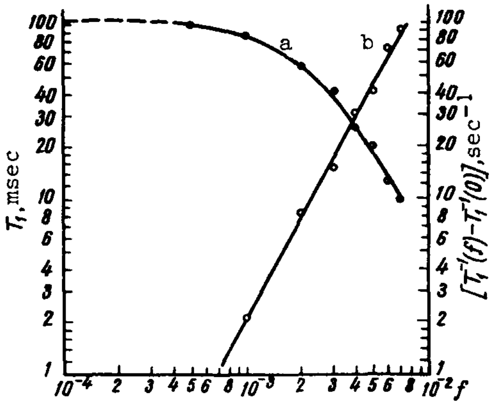

Fig. 2. Plots of $T_1(f)$ (a) and $T_1^1(f) - T_1^1(0)$ (b) in ruby for the 1/2 ↔ -1/2 transition at $\theta = 0°$ in a magnetic field H = 3360 Oe, at T = 4.2°K. ● - experimental points, o - points recalculated from the experimental values.

of $T_1(0)$ was obtained by extrapolating the $T_1(f)$ curve to very low concentrations. The lines b on Figs. 1 and 2, with slopes 2 and 1.9 respectively, illustrate the good agreement between the measured values of T_1 and formula (1) over the entire investigated interval of Cr^{3+} ion concentration.

Investigations of the temperature dependence of T_1 have shown that $T_1 \sim T^1$ in the interval T = 1.6 - 4.2°K at all investigated Cr^{3+} ion concentrations, showing no anomalies whatever even at large concentrations.

Our data allow us to make the following conclusions concerning the spin-lattice relaxation in ruby. The temperature dependence shows that the spin-lattice relaxation results from direct processes of energy exchange between the spin system and the lattice. The character of the concentration dependence of the relaxation rate indicates that there are two different effective spin-phonon interaction mechanisms. One depends on the concentration of the paramagnetic ions and is responsible for relaxation at low concentrations ($f \lesssim 0.05\%$). This is obviously the Kronig-Van Vleck mechanism. Calculations [8] confirm this conclusion. The second mechanism leading to a concentration dependence of the relaxation time becomes predominating at $f \gtrsim 0.3\%$. The nature of this mechanism is probably connected with the interaction between the Cr^{3+} ions. The various mechanisms considered in [9-11] (relaxation via "exchange pairs," relaxation via modulation of indirect exchange interactions) point in principle to a concentration dependence of the spin-lattice relaxation rate, but do not lead to the actually observed (near-quadratic) character of this dependence. To establish an adequate mechanism responsible for the observed concentration dependence, further theoretical research is necessary.

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RESONANT HEATING OF A PLASMA BY A HIGH-FREQUENCY FIELD

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We present in this paper the preliminary results of experiments on heating of a dense plasma with powerful high-frequency pulses under conditions when a fast magnetic-sound wave is resonantly excited in the plasma ($\Omega_e \gg \omega_e$, $\omega_i \ll \omega_e$, where Ω_e is the electron plasma frequency, ω_i and ω_e the ion and electron cyclotron frequencies, respectively, and ω the working frequency). The efficacy of heating with a magnetic-sound wave was investigated theoretically and verified experimentally in [1-5].

A diagram and a detailed description of the setup are given in [6]. The investigations were made on a decaying plasma situated in a quasi-constant longitudinal magnetic field, the intensity of which could reach 6000 Oe. The plasma was produced by a reflex pulsed discharge in hydrogen and helium at pressure $\sim 10^{-3}$ mm Hg. The inside diameter of the glass discharge tube was 6 cm and the distance between electrodes 88 cm.

A high-frequency field was applied to the decaying cold plasma (temperature ~1 eV). The field was excited by discharging a 5.25×10^{-9} F capacitor bank charged to 36 kV through inductance coils wound on the discharge tube in such a manner that the field along the axis was periodic with an axial period $\lambda = 20$ cm. The length of the coil system was ~80 cm (4 periods). The resonant-circuit oscillation frequency was 7 Mc and the amplitude of the axial hf magnetic field $\tilde{H}_z = 140$ Oe.

We measured the coefficient of energy transfer from the hf field of the plasma circuit, equal to the ratio of the energy absorbed by the plasma to the total energy stored in the cir-