THE SPIN-LATTICE RELAXATION TIME OF THE Ti^{3+} *ION IN CORUNDUM*

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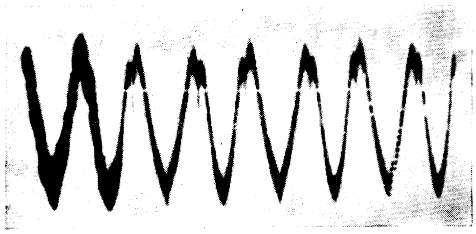
Results of measurements of the spin-lattice relaxation time of the Ti^{3+} ion in corundum at liquid-helium temperature, obtained by the pulse saturation method, are presented. At a temperature of 2° K a "hole" is found to appear in the paramagnetic absorption line under the action of a brief saturating pulse.

AN estimate by the continuous saturation method of the spin-lattice relaxation time τ_1 of samples of corundum containing Ti^{3+} as an isomorphous impurity at liquid helium temperatures was reported earlier.[1] This estimate gave the temperature dependence of τ_1, but its absolute values can only be considered very approximate. In the first place one had to make a somewhat arbitrary assumption as to the possible magnitude of $g_\perp$, which is not very different from zero, and in the second place it was difficult to determine the true value of the spin-spin relaxation time τ_2, since the asymmetry of the line shape and its considerable width clearly indicated the presence of inhomogeneous broadening.

To improve the absolute values of τ_1 measurements by the saturating pulse method were undertaken, using the apparatus described earlier.[2]

At 2° K a saturating pulse of peak power of the order of 1 W and of 10–20 μsec duration produced a "hole" in the EPR (electron paramagnetic resonance) line, which was being observed with 50 cps modulation of the resonant magnetic field. The experiments were performed with parallel orientation of the magnetic field relative to the crystal trigonal axis. By applying the saturating pulses every fourth cycle of the magnetic field modulation, i.e., every 80 μsec, it was possible to follow the behavior of the hole in the line between two consecutive pulses. The figure shows a photograph of the screen of an oscilloscope, the horizontal sweep of which was synchronized with the saturating pulses. The EPR line is observed eight times during each sweep (twice in each modulation cycle). The first line corresponds to the moment of application of the saturating pulse. During the subsequent passages through resonance the EPR line appears with a hole of width less than



5 Oe, the depth of which decreases gradually with a characteristic time $\tau = (5 \pm 1) \times 10^{-2}$ sec.

If it is assumed that the width of the hole does not change during the time of observation, then this characteristic time τ is the spin-lattice relaxation time τ_1. However the magnitude of the hole can also decrease as a result of cross-relaxation within the line, the presence of which should produce a broadening of the hole. In this case τ_1 turns out to be longer than τ. However, in our experiments, no significant widening of the hole with time was observed.

At 4.2°K the hole in the line was not observed because of insufficient power to saturate. This is in agreement with the estimated shortening of τ_1 as the temperature is increased from 2 to 4.2°K, given in [1] (10^3 times).

The occurrence of a hole in the EPR line at 2°K under the influence of a short saturating pulse can apparently be given the following explanation. The EPR data on the Ti^{3+} ion in the corundum lattice leads one to expect that if the Ti^{3+} ion enters into the lattice exactly substitutionally, $g_\perp$ equals zero. The presence of a random distribution of Ti^{3+} ions would lead to a deviation of the values of $g_\perp$ for the individual ions from zero and to the appearance of a non-zero contribution to the EPR line. The greater the shift in position of a Ti^{3+} ion from its corresponding zero value of $g_\perp$, the greater the intensity contribution. On account of the random character of the displacements of the individual ions, ions having nearly equal g factors can turn out to be far away from each other, thus hampering the cross-relaxation interaction between them. On the other hand, the cross-relaxation interactions within the line are in the present case extremely weak because $g_\perp$ is close to zero.

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[1] L. S. Kornienko and A. M. Prokhorov, JETP **38**, 1651 (1960), Soviet Phys. JETP **11**, 1189 (1960).

[2] P. P. Pashinin and A. M. Prokhorov, JETP **40**, 49 (1961), Soviet Phys. JETP **13**, 33 (1961).

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