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Spin-Lattice Relaxation in some Rare Earth Ethylsulphates¹

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The work of Finn, Orbach and Wolf [1] on spin-lattice relaxation in cerium magnesium nitrate at temperatures in the liquid helium range supports the hypothesis that in this substance the dominant relaxation mechanism is by direct phonon transitions between the states of the ground doublet and a low-lying excited state of the magnetic ions. This 'statistical' process leads to a temperature dependence of the relaxation time T_1 proportional to $\exp(\Delta/kT)$, where Δ is the energy of the excited state.

We have carried out similar investigations on the ethyl-sulphates of neodymium, dysprosium, erbium and ytterbium, in order to discover whether the same mechanism is important in these substances. We find that in dysprosium ethylsulphate at temperatures between 3.0°K and 1.6°K the relaxation time varies as $\exp(\Delta/kT)$ with $\Delta/k = 23.6 \pm 2^\circ$. In this substance the ground state of the dysprosium ion is predominately $J_Z = \pm 9/2$, with excited states at 23.0° and 29.1° (Gramberg and Kahle, quoted by Meyer and Smith [2]) the lower of these states being predominately $J_Z = \pm 7/2$. It appears then that in this salt the statistical process is again the predominant relaxation mechanism. Similar results were obtained for ytterbium ethylsulphate, with $\Delta/k = 40 \pm 2^\circ$. Here we have no measured value for the energy of the first excited state, though the specific heat measurements of Meyer and Smith [2] would indicate a somewhat higher value than 40°.

The measurements on the other two salts showed a quite different temperature-dependence. Since the lowest excited states of the neodymium ion in the ethyl sulphate are estimated by Elliott and Stevens [3] to lie

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at approximately 180° and 240° , the probability of phonon-induced transitions to these levels is comparatively small. There is no accurate information on the excited states of the erbium ion in the ethylsulphate; the lowest levels are believed to lie at about 70° above the ground state.

Preliminary measurements have been made on the field dependence of the relaxation time in the dysprosium salt. These have not been analysed in detail, but show a variation of the expected form.

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