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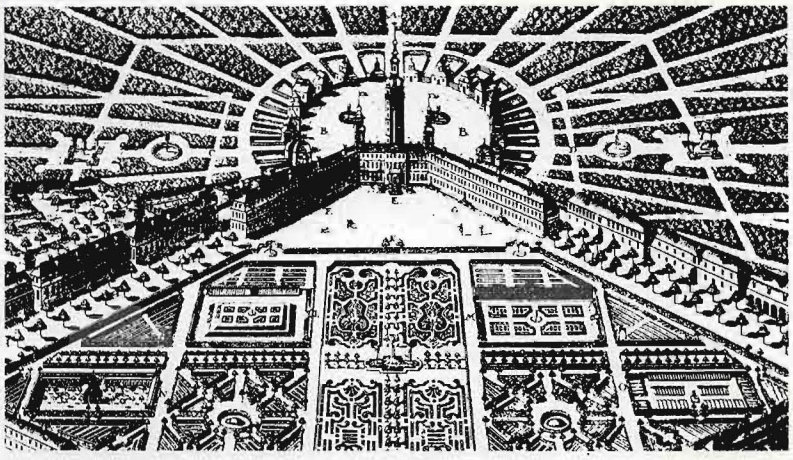

NORTH-HOLLAND

LT-17 (Contributed Papers)
U. Eckern, A. Schmid, W. Weber, H. Wühl (eds)

MAGNETIC PROPERTIES OF FROZEN AQUEOUS CEROUS MAGNESIUM NITRATE SOLUTION*

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The magnetic susceptibility and spin-lattice relaxation times were measured in a frozen Cerous Magnesium Nitrate (CMN) solution at 25°C saturated. The susceptibility measurement yields an isotropic g-factor of g=1.81. Between 1K and 2K, the spin-lattice relaxation times are much shorter than those of a CMN crystal.

1. INTRODUCTION

$Ce_2Mg_3(NO_3)_{12}24H_2O$ is a widely used salt for cooling and low temperature thermometry. Its g-factor and thus its susceptibility are highly anisotropic (1) and its spin-lattice relaxation times become of the order of 1s at 1K (2). A saturated room temperature water solution of the subatance when cooled, freezes into a glasslike solid (3). At 25°C, the saturated solution is 65.7% CMN and 34.4% H_2O by weight (3,4). Examination of a frozen CMN solution by means of EPR shows a relatively broad maximum in the derivative of absorption at about .22T as contrasted with a very sharp peak at about .33T for CMN and CMN and saturated solution mixture. This shows the different character of the CMN solution.

2. EXPERIMENTAL METHOD

The samples were prepared from commercially obtained cerous nitrate with 99.99% purity with respect to other rare earth. To further purify the substance, CMN crystals were grown and redissolved. This process was repeated several times. The saturated solution was then frozen. The frozen solution was in the shape of a 1x1 cylinder and was solidified by slowly cooling it in liquid nitrogen vapor which yielded a clear sample without cracks.

Susceptibility was measured by means of an ac bridge described by Maxwell (5) at frequencies of 43, 98, and 188 Hz. Relaxation times T_1 were measured by the method of Casimir and duPré (6) with dc applied magnetic fields of up to 17mT using the same susceptibility bridge capable of both in and out of phase measurements.

3. RESULTS AND DISCUSSION

Fig. 1 is the plot of the in-phase susceptibility as a function of the inverse temperature between 4.2K and 1K.

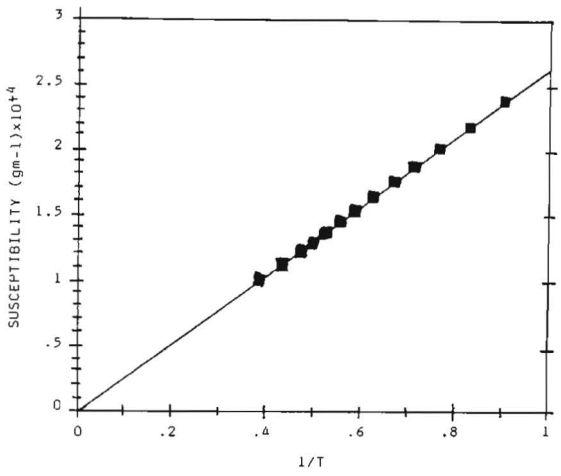

FIGURE 1

It shows that the substance obeys Curie's law in this temperature range. From this measurement we can calculate the Curie constant C as $C=2.65\times10^{-4}$ per gram of solution, or $C=4.03\times10^{-4}$ per gram of dissolved CMN. Since

$$C=(N/V)\frac{\mu_B^2 g^2}{4k}$$

this gives g=1.81 to within 1%. Although this value is close to the value of $g_\perp=1.84$ normal to the C-axis of a single CMN crystal, it is vastly different from that expected from a randomly oriented powder which would give (7)

$$g_{eff}=[(1/3)g_{\parallel}^2+(2/3)g_{\perp}^2]^{1/2}=1.50$$

assuming $g_{\parallel}\simeq 0$.

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Fig. 2 shows the inverse spin-lattice relaxation time as a function of temperature between 1K and 2K.

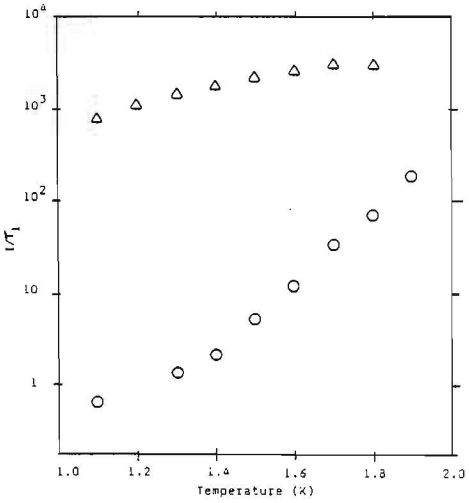

FIGURE 2

The triangles denote the relaxation times of the saturated solution while the circles denote those of a single clear CMN crystal of approximately the same dimension. In this temperature range the relaxation times of the saturated solutions change by a factor of four while those of a single crystal change by over two orders of magnitude. T_1's of the saturated solution are about three orders of magnitude shorter in the saturated solution than the crystal. The relaxation time of the solution also appears to be field dependent as shown in Fig. 3.

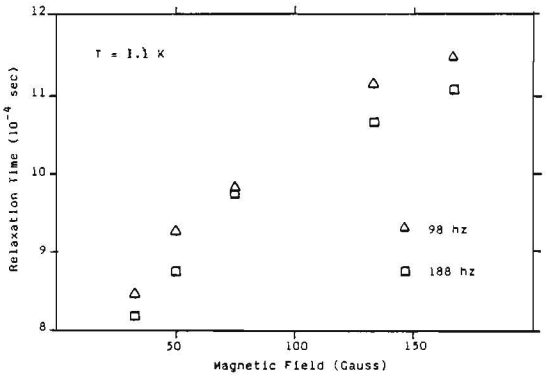

FIGURE 3

Between 1K and 2K the data can be phenomenologically represented as

$$T_1 = \tau_0 T^{-N}$$

where T_1 is the spin-lattice relaxation time and τ_0 and N are constants and T is the temperature. At 13.3mT, τ_0=1.42 ms and N=2.70. Pure CMN crystal, on the other hand, has a relaxation time which depends on temperature as (2)

$$T_1 = \tau_0 \exp(\Delta/T)$$

with $\Delta \approx 34$K and at lower temperatures becomes proportioned to T^{-2} because of a phonon-bottleneck of a direct process.

We assume that neither the Orbach process (2) nor the bottleneck occurs in the saturated solution. The shorter relaxation time should make the solution a better thermometric substance than pure CMN.

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