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MAGNETIC PHASE DIAGRAM OF THE $Ni(NO_3)_2 6NH_3$

by

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ABSTRACT

The magnetic phase diagram of $Ni(NO_3)_2 6NH_3$ was determined from the field and temperature dependence of the magnetic susceptibility. The zero temperature exchange and anisotropy fields were determined to be $H_E(0) \tilde{=} 26$ kOe and $H_A(0) \tilde{=} 0.7$ kOe respectively.

RESUMO

O diagrama de fase magnético do $Ni(NO_3)_2 6NH_3$ foi determinado por meio da dependência da susceptibilidade magnética com o campo e com a temperatura. Foram determinados os campos de "exchange" e de anisotropia a zero graus que são $H_E(0) \tilde{=} 26$ kOe e $H_A(0) \tilde{=} 0.7$ kOe respectivamente.

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The $Ni(NO_3)_2 6NH_3$ is isomorphous to the Nickel Hexamine Halides whose magnetic and thermal properties have been extensively investigated [1-6]. It is cubic and the $Ni6NH_3^{++}$ complexes are disposed in a f.c.c. array with the lattice parameter $a = 10.96$ Å [7]. The six ammonia molecules form an octahedron around the Ni^{++} ion and at high temperatures they can rotate about the axes of the octahedron (which coincide with the cubic axes) thus producing an averaged cubic field on the Ni^{++} ion. At low temperatures this rotational motion is hindered, and according to the model proposed by Bates and Stevens [3], the overall symmetry of the cristalline field produced by the NH_3 molecules is then trigonally distorted. The work of Trapp and Shyr [6] indicates the value $D \simeq 0.4$ K for the splitting of the Ni^{++} ground triplet of all the halides, but, no measurement of D is reported for the nitrate.

On the other hand $Ni(NO_3)_2 6NH_3$ shows unambiguously an antiferromagnetic transition at $T_N = 1.35$ K [8], and in this letter we report measurements of the temperature and magnetic field dependence of the magnetic susceptibility in powdered samples, from which we could determine its magnetic phase diagram, and estimate the strength of the exchange and anisotropy fields.

Fig. 1 shows curves of susceptibility versus field at two constant temperatures. At the lowest temperatures measured, the susceptibility follows quite well the ex-

pected behavior for a cubic,low anisotropy antiferromagnet (see for instance fig. 5 of ref. 9). The first peak at about 6 kOe corresponds to a spin-flop type of transition, and the second one, at about 50 kOe corresponds to the canted-paramagnetic transition. Fig. 2 shows their temperature dependence. For T very close to T_N these peaks become unconspicuous because the phase boundary is a line of almost constant T , and so we made use of plottings of susceptibility versus temperature at constant field to draw the phase boundaries. The triple point is T= (1.34 ± 0.01) K and H= (7.5 ± 0.3) kOe . An extrapolation of the boundaries for T = 0 yields $H_{SF}(0)$= (6.0 ± 0.3) kOe and $H_p(0)$= (52 ± 2)kOe where the uncertainties indicated are due mostly to the extrapolation process.

From the above numbers we can readily estimate the exchange field $H_E(0) \tilde{=} 26$ kOe and the anisotropy field $H_A(0) \tilde{=} 0.7$ kOe for T = 0 . The value of $H_E(0)$ is consistent with the Weiss temperature θ= -3.3 K presented in ref. 8.

The parameter D can be evaluated from $H_{SF}(0)$ and $H_p(0)$ if the relative orientation of spins and anisotropy axes are known. A first attempt , considering the crystallites of our powdered samples constituted of equal proportions of uniaxial antiferromagnetic domains with the anisotorpy axis in each of the four equivalent <111> directions (the anisotropy axes being the directions of easy magnetization), led to the value $D \tilde{=} 0.1$ K. If we consider now arrangements in which the spins are not parallel to the local symmetry axes , the calculation

becomes more involved and certainly leads to higher values of D, and quick estimates of the most unfavorable cases made us foresee increases of at most factors of three. The rather naïve assumption of uniaxial domains was inspired in Bates' model for the halides [3,4] and any attempt to justify it would be necessarily lenghty and outside the scope of this letter. It seems, however, that any calculation of D based on the present data will lead to a value smaller than that which has been reported for the halides [6].

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FIGURE CAPTIONS

Figure 1 - Field dependence of the magnetic susceptibility at constant temperature for $T = 1.05$ K and $T = 0.32$ K .

Figure 2 - Magnetic phase boundaries. The points marked with triangles were taken from plottings of susceptibility versus temperature at constant field. Squares and dots refer to different samples.

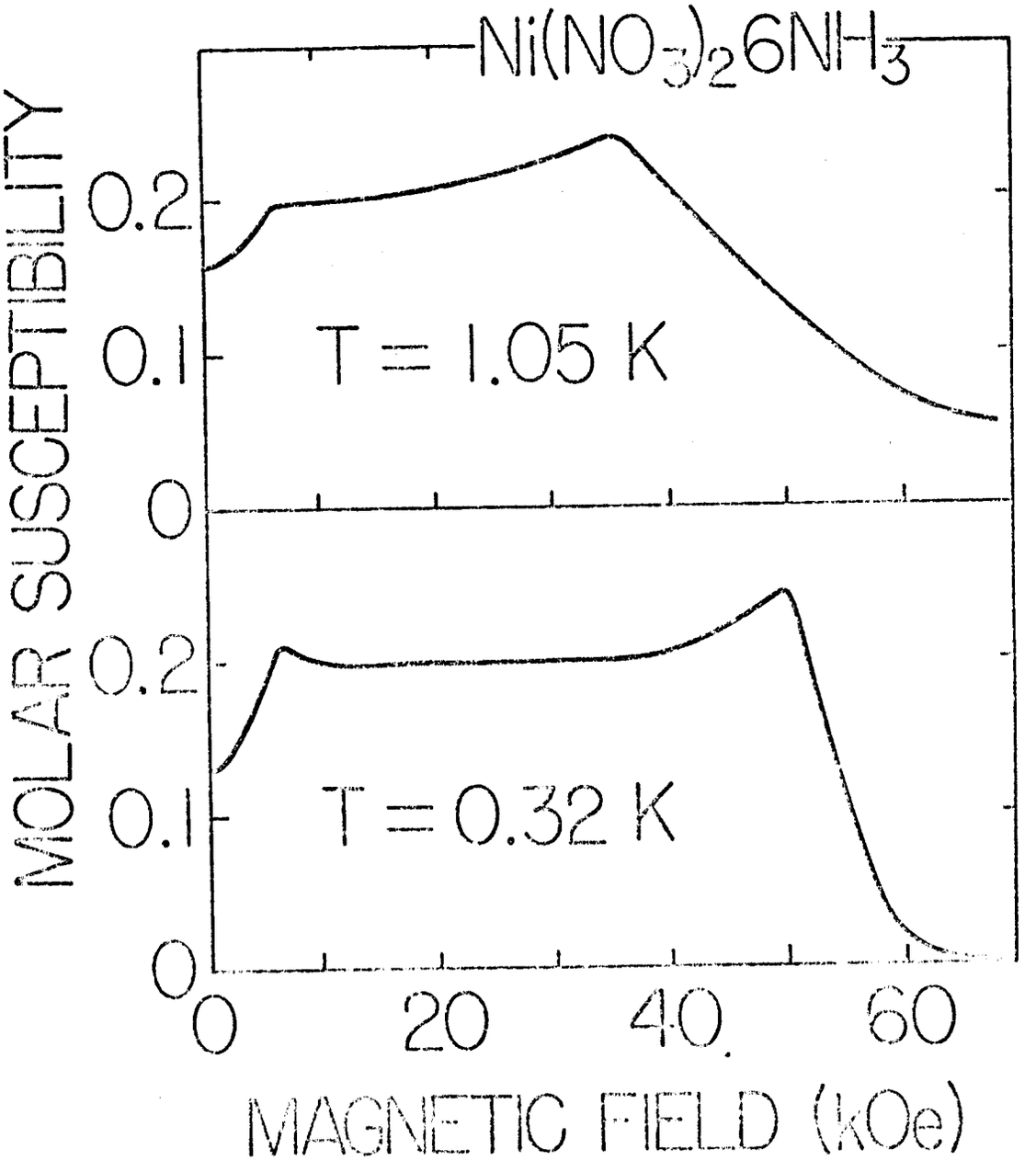
Ni(NO3)26NH3
MOLAR SUSCEPTIBILITY
0.2
0.1
0
T = 1.05 K
0.2
0.1
0
T = 0.32 K
0
20
40
60
MAGNETIC FIELD (kOe)

Figura 1

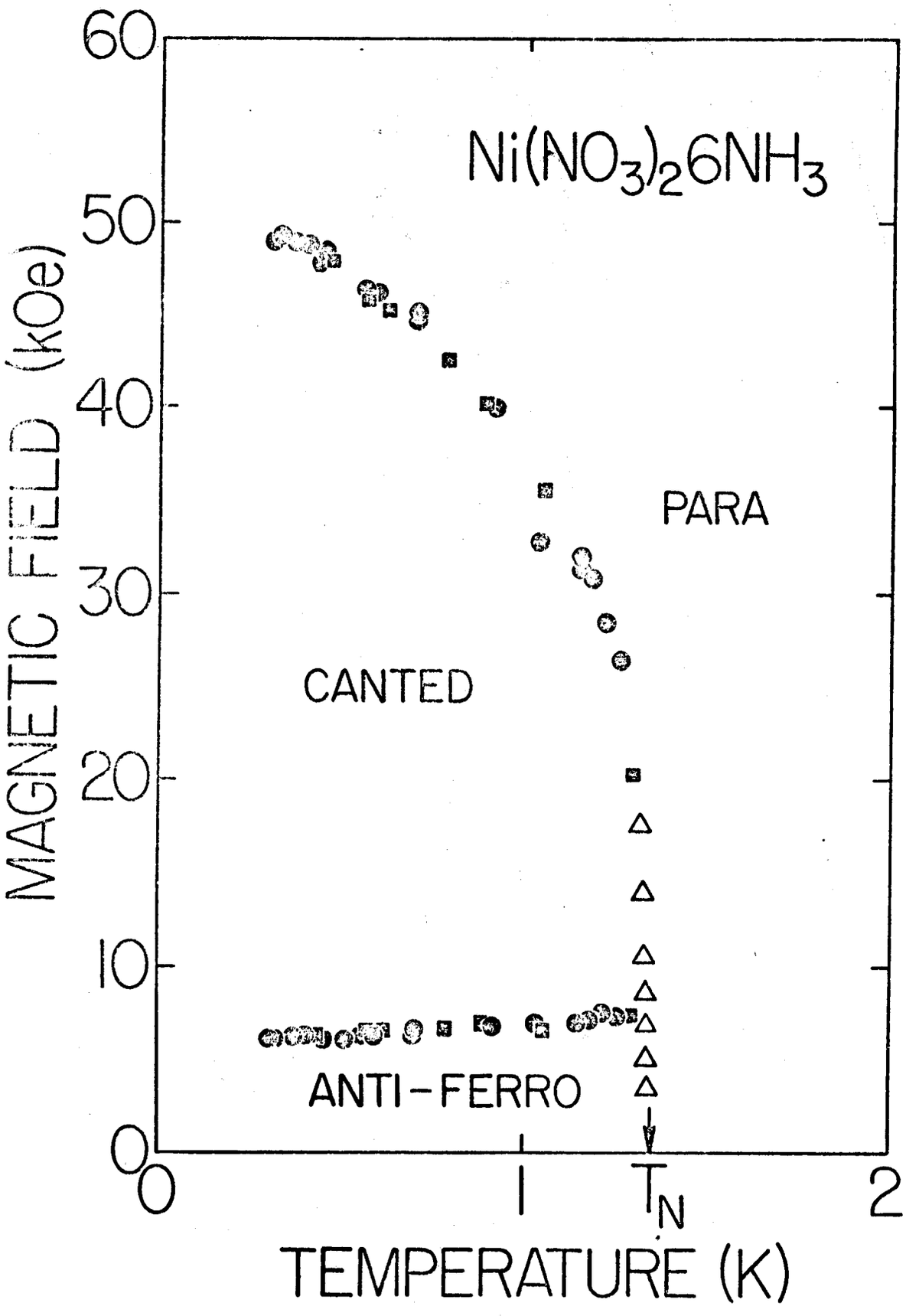
Ni(NO3)26NH3
MAGNETIC FIELD (kOe)
60
50
40
30
20
10
0
PARA
CANTED
ANTI-FERRO
0
1
TN
2
TEMPERATURE (K)

Figura 2