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A.C. MAGNETIC SUSCEPTIBILITY DETERMINATION OF MAGNETIC PHASE TRANSITION IN $NiCl_2 \cdot 6H_2O$.

by

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ABSTRACT

Boundaries of the antiferromagnetic-spin flop and antiferromagnetic-paramagnetic phases of $NiC\ell_2 \cdot 6H_2O$ single crystal are obtained from magnetic susceptibility measurements. We found the triple point at 3.98 ± 0.02 K and 44.1 ± 0.2 kOe and the temperature T_{AE} = 5.8 ± 0.1 K .

RESUMO

As fronteiras entre as fases antiferromagnética-"spin-flop", e antiferromagnética-paramagnética para um cristal único de $NiC\ell_2 \cdot 6H_2O$ foram obtidas a partir de medidas de susceptibilidade magnética. Determinou-se o ponto triplo a 3.98 ± 0.02 K e 44.1 ± 0.2 kOe ,e a temperatura T_{AE} = 5.8 ± 0.1 K .

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$NiCl_2 \cdot 6H_2O$ is an antiferromagnet with $T_N = 5.34$ K [(1)]. The crystal is monoclinic belonging to the C2/m space group [(2)], the a axis making an angle of $122^{\circ}10'$ with the c axis. Neutron difraction data [(3)] indicate a I_c2/c magnetic group and that the spin direction is approximately at 10° from the a axis in the direction of the c axis; this result is confirmed by careful magnetic susceptibility measurements at zero field [(4)] and by antiferromagnetic resonance[(5)]. Date and Motokawa [(5)] report a critical field of 40.0 ± 1 kOe .

In this letter we report the determination of the antiferromagnetic-spin flop and antiferromagnetic--paramagnetic boundaries by an a.c. magnetic susceptibility technique described in ref. (6), with magnetic fields up to 70kOe provided by a superconducting selenoid.

Single crystals, grown from aqueous solution at room temperature, were oriented within $\pm 3^{\circ}$ by their crystal habit to have the magnetic axis parallel to the external magnetic field and to the field provided by the pick-up coils.

Figure 1 is a typical trace of $\chi \times H$ obtained by keeping constant the temperature and sweeping the field. The field at the susceptibility maximum corresponds to the antiferromagnetic-spin flop critical field.

The susceptibility peak becomes higher and sharper with decreasing temperature. The susceptibility is nearly constant and independent of temperature above the spin--flop field and tends to zero with decreasing temperature in small fields, a result that could be expected since, in general, $\chi_{\parallel}$ goes to zero and $\chi_{\perp}$ remains constant for a typical antiferromagnet. No hysteresis effect was observed when crossing the antiferromagnetic-spin flop boundary.

When the field is swept across the antiferromagnetic-paramagnetic boundary a maximum in the susceptibility is observed, this maximum becomes broader with increasing temperature.

In Figure 2 we have a plot of the susceptibility maxima in the $H \times T$ plane. The points in the anti-para phase boundary for $H < 20$ kOe are from specific Heat data of Johnson and Reese [7] .

We did not find evidence of the spin-flop-paramagnetic boundary. This may be an indication that this boundary is almost vertical since our measurements were made by sweeping the field at constant temperature. Thus, the dashed line in Figure 2 was arbitrarily traced to suggest this result. The magnetic triple point estimated from the experimental curve is $T = 3.98 \pm 0.02^{o}K$ and $H = 44.1 \pm 0.2$ kOe . From molecular field theory [8], one obtains the critical field H_{AFSF} for the antiferromagnetic-spin flop boundary

$$H_{AFSF} = \frac{k\ T_{AE}}{\mu_B g} \left(1 - \frac{\chi_{\parallel}}{\chi_{\perp}} \right)^{-1/2}$$

where T_{AE} is the caracteristic temperature associated with the anisotropy exchange gap. Using $g = 2.2$, and extrapolating the critical field to $T = 0$ K we found $T_{AE} = 5.8 \pm 0.1$ K. The spin flop field rises from 39.6 kOe at 1.1 K to 44.1 kOe at the magnetic triple point, these results are in good agreement with critical field of 40 ± 1 kOe obtained from antiferromagnetic resonance data [(5)].

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FIGURE CAPTIONS

Fig. 1 - $\chi \times H$ at constant temperature showing the anti ferromagnetic spin-flop transition.

Fig. 2 - Magnetic Phase diagram for $NiC\ell_2 \cdot 6H_2O$.

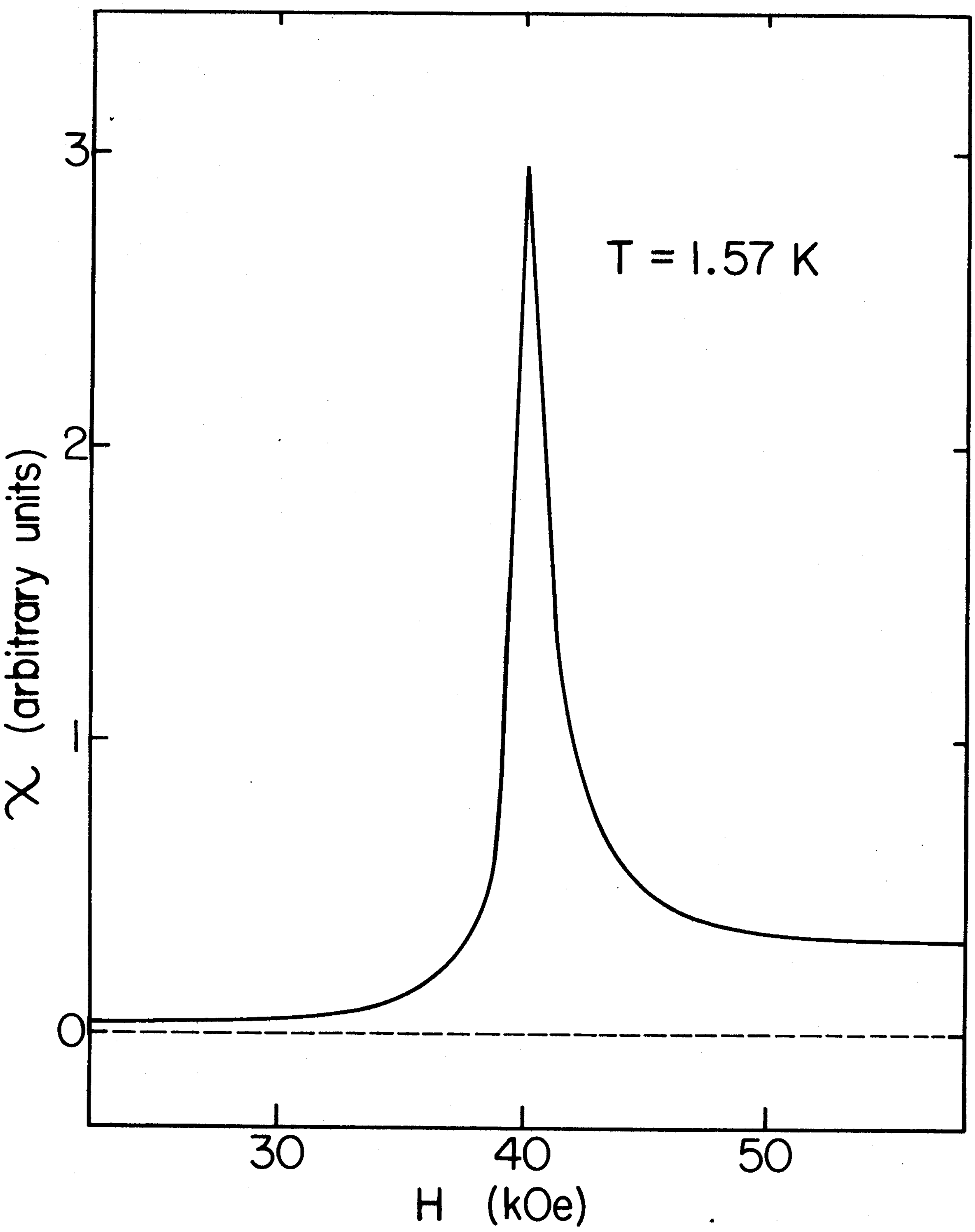
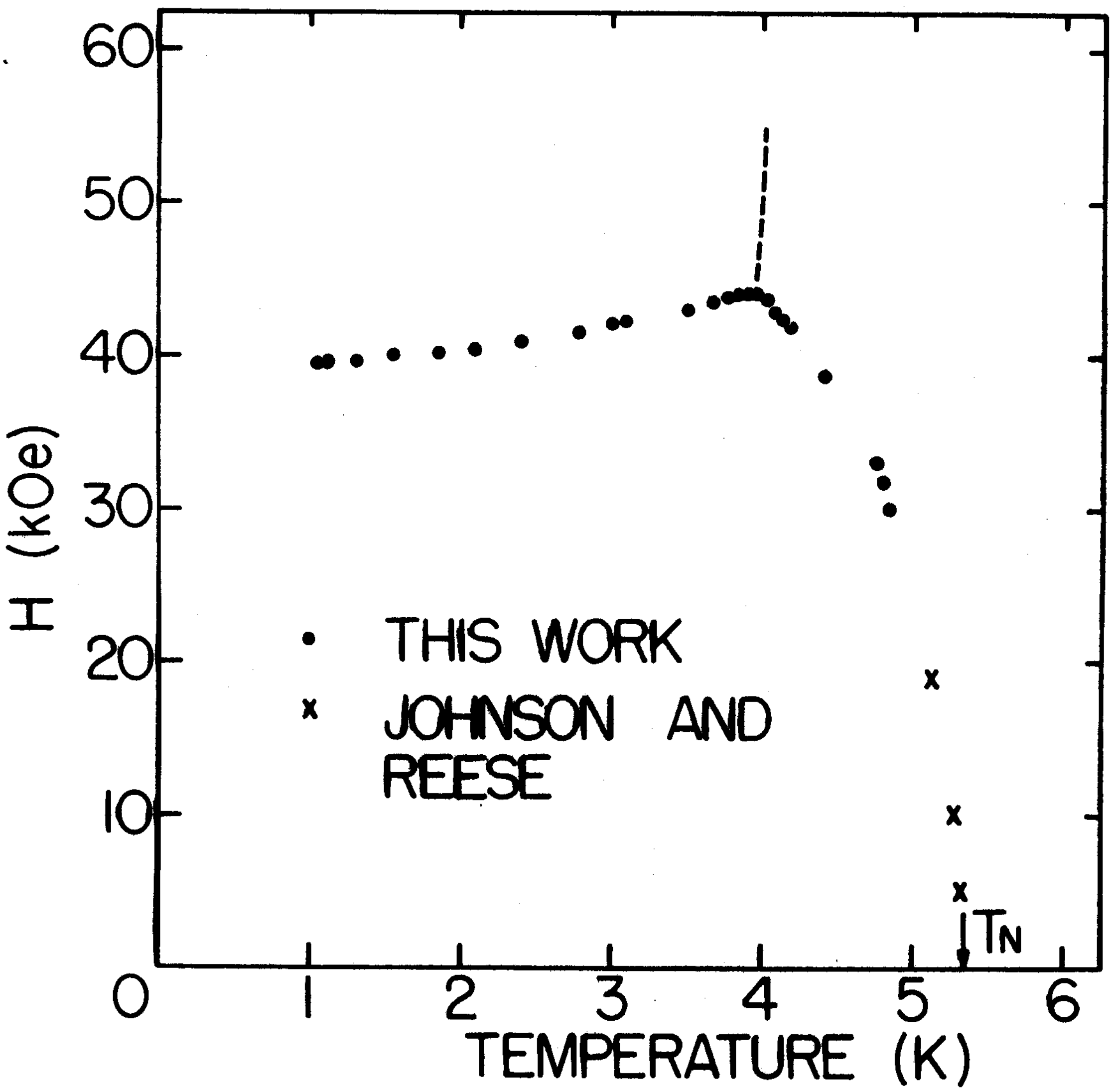


FIG. 1



60
50
40
30
20
10
0
H (kOe)
THIS WORK
JOHNSON AND REESE
T_N
1
2
3
4
5
6
TEMPERATURE (K)

FIG. 2