PHASE TRANSITIONS IN RbCoCl$_3$ · 2H$_2$O

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Differential susceptibility measurements were performed on a single crystal of RbCoCl$_3$ · 2H$_2$O. An anti-ferromagnetic ordering was found at 2.975 K.

In the last few years much attention has been paid to the magnetic behaviour of salts with the chemical composition: AMX$_3$ · 2H$_2$O (A is positive univalent, e.g. Rb, Cs; M is the magnetic ion, e.g. Cu, Co, Mn; X is negative univalent). In many crystals of this series anti-ferromagnetic ordering is found at temperatures of liquid helium, e.g. CsCoCl$_3$ · 2H$_2$O with T_N = 3.38 K [1] and [(CH$_3$)$_3$NH] CoCl$_3$ · 2H$_2$O with T_N = 4.135 K [2].

In this paper we present results of susceptibility measurements on RbCoCl$_3$ · 2H$_2$O, the crystal structure of which has been described by Harkema et al. [3]. Use has been made of a mutual inductance bridge. The differential susceptibility ($\chi = \chi' - i\chi''$) has been determined as a function of temperature (1.4—4.2 K) and magnetic field H ($<$15 kOe) at a frequency of 275 Hz.

In fig. 1 the susceptibility in the c-direction (χ_c) at H = 0 has been presented as a function of temperature. At T = 2.990 K the curve has an extremely high peak value; just below this temperature χ decreases
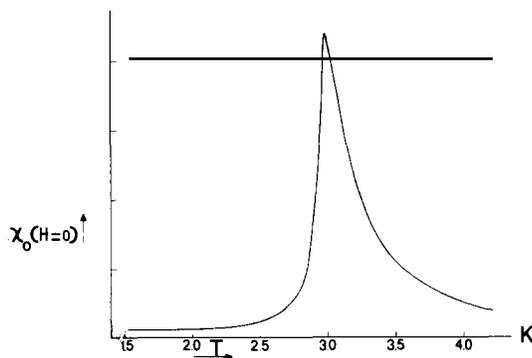

Fig. 1. The susceptibility χ_c in arbitrary units as a function of temperature.

strongly; the maximum slope in the χ versus T curve is found at T = 2.975 K ($\pm$ 0.005 K), the Néel point (T_N). At $T <$ 2.4 K the susceptibility is small and only slightly dependent on temperature.

At T = 4.2 K the usual behaviour is found for χ_c' as a function of H; from relaxation measurements we estimate an internal field of about 1.0 kOe. At $T <$ 3.3 K two small peaks in the χ_c' versus H curve are observed. A third peak is seen for $T <$ 3.000 K and at a very low field; the peak value is extremely high. The absorption curve χ_c'' versus H shows especially that this low field peak consists of two transitions, close to each other. In fig. 2 the field values of these peaks are given versus T. At 3.0 K the two small peaks amounted to a change in $\chi'(H)/\chi$ (H = 0) of 0.5% and 0.05%; experimental error in this region amounted to approximately 0.002%.

The temperature and field dependence of χ in a direction perpendicular to the b- and c-axis may be compared with those in the c-direction. The maximum value of $\chi(T)$ is about 10 times smaller. The phase transitions are found at fields which are about a factor 1.5 higher. In this direction we also observed hysteresis phenomena.
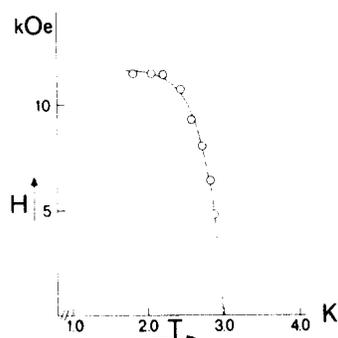
Susceptibility measurements in the b-direction reveal the extraordinary large anisotropy of the crystal; $\chi_b(T)$ is almost independent of T and about 1/500 of the maximum value of χ_c. A very small peak in $\chi_b(T)$ is found at T = 2.98 K. As a function of H we find one phase transition, possibly followed by another one. In fig. 3 the field value of the first transition has been given as a function of temperature.

The temperature behaviour of χ at zero field is comparable to that of [(CH$_3$)$_3$NH] CoCl$_3$ · 2H$_2$O [2]. Also one finds here a strong anisotropy: χ_c versus T has an analogous sharp increase, χ_b is almost inde-
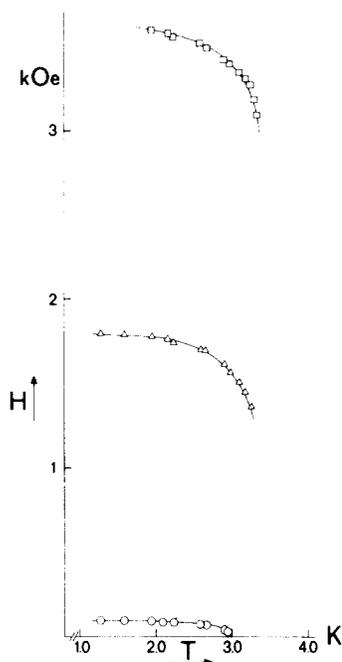
Fig. 2. The transitions in the c-direction.

Fig. 3. The transition in the b-direction.

pendent of T and also amounts to $1/500$ of the value of χ_c at the top. Recent measurements show that this salt has a transition to a meta magnetic state in its c-direction at 64 Oe [4]. No mention is made of other transitions at higher fields.

If we compare the crystal structure of the three Co-salts, we see that they all have Co-Cl-Co chains, and so a strong coupling between the Co spins is possible. The spin-structure of $CsCoCl_3 \cdot 2H_2O$ and of $[(CH_3)_3NH] CoCl_3 \cdot 2H_2O$ is mainly determined by these chains. On account of these results and of the measurements presented here, we suggest the possibility that the spin-arrangement of $RbCoCl_3 \cdot 2H_2O$ can

be represented by strong coupled canted chains along the c-direction. If the chains in one b-c plane (5.62 Å from each other) give a resulting magnetic moment in this plane with a large component in the c-direction (this means a small angle with the c-axis) it can be expected that at low field a large change in the magnetization will take place. In this case the resulting moments in two nearest b-c planes (8.36 Å from each other), which are anti-parallel at $H = 0$, now become parallel. In this model we cannot give an explanation of the existence of the two small peaks. The possibility that it is due to pollutions of $Rb_2CoCl_4 \cdot 2H_2O$ must be excluded, for this salt has a Néel temperature at 1.35 K [5].

References

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