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 ($\chi_c$) 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 $\chi$ decreases strongly; the maximum slope in the $\chi$ 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 $\chi'_c$ 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 $\chi'_c$ 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 $\chi''_c$ 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 $\chi$ 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 $\chi_c$. 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 $\chi$ 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; $\chi_c$ versus $T$ has an analogous sharp increase, $\chi_b$ is almost inde-
Fig. 2. The transitions in the c-direction.

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$_3$·2H$_2$O and of [(CH$_3$)$_3$NH]CoCl$_3$·2H$_2$O 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$_3$·2H$_2$O 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$_2$CoCl$_4$·2H$_2$O must be excluded, for this salt has a Néel temperature at 1.35 K [5].

References