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To cite this version:
J. Schouten, K. Takeda, K. Kopinga. BOND IMPURITY EFFECT IN THE LOW-DIMENSIONAL MAGNETIC SYSTEM (CH₃)₃NHCoCl₃.2H₂O. Journal de Physique Colloques, 1978, 39 (C6), pp.C6-723-C6-724. <10.1051/jphyscol:19786321>. <jpa-00217768>

HAL Id: jpa-00217768
https://hal.archives-ouvertes.fr/jpa-00217768
Submitted on 1 Jan 1978

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BOND IMPURITY EFFECT IN THE LOW-DIMENSIONAL MAGNETIC SYSTEM $\text{(CH}_3\text{)}_2\text{NHCoCl}_3\cdot\text{2H}_2\text{O}$

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Abstract.—The heat capacity of the pseudo one-dimensional system $\text{(CH}_3\text{)}_2\text{NHCoCl}_3\cdot\text{2CuCl}_3\cdot\text{2H}_2\text{O}$ is measured for a wide range of concentrations $x$. The behaviour of $T_N(x)$ differs significantly from the results reported on other pseudo 1-d systems in that respect that $T_N$ is almost independent of $x$ up till $x = 0.10$.

A onedimensional (1-d) magnetic system shows no long range order for $T > 0$ K, although the intra-chain correlation length $l_{\text{ic}}(T)$ grows rapidly as $T$ approaches zero. In a pseudo 1-d system a transition to a 3-d ordered state will be triggered by the interplay of the highly correlated chain and the weak interchain interaction $J'$. Subsequently the ordering temperature of such systems is drastically affected by limitations set to the correlation length by magnetic or nonmagnetic impurities/1,2/. In this paper we will report on $T_N(x)$ of $\text{(CH}_3\text{)}_2\text{NHCoCl}_3\cdot\text{2CuCl}_3\cdot\text{2H}_2\text{O}$. The host system $\text{(CH}_3\text{)}_2\text{NHCoCl}_3\cdot\text{2H}_2\text{O}$ is composed of ferromagnetic Ising chains, $J/k_B = 15.4$ K, with a weak interchain coupling $J'/J = 0.01/3/$. The 3-d transition occurs at $T_N = 4.153$ K and is accompanied by a sharp peak in the heat capacity. $\text{(CH}_3\text{)}_2\text{NHCoCl}_3\cdot\text{2H}_2\text{O}$ is isomorphous to the cobalt salt and orders at $T_N = 0.157$ K with $J/k_B = 0.28 K/4/$. The crystals used in the experiments were grown from an aqueous solution of $\text{CoCl}_2\cdot\text{6H}_2\text{O}$, $\text{CuCl}_2\cdot\text{2H}_2\text{O}$ and $\text{(CH}_3\text{)}_2\text{NHCoCl}_3$. The Cu-concentration in the crystals was measured by chemical analysis, and was found to be systematically twice the solution concentration.

We measured the specific heat between 1.5 and 5 K on small single crystals with an average mass between 0.4 and 0.8 grams. The values of $T_N$ which were deduced from the maximum in the specific heat are plotted in figure 1 as a function of $x$. Inspection of this figure reveals that in contrast to the behaviour reported for nonmagnetic impurities/2/, the decrease of the ordering temperature for $x<<1$ is not proportional to $x$, but has zero slope for $x=0$. Hone et al. /1/ showed that for magnetic impurities

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The deviation of the theoretical prediction from the experimental data may be due to several effects. First of all the assumption $J_{\text{II}} = J_{\text{Cu-Cu}}$ obviously disagrees with the usual approximation $J_{\text{IH}} = (J_{\text{II}} J_{\text{HH}})^{1/2}$. /1/ This value of $J_{\text{IH}}$ clearly disagrees with the usual approximation $J_{\text{IH}} = (J_{\text{II}} J_{\text{HH}})^{1/2}$. /1/

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![Graph](image-url)
may be incorrect, since the local environment of the Cu-ions in the cobalt salt differs slightly from that in the pure copper salt. As already indicated above the theoretical predictions are very sensitive to this value. Secondly some clustering of the copper ions may occur, which will cause the actual number of copper clusters to be less than the number based on a statistical distribution. However such a clustering effect is not very likely in view of isomorphy between the copper and cobalt salt. Moreover, the meanfield treatment of the interchain interaction used in the theory of Hone may be less appropriate to (CH₃)₃NHCoCl₃.2H₂O, since this salt has been shown to display rather pronounced two-dimensional characteristics. Currently ESR experiments in the Cu-doped (CH₃)₃NHCoCl₃.2H₂O are in progress in order to verify the anomalous magnitude of J₁H as well as the absence of clustering phenomena. To this aim also susceptibility measurements will be undertaken. If the value of J₁H proves to have the same order of magnitude as J₁H and no clustering occurs, (CH₃)₃NHCo₁-xCuₓCl₃.2H₂O seems the first realisation of a bond impurity system.

References


