CRITICAL EPR LINE BROADENING IN THE DOUBLE-LAYER ANTIFERROMAGNET $K_3Mn_2F_7$

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The divergence of the EPR linewidth of Mn^{2+} in $K_3Mn_2F_7$ when approaching $T_N = 58.3$ K has been measured at 25 GHz for magnetic fields parallel and perpendicular to the easy axis. The critical exponent p is in accord with the relation $p = (3 - 2\eta)\nu$ for critical coefficients of 2D systems.

The anomalous behavior of the EPR linewidth ΔH_{EPR} in antiferromagnets when approaching the Néel temperature is a combined effect of diverging spin correlations and critical slowing down of the spin fluctuations for wave vectors near $\boldsymbol{q}_0$, the superlattice vector characteristic for the ultimate ordered configuration. Quite different behavior of ΔH_{EPR} on temperature has been reported for two-dimensional (2D) systems as compared to 3D ones. Using the empirical power law

$$\Delta H_{EPR}(T) = \Delta H_{\infty}\{1 + C[(T - T_N)/T_N]^{-p}\} \quad (1)$$

to describe the divergence of the linewidth near T_N, we have $p \approx 1.2$ and $p \approx 2.5$ for the 3D MnF_2 [1] and the 2D layered structures K_2MnF_4 and Rb_2MnF_4 [2], respectively. In this paper we present data on the EPR linewidth in the double-layer antiferromagnet $K_3Mn_2F_7$ ($T_N = 58.3$ K), which may be considered as a first step from the square-lattice K_2MnF_4 structure toward the cubic $KMnF_3$. The experimental set-up consisted of a superheterodyne 25 GHz EPR spectrometer equipped with phase-sensitive detection.

In fig. 1 the full width at half maximum of the EPR is plotted versus temperature, both for the external field H_0 along and perpendicular to the easy axis of magnetization (c axis). The data follow the power law, eq. (1), with $\Delta H_{\infty} = (102 \pm 5)$ G and $p = 2.7 \pm 0.1$ for $H_0 \| c$ axis, and $\Delta H_{\infty} = (99 \pm 5)$ G and $p = 2.6 \pm 0.1$ for $H_0 \perp c$ axis. It is noted that the p's are comparable to those in the 2D systems.

The data may be interpreted by use of the theoretical treatment of EPR broadening by Huber and Richards [3, 4], which has resulted in the relation $p = (3 - 2\eta)\nu$ between critical coefficients of 2D systems. Taking $\nu = 1.1 \pm 0.2$ for the critical coefficient of the correlation length and $\eta = 0.20 \pm 0.05$ for the deviation from the Ornstein–Zernike formula [5], we arrive at a calculated $p = 2.9 \pm 0.5$, which is in excellent accord with experiment. Further experiments, not discussed here in detail, have revealed that in the regime of rising ΔH_{EPR} the angular dependence quite closely follows $1 - \frac{1}{2}\sin^2\theta$, with θ the angle of H_0 with the c axis. This indicates that the short time correlation limit is appropriate, i.e., $g\mu_B H_0/\hbar\Gamma(\boldsymbol{q}_0) \ll 1$, where $\Gamma(\boldsymbol{q})$ is the damping of the spin fluctuations at $\boldsymbol{q}$. The temperature dependence of the anisotropy in ΔH_{EPR} is otherwise consistent with a magnetic anisotropy of primarily dipolar origin, as is accepted to be the case in $K_3Mn_2F_7$.

Finally, while the exponent p in $K_3Mn_2F_7$ is typically 2D, it is worth comparing the fall of

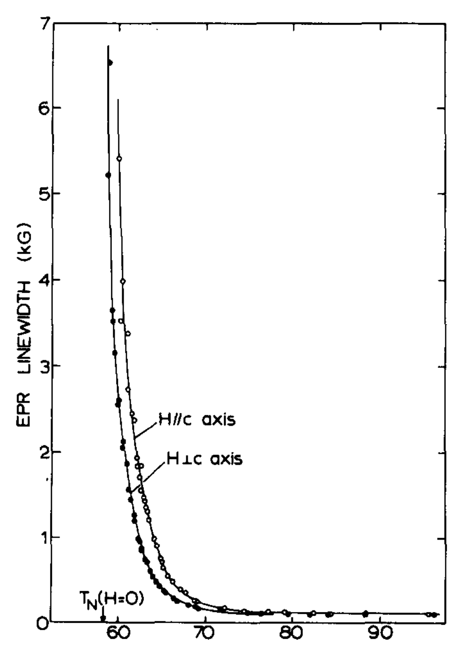

Fig. 1. Full width at half maximum of the EPR versus temperature, both for external fields parallel and perpendicular to the easy axis of magnetization.

$\Delta H_{EPR}(T)$ in the double layer with those in single-layer 2D as well as 3D. Here, we see that the absolute magnitude of $\Delta H_{EPR}(T)/\Delta H_{\infty}$ in the double layer is intermediate between the latter cases. This may be regarded as yet another indication, additional to the results of the neutron work [5], that spin correlations persist in a smaller temperature region above T_N than in comparable single-layer 2D structures.

References

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