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L.048 CRITICAL BEHAVIOR OF CERIUM MAGNESIUM NITRATE.

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We have measured the ac and dc magnetic susceptibility of a single crystal sphere of cerium magnesium nitrate (CMN) as a function of entropy, S, down to 0.32 mK. The method of measurement is described elsewhere.[1] The magnetic susceptibility χ can be related to the specific C heat by the relation[2] derived by M.E. Fisher for an antiferromagnet about its critical point

$$\frac{C}{R} \propto \frac{\partial(\chi T)}{\partial T} \qquad (1)$$

where R and T are the universal gas constant and temperature respectively. Below the critical temperature χ is taken as $\chi_{\parallel}$, the real component of susceptibility parallel to the preferred axis. W.P. Wolf and A.F.G. Wyatt[3] show that this relation is also valid for substances with appreciable long range interactions.

In order to ascertain the validity of the relation of Eq. 1 in CMN we have adopted the S-T scale of R.A. Fisher et al[4] and assigned a temperature to our susceptibility points using the S-χ relation of this investigation. The results are shown in Fig. 1 where our data was normalized to the specific heat measurements of Fisher et al[4] at 2.08 mK. The circles show our ac data, crosses our dc data, the triangles represent specific heat measurements of Fisher et al[4] and the squares their values of $\frac{\partial(\chi T)}{\partial T}$. The dashed line indicates the value of $\frac{\partial(\chi T)}{\partial T}$ of Fisher et al[4] below T_C. It appears that above T_C our values of $\frac{\partial(\chi T)}{\partial T}$ are in somewhat better agreement with the specific heat measurements than the comparable values of Fisher et al[4]. Below T_C no agreement of $\frac{\partial(\chi T)}{\partial T}$ with the specific could be expected since in the ac method we are measuring $\chi_{\perp}$ with a small admixture of $\chi_{\parallel}$ and the relation of Eq. 1 is valid for $\chi_{\parallel}$ only. Near T_C however it appears that the dc susceptibility measures a greater portion of $\chi_{\parallel}$ as shown by the better agreement of $\frac{\partial(\chi T)}{\partial T}$ with the specific heat.

In the critical region the specific heat obeys the relation[5]

$$C = \varepsilon^{-\alpha} \tag{2}$$

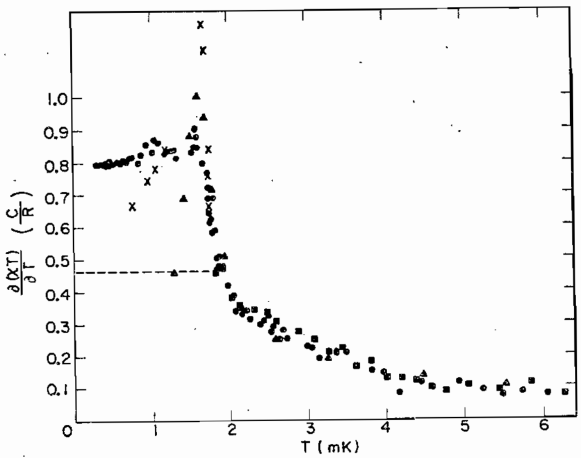
where $\varepsilon = |T-T_C|/T_C$ and T_C is the critical temperature. Since $\frac{\partial(\chi T)}{\partial T}$ is proportional to the specific heat, we have plotted this quantity vs ε with a value of $T_C = 1.685$ mK on a log log scale. This is shown in Fig. 2. The circles represent the dc data for $T < T_C$. The squares the dc data for $T < T_C$ and the crosses the ac measurement for $T < T_C$. The lines below $\varepsilon = 0.09$ represent an $\alpha = 0.063$ while at higher temperature one can represent the specific heat by $\varepsilon^{-0.425}$ up to $\varepsilon = 1$. A remarkable property of CMN is its large region of critical behavior.

Although no general critical power law behavior has been postulated for the susceptibility of an antiferromagnet, our data can be represented by

$$\frac{\chi_C - \chi}{C} \propto \varepsilon^{\kappa\pm} \tag{3}$$

where χ_C is the maximum susceptibility and $\kappa_\pm$ is a constant which generally takes on different values for $T > T_C$, κ_+, and $T < T_C$, κ_-.

A plot of $\frac{\chi_C - \chi}{C}$ vs ε, where C is the Curie constant is shown in Fig. 3. The crosses are the ac susceptibility for $T > T_C$ while the circles are dc susceptibilities for $T < T_C$. The line drawn represents $\kappa_+ = 1$. From this we may conclude that $\kappa_+ = 1 \pm 0.01$. For $T < T_C$ the scatter is much greater, and a line drawn through the points for $\varepsilon \geq 0.2$ gives $\kappa_- = 1.5$. Here again the large range of "critical point" behavior is remarkable. In order to obtain a power law in this case, the critical temperature was chosen to be $T_C = 1.635$ mK or 0.05 mK lower than that for the specific heat. This is within the range of error quoted by Fisher et al[4], although it is possible that the specific heat maximum comes at a temperature 0.05 mK higher than the maximum in susceptibility.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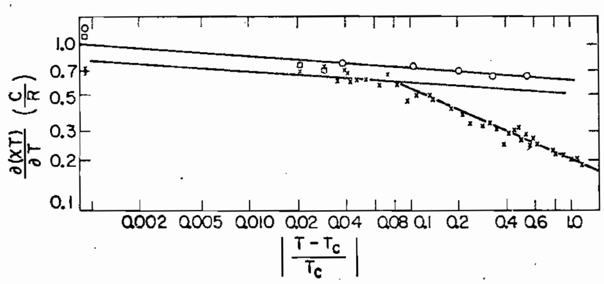
T (mK)

Fig. 1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1.0

Fig. 2

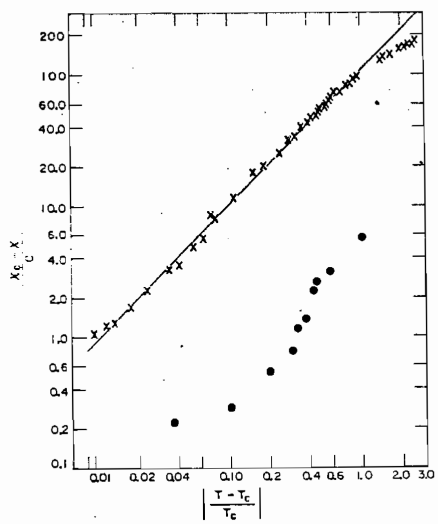

Fig. 3

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