Calorimetric Determination of the Magnetization in a Spin-Glass

Recently Fogle *et al.*[1] published a detailed calorimetric study of a CuMn 0.279% spin-glass alloy. The extremely high precision of their measurements enabled them to investigate the magnetic field dependence of the heat capacity, C. Attempting to verify the Maxwell relation

$$(\partial^2 M/\partial T^2)_H = (1/T)(\partial C/\partial H)_T \qquad (1)$$

they obtained a susceptibility

$$\chi_c = \alpha + \beta T + \frac{1}{H}\int\int dT^2 \frac{1}{T}\frac{\partial C}{\partial H}$$

from their data. Since χ_c did not agree with the magnetic susceptibility (measured in $H < 100$ G) they suggested a failure of thermodynamics due to nonergodic behavior in the spin-glass state.

It is the purpose of this Comment to suggest that their data are consistent with the thermodynamic relationship of Eq. (1). Their apparent discrepancy came about because they underestimated the effect on the magnetic susceptibility of magnetic fields as large as those used in the experiments (up to 1000 G).

In Fig. 1 we present measurements of the field-cooled magnetization of a CuMn 0.28% alloy. The measurements were performed on a vibrating-sample magnetometer in applied fields up to 1000 G. The values of M/H were scaled up by about 10% so that the low-field data agree with the ac susceptibility data of Ref. 1 at T_{sg}.

From the data in Fig. 1 it is apparent that M/H is not independent of the applied field, H, and thus, if Eq. (1) is valid, C is not strictly quadratic in H. However, in Ref. 1 χ_c was obtained by fitting C vs H with a function $A + BH^2$ and then evaluating the integral $\iint dT'^2 T^{-1} \partial C/\partial H = 2H \iint dT^2 \times (B/T)$. Since it is at higher fields that the most accurate value of $\partial C/\partial H$ is obtained by the parabolic fit, we chose values of the constants of integration, α and β, apprpriate to fields of about 800 G. The χ_c so obtained is indicated by the solid curve in Fig. 1 in agreement with the measured values of M/H.

Thus, we find that the calorimetric data of Ref. 1 are in satisfactory agreement with dc magnetization measurements performed in the appropriate fields. We conclude that there is no indication that the thermodynamic relation, Eq. (1), has failed in the spin-glass state.

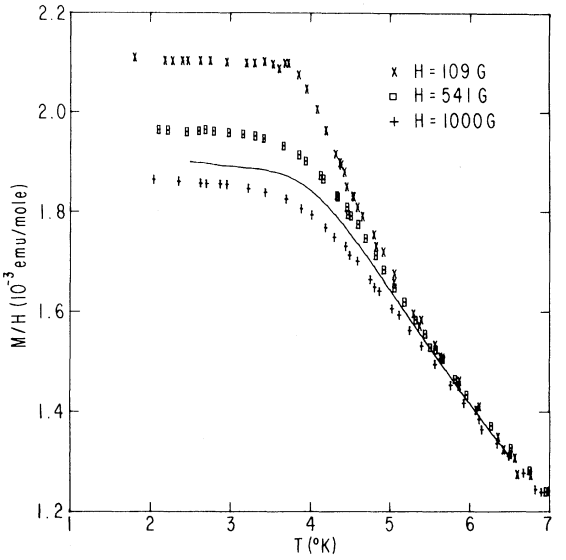

FIG. 1. M/H vs T measured in (and cooled in) three values of applied field for a CuMn 0.28% sample. The solid curve is χ_c, obtained by integrating the calorimetric data of Ref. 1, with constants of integration chosen as discussed in the text.

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[1]W. E. Fogle, J. D. Boyer, N. E. Phillips, and J. Van Curen, Phys. Rev. Lett. 47, 352 (1981).