Comment on "Time Decay of the Remanent Magnetization in Spin-Glasses"

In a recent Letter, Chamberlin, Mozurkewich, and Orbach[1] (CMO) have reported a beautiful set of measurements on the time dependence of the thermoremanent magnetization ($\sigma_{\rm TRM}$) decay in Cu:Mn and Ag:Mn spin-glasses. They found that $\sigma_{\rm TRM}$ can be accurately characterized by a "stretched" exponential of the form $\sigma_{\rm TRM}=\sigma_0 \times\exp[-C(\omega t)^{1-n}(1-n)]$ where n is a function of reduced temperature T/T_g. As they pointed out, such a time dependence is predicted by the "cooperative-relaxation" model[2,3] proposed by one of us that has general applicability to various relaxations in condensed matter including glasses, amorphous polymers, polymer melts, ionic conductors, etc. The model predicts not only that $\sigma_{\rm TRM}=\sigma_0\exp[-(t/\tau_p)^{1-n}]$, $0<n<1$, but also the effective relaxation time τ_p is related to the primitive relaxation time τ_0 (denoted by T_0 in Ref. 1) of a primary spin by the relation $\tau_p=[(1-n)\times\exp(n\gamma)\omega_c^n\tau_0]^{1/(1-n)}$. Here ω_c (denoted by E_c in Refs. 1 and 2) is the high-frequency cutoff of the linear density of excitations and γ is Euler's constant. *No* relation between ω_c and τ_0^{-1} exists nor has been suggested by the model. They are *independent* physical quantities. In using our model, CMO have assumed that they can linearly extrapolate the data in Fig. 4 of Ref. 1 to the limit of $n=1$. The result obtained by this extrapolation, namely $\omega_c=\tau_0^{-1}=\omega$, is further assumed to be valid for the actual data points at various temperature. These assumptions are alien to and incompatible with the model and have led CMO to an unsurprising but incorrect conclusion that the ". . . theory in its present form is not directly applicable to spin-glasses." An accurate statement for CMO should read: We have added assumptions to Nagi's model leading to $\omega_c=\tau_0^{-1}=\omega$ and this modified version of the model is not directly applicable to spin-glasses.

We show in fact if one uses the *original* model, no difficulty arises and meaningful interpretation of the CMO experimental data is achieved. It is important to keep in mind that for a spin-glass, the level-spacing distribution that enters in the "cooperative-relaxation" model depends on temperature because of the sensitivity of correlations on T, especially near T_g. It then follows from the model that *both* n and ω_c will vary with temperature. The primary relaxation time τ_0 is assumed to be T independent. For any choice of the constant τ_0 we can solve

$$\tau_p(T)=\{[1-n(T)][e^{\gamma}\omega_c(T)]^{n(T)}\tau_0\}^{1/[1-n(T)]} \quad (1)$$

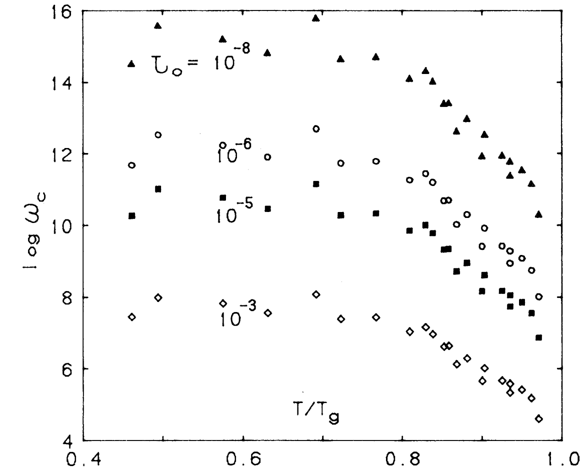

FIG. 1. Solutions of ω_c as a function of T/T_g according to Eq. (1) with $\tau_p(T)$ and $n(T)$ taken from Ref. 1.

for $\omega_c(T)$ with $\tau_p(T)$ and $n(T)$ taken from measurements of CMO in 2.6% Ag:Mn + 0.46% Sb. Solutions of $\omega_c(T)$ for several choices of τ_0 are shown in Fig. 1. The time involved in the measurements of CMO lies in between 10^{-1} and 10^3 sec. For any of these choices of τ_0 in Fig. 1, the condition $\omega_c(T)t\gg 1$ for applicability of the model is always satisfied. Inferences from either the energy scale of T_g or the temperatures at which magnetic two-level systems[4] are observed suggest that $10^{10}\leq\omega_c(T/T_g\ll 1)\leq 10^{12}$ rad/sec. This estimate for ω_c together with the results of Fig. 1 at low temperatures locate τ_0 to be 10^{-5} to 10^{-6} sec. Although independent measurements of the primary relaxation time τ_0 for TRM below T_g are not available at this time, this rough estimate is physically quite reasonable. We point out that the original model is applicable also to other types of spin-glasses as described in a recent article.[3]

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