Comment on "Flux Trapping and Superconductive Glass State in La_2CuO_{4-y}:Ba"

Müller, Takashige, and Bednorz[1] describe the irreversibilities of the magnetization in a La_2CuO_{4-y}:Ba superconductor of granular structure. They stress similarities with spin-glasses suggestive of a "superconductive-glass" phase limited by some sort of de Almeida–Thouless critical line. Figure 1, which compares their data to data obtained in Cu:Mn,[2] emphasizes these similarities: The response to a field applied at low temperature contains an irreversible part ΔM which is partially annealed away on increase of the temperature to, say, T_B; the magnetization is then found reversible in a thermal cycle at all $T < T_B$ until a maximum annealing temperature T_D is reached where the magnetization is found reversible in this field at all temperatures. One model[2-4] which accounts for the hysteresis assumes a frozen landscape $P(W)$ of potential wells and hills of sufficient depth and height to inhibit the evolution of the system in phase space: The time it takes the system to exit from a metastable situation characterized by a particular well is $\tau = \tau_0 \exp(W/kT)$, where W corresponds to the energy difference from the well to the hill. Clearly a barrier height $W_c = kT \ln(t/\tau_0)$ determines which states have not relaxed during the measuring time t at the temperature T $[t < \tau(T)]$ and conserve a memory of previous events. In Cu:Mn(5 at.%), measurements performed in terms of the temperature at fixed time or in terms of time at fixed temperatures superimpose onto a unique function of $T \ln(t/\tau_0)$. Similarly, the amplitude and the nonexponential character of the relaxations observed by Müller, Takashige, and Bednorz at fixed T follow from the measured T dependence of the magnetization. In Fig. 1, we have approximately fitted the irreversible magnetizations with a law

$$\Delta M/\Delta M_0 = (\Delta\chi/\Delta\chi_0)\exp[(-T/T_0)\ln(t/\tau_0)] = (t/\tau_0)^{-T/T_0},$$

where $T_0 = 107$ and 210 K and $\tau_0 = 10^{-13}$ and 10^{-15} s in Cu:Mn and in La_2CuO_{4-y}:Ba, respectively. In Cu:Mn(5 at.%), a failure in this $T \ln(t/\tau_0)$ scaling signals the collapse of the $P(W)$ distribution at the spin-glass transition $T_c = 29$ K which is much higher than D where the remanent vanishes at the time scale of static measurements.[2,3] In the superconductor, likewise, point D is most certainly a function of $T \ln(t/\tau_0)$ and belongs to a time-dependent curve of the (H,T) plane which cannot be a transition line. In the absence of further evidence it is misleading to speak of a "superconductive glass" state and to hint, in this way, that there is in the hysteresis of these systems (with these fields) much more than was observed in type-II superconductors with pinning.[4-6]

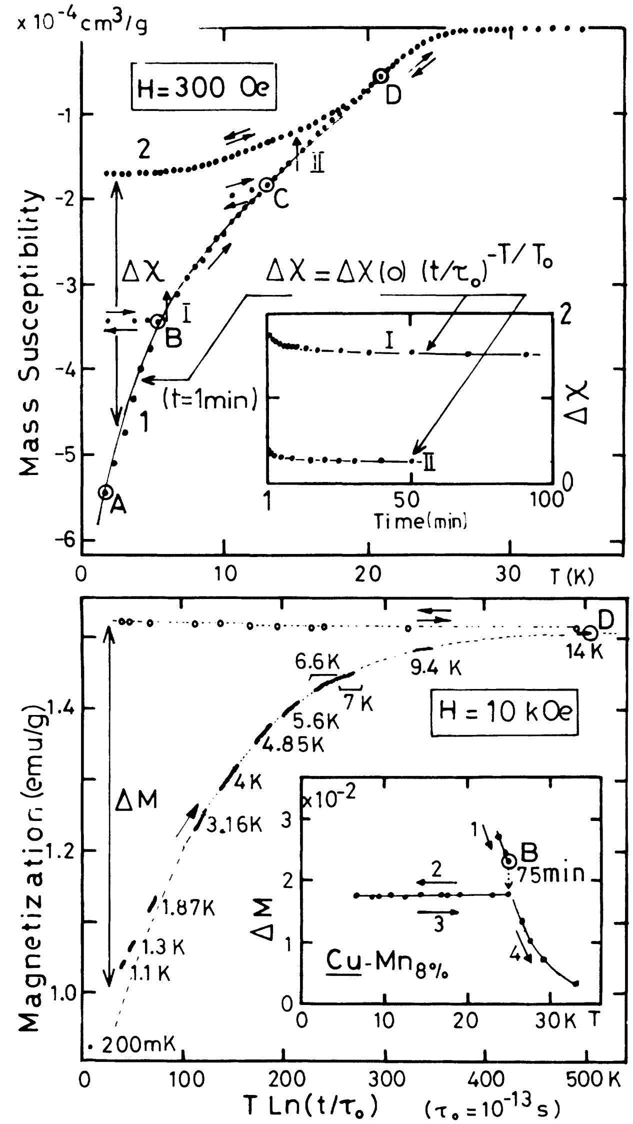

FIG. 1. The upper curve shows, with the data of Ref. 1, how the time dependence of the relaxation in high-T_c superconductor La_2CuO_{4-y}:Ba (inset) follows from the temperature dependence of the magnetization. The plot takes advantage of the same time-temperature correspondence which permits the superposition of our magnetization data vs $T \ln(t/\tau_0)$ in spin-glass Cu:Mn(5 at.%) (Ref. 3) (lower curve).

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