## Comment on "Memory Effects in an Interacting Magnetic Nanoparticle System"

Very recently, Sun *et al.* reported that striking memory effects have been clearly observed in their NEW experiments on an assembly of interacting nanoparticles [1]. They claimed that the phenomena observed support the existence of a spin-glasslike phase in the system and a hierarchical model, which required a large number of degrees of freedom to be coupled. There is no doubt that a particle system may display spin-glasslike behaviors [2]. But their statement that the phenomena observed in their new experiments must not be produced by the independent behavior of individual particles is incorrect. We demonstrate below that if one performs the same experiments on a noninteracting particle system with a size distribution, all the phenomena reported in Ref. [1] can be observed. Therefore, the experimental approach employed in Ref. [1] is an improper way to study the memory effect.

The particles in this study are the Co particles fabricated by the conventional chemical method. The transmission electron microscopy study shows that the particles are about 5 nm in diameter with a relatively narrow distribution. To avoid the interaction, Co particles are dispersed into hexane solution. Shown in inset A of Fig. 1 are the ZFC and FC magnetization curves measured in a 100 Oe field with a temperature sweeping rate of 2 K/m. A peak in ZFC curve appears at 35 K, which corresponds to the average blocking temperature of the sample, $\langle T_B \rangle$. To examine whether the particles are interacting, we plot the reciprocal FC magnetization as a function of the temperature ($1/M_{FC} \sim T$), as shown in inset B of Fig. 1. The perfect linearity of the curve for $T \geq 30$ K indicates that the dynamics of the particles above $\langle T_B \rangle$ can be well described by superparamagnetism. Therefore, the magnetic properties of the sample depend only on the behaviors of the individual particles, and the FC curve represents also the thermal equilibrium states of the sample.

For such a nearly noninteracting particles assembly, one should not expect to be able to observe the memory effect, a spin-glass characteristic. Indeed, we have not observed the memory effect in the low frequency ac susceptibility measurements following the method used by Jonason *et al.* [3] on our sample (the results not shown here). But we will demonstrate that if we repeat the measurement scheme used by Sun *et al.* on our noninteracting particles, the steplike $M(T)$ curves as shown in Fig. 2 of Ref. [1] will be also obtained. This steplike behavior was interpreted by Sun *et al.* as the memory effect resulted from the strong interparticle interactions. Shown in Fig. 1 are the steplike $M(T)$ curves measured on our sample. In these measurements, the temperature sweep rate is 2 K/m, applied field is 100 Oe, and the waiting time for each temporary stop (at 25 and 15 K) is 2 h. It is evident that the steplike like behavior in $M(T)$ curves is basically the same as that shown in Fig. 2 of Ref. [1] for the interacting permalloy particles.

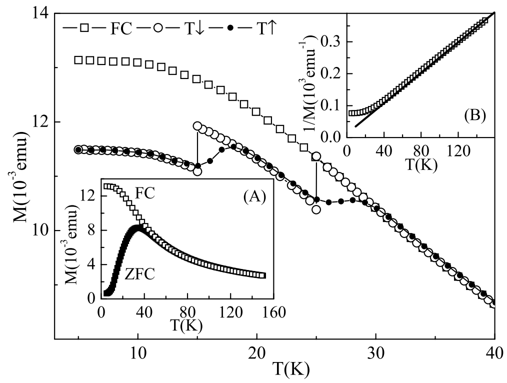


FIG. 1. The steplike $M(T)$ curves obtained on the nearly noninteracting Co particles by repeating the measurement scheme used by Sun *et al.* for observing memory effect. Inset A: ZFC and FC curves. Inset B: the reciprocal FC magnetization versus temperature.

To demonstrate that other results (Figs. 3–5 in Ref. [1]) for an interacting particle system can also be obtained in the noninteracting particle system by using the same measurement scheme, we have carried out all the corresponding experiments. As expected, we have reproduced all the phenomena reported in Ref. [1]. We have also performed the numerical calculations for all the experimental measurements using the energy distribution extracted from the experimental ZFC curve and the simple thermal activation model. It is found that the numerical results are almost quantitatively in agreement with the experiments. A similar numerical result was also obtained by Sasaki *et al.* [4].

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