Comment on "Coexistence of ferromagnetism and superconductivity in Sn nanoparticles"

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Recently, the average particle moments μ_p of Sn nanoparticles were observed to increase linearly with increasing temperature according to the fitting of $M(H)$ curves by the Langevin law. This anomalous behavior was attributed to the thermoinduced magnetization. Here we show that this conclusion is premature and further studies are needed to fully understand the mechanisms of this anomalous behavior.

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In a recent paper, the authors of Ref. 1 reported the observation of ferromagnetism and superconductivity in Sn nanoparticles. The $M(H)$ data of Sn nanoparticles show a partial saturation magnetization modeled by the Langevin law and a high-field linear diamagnetic component.[1] The authors stated that the average particle moments μ_p of Sn increase linearly with increasing temperature according to the fitting of $M(H)$ curves by the Langevin law, as shown in Fig. 5 of Ref. 1. This anomalous behavior was attributed to the thermoinduced magnetization.[1] Here we will argue that the analysis may be premature and the temperature dependence of μ_p of Sn particles could be partly resulting from ignoring the size distribution in the interpretation of the $M(H)$ data.

Associated with the increase in average particle moment, the authors reported that the saturation magnetization $M_S(T)$ of Sn nanoparticles not increases with the temperature. The saturation magnetization is almost independent of temperature or it only slightly decreases with increasing temperature, as shown in Fig. 3 of Ref. 1. It implies a strange result that the number N of Sn nanoparticles decreases with increasing temperature for that $M_S(T)=N\mu_p$.

Until now, there are two main possible mechanisms to explain the increase in the average particle moment with increasing temperature in nanoparticles. One is the thermoinduced magnetization.[2] It predicts that there is a thermoinduced contribution of magnetic moments that arise from the excitation of the uniform spin-precession mode of sublattices in antiferromagnetic materials. Because the excited sublattice spins are not exactly antiparallel, thermal excitation results in a nonzero magnetic moment of antiferromagnetic nanoparticles.[2,3] Obviously, this mechanism cannot be applied to explain the result reported in Fig. 5 of Ref. 1 due to the lack of antiparallel sublattice spins in Sn nanoparticles. The other mechanism proposed by Silva *et al.* shows that ignoring the size distribution in the interpretation of the $M(H)$ data will also lead to this unusual behavior.[4] Silva *et al.* points out directly that dealing with nonuniform systems by a nondistributed Langevin function results in the increase in μ_p and decrease in N with increasing temperature. However, by taking into account the size distribution, the average particle moment will decrease with temperature.[4] Figure 2 of Ref. 1 clearly shows that the size of Sn nanoparticles follows a log-normal distribution. Therefore, the temperature dependence of μ_p of Sn particles could be partly resulting from ignoring the size distribution in the interpretation of the $M(H)$ data. To fully understand the mechanisms of this anomalous behavior observed in Sn particles, it still needs further study. A possible model presented recently,[5] which assumes that the up and down spins within ultrafine diamagnetic system are spatially separated, may shed lights on this anomalous behavior.

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