Comment on "Conductance Fluctuations of Mesoscopic Spin Glasses"

Recently, de Vegvar, Levy, and Fulton [1] (DLF) presented a particularly clear demonstration of the role of the partially frozen spin configuration in metallic spin glasses in determining the random universal conductance fluctuation (UCF) magnetofingerprint [2]. Unlike previous experiments showing the role of spins in setting the UCF resistance [3], those of DLF show explicitly that the spin-glass sample breaks time-reversal symmetry, which can be done only by the spins themselves. By using multiprobe resistors, DLF are able to measure an antisymmetric term in the resistance tensor describing a resistor with two pairs of leads. A random term with about the predicted UCF magnitude appeared in this antisymmetric piece of the four-probe resistance tensor. The antisymmetric behavior at zero applied magnetic field, indicating odd time-reversal symmetry by the Onsager relations, clearly demonstrates that the frozen spin configuration produces a random resistance [1].

One anomaly in the DLF results, however, requires some clarification. Thermal cycling to slightly above the spin-glass freezing temperature randomized the spin-dependent field-symmetric Onsager-antisymmetric part of the UCF magnetofingerprint by 30% to 70% [1]. However, as DLF point out, this particular UCF component is explicitly odd under time reversal and must be zero unless the sample itself breaks time-reversal symmetry. Thus over an *ensemble* of independent anneals to well above T_G at zero field this term must have an average value of *zero*, not 30% to 70% of the value in a particular frozen state.

A possible explanation might be found if small regions had a high Mn density and did not melt at T_G, so that the multiple anneals did not randomly sample a full thermodynamic ensemble. If a significant fraction of the spins formed some ordered state which melted well above T_G, one could also account for the surprising reduction of Kondo resistance noted by DLF. Furthermore, particularly if such regions have predominantly antiferromagnetic order, one might have an explanation for the surprising lack of change of the spin-dependent UCF fingerprints when the field is cycled far above the typical spin-glass exchange field.

Once this complication is straightened out, the distinction between the Onsager antisymmetric term, which is sensitive to global spin flips, and the symmetric term, which is not, may prove quite useful. In a four-probe measurement, one can in principle measure both the noise spectra of the antisymmetric and symmetric off-diagonal terms of the resistance matrix in zero field. It has been proposed that the available spin configurations can be divided into two sets which are time-reversed versions of each other and which equilibrate much more slowly with each other than either equilibrates internally [4]. If this proposal is correct the symmetric UCF spin noise spectrum and antisymmetric UCF spin noise spectrum should have substantially different temperature and frequency dependences.

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