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The random dipolar-field approximation for systems of interacting magnetic particles

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ABSTRACT

The dipolar interaction is known to play an important role on the magnetic properties of small magnetic particles. For moderate concentrations the most noticeable effect is an increase of the relaxation time, whereas for sufficiently dense systems some degree of correlational order may be observed. In this paper, a mean-field approximation is introduced to correctly account for these changes. It is based on the interpretation of the dipolar field, produced by an ensemble of particles, as a random field acting on a reference particle. This field contains the statistical moments of the magnetisation of the reference particle and is computed assuming a random spatial distribution of the particles. The result is a new term in the free energy of the reference particle, expressed as a cumulant expansion of the random field, carried up to fourth-order. This model correctly predicts both the increase in the relaxation time and a phase transition to a ferromagnetic state for sufficiently dense systems. The dynamics is also studied by introducing this new free energy into the Fokker-Planck equation for the single-particle magnetic moment. The result is a non-linear Fokker-Planck equation, which is solved numerically to illustrate the divergence of the relaxation time at the phase transition.

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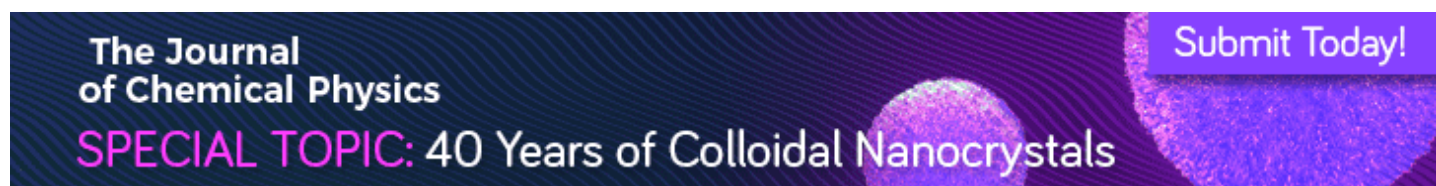
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