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Magnetic behavior of interacting nanoparticles in a face-centred cubic lattice

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Abstract – A system of interacting magnetic nanoparticles has been studied through Monte Carlo simulations on a fcc lattice. The particles are coupled by long range dipolar forces and they present a single ion uniaxial anisotropy, whose magnitude is chosen from a Gaussian distribution, and axis oriented randomly in the three dimensional space. We determined the blocking temperature and the hysteresis curves as a function of the ratio between the dipolar interaction and uniaxial anisotropy.

The development of new techniques [1] to produce ordered arrays of magnetic nanoparticles brings new perspectives in the study of the magnetic properties of these systems. It is well known [2], that the ground state and spin arrangement of pure dipolar systems depend strongly on the lattice symmetries. In this work we use Monte Carlo simulations to present the very different magnetic properties of nanoparticles in the different scenarios: very diluted particles, essentially non interacting, particles arranged on a fcc lattice and liquid like arrangement. The easy axes are distributed in a random fashion in the three dimensional space and the energy barrier, related to the uniaxial anisotropy, is selected from a Gaussian distribution. We assume the particles interact through long range dipolar forces and we determined some typical magnetic properties for the system. Particularly, we determined the Zero Field Cooled magnetization and susceptibility as a function of temperature for each value of the ratio between the magnitude of the dipolar coupling and height of the energy barrier. We have shown that the blocking temperature of the system increases with the magnitude of the dipolar interaction. The coercive field and remanence for the ordered system present smaller values than those observed for the disordered systems. This can be seen in Figure 1 where the ratio α between dipolar and uniaxial anisotropies is taken equal to 0.2. We also show in Figure 2 a plot of the coercive field as a function of the parameter α. These results are in agreement with some recent experimental measurements made on the magnetoferritin nanoparticle [3].

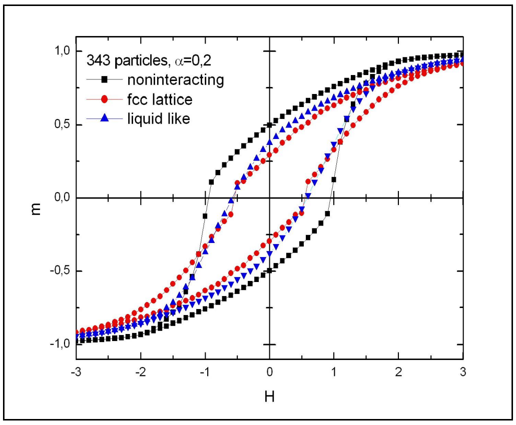

Figure 1: Hysteresis curves for diluted, liquid like and ordered fcc. α = 0.2

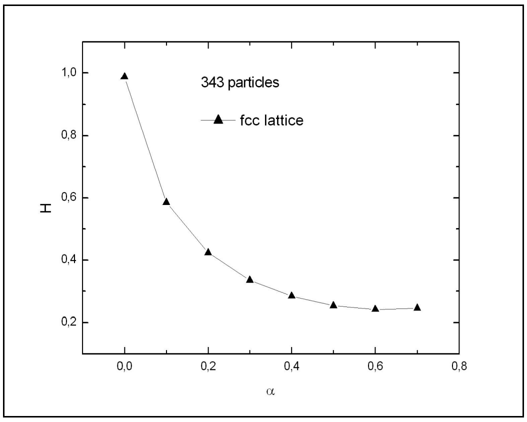

Figure 2: Coercive field versus dipolar energy, fcc lattice.

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