

Effects of dipolar interactions on magnetic properties of granular solids

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The magnetism of ultrafine particles has been studied for more than fifty years, but it is still a field to be better understood, not only from the technological point of view, but also owing to fundamental questions on the basic Physics of some observed phenomena. From an interdisciplinary viewpoint, the fine particle magnetism brings about interest in some areas that study systems which present natural dispersions of magnetic crystallites, such as some animals or geological elements. Also, one can artificially produce materials of potential application in chemistry and engineering (magnetic fluids, magnetic paints, catalysis, magneto-rheological fluids, magnetic recording), facts that turn out the study of nanostructured magnetic materials to be of broad interest and utility.

In this talk, a general perspective of recent investigations in granular magnetic systems formed by ultra-fine particles embedded in a non-magnetic matrix will be given. Besides the effect of grain size distribution, which strongly affects the magnetic response of the granular system [1], important factors need to be controlled, such as the surface of the particles (both roughness and composition gradient), the shape, and the phases formed within the nanograins [2]. Another crucial point is the role played by magnetic interactions among the magnetic entities. This subject has been extensively studied from both experimental and theoretical sides [3-5], but until now there is not a clear picture of how the dipole-dipole interactions affect the macroscopic magnetic response of the system. As a matter of fact, many different, often conflicting models have been applied to explain the experimental data on magnetic nanoparticle systems. For example, one of the approaches considers the interparticle interactions through a change of the energy barriers of isolated particles [3]. This approach corresponds to replacing a genuine many-body effect with a

single-particle description; it is therefore no more than a simplified representation of a much more complex, and qualitatively different situation. On the other hand, a second approach takes into account collective phenomena [4], but the predictions of such a model seem to contradict many experimental results. Consequently, there has been a considerable discussion about the existence of significant collective effects in magnetic nanoparticle systems, and several speculations regarding a spin-glass-like phase at low temperatures on dipole-dipole interacting systems [3].

Recent approaches will be shown and compared in order to illustrate the complexity and exhibit some questions that are still unanswered in this fascinating area of magnetism and solid state Physics.

References

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