

Abstract for an Invited Paper  
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**Exchange bias in core/shell magnetic nanoparticles: experimental results and numerical simulations<sup>1</sup>**

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In this talk, we will review some of the main experimental observations related to the occurrence of exchange bias in magnetic systems, focusing the attention on the phenomenology appearing in nanoparticles with core/shell structure as compared to thin film bilayers [1]. The main open questions posed by the experimental observations will be discussed and contrasted to existing theories and models for exchange bias [1]. We will also present some recent numerical simulations [2-4] based on a simple model of a core/shell nanoparticle, showing evidence that the magnetic order of interfacial spins accounts for most of the experimental observations. Finally, we will discuss the occurrence of exchange bias on laser-ablated granular thin films composed of Co nanoparticles embedded in amorphous zirconia matrix [5]. The deposition method allows controlling the degree of oxidation of the Co particles by tuning the oxygen pressure at the vacuum chamber. The nature of the nanoparticles embedded in the nonmagnetic matrix may be monitored from metallic, ferromagnetic (FM) Co to antiferromagnetic (AFM)  $\text{CoO}_x$ , with a FM/AFM intermediate regime for which the percentage of the AFM phase can be increased at the expense of the FM phase, leading to the occurrence of exchange bias in particles of about 2 nm in size. This is a model system to study some of the features of exchange bias in nanoparticles, such as particle size dependence, induced exchange anisotropy on the FM leading to high irreversible hysteresis loops, and blocking of the AFM clusters due to proximity to the FM phase.

[1] For a recent review see, for example, “Exchange bias phenomenology and models of core/shell nanoparticles”; Iglesias, O.; Labarta, A.; and Batlle, X. *Journal of Nanoscience and Nanotechnology* **8**, 2761 (2008).

[2] “Microscopic origin of exchange bias in core/shell nanoparticles”; Iglesias, O.; Batlle, X.; Labarta, A.; *Physical Review B* **72**, 212401 (2005).

[3] “Modelling exchange bias in core/shell nanoparticles”; Iglesias, O.; Batlle, X.; Labarta, A., *Journal of Physics-Condensed Matter* **19**, 406232 (2007).

[4] “Particle size and cooling field dependence of exchange bias in core/shell magnetic nanoparticles”; Iglesias, O.; Batlle, X.; Labarta, A.; *Journal of Physics D: Applied Physics* **41**, 134010 (2008).

[5] “Exchange coupling in Co- $\text{CoO}_x$  nanoparticles in zirconia matrix”; M. Kovylyna, M. Garcia del Muro, Z. Konstantinovic, O. Iglesias, M. Varela, A. Labarta and X. Batlle (submitted).

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