Centre de Nanosciences et de Nanotechnologies

Séminaire/ Seminar

Mercredi 12 décembre

11 heures
Salle A009 C2N site Palaiseau

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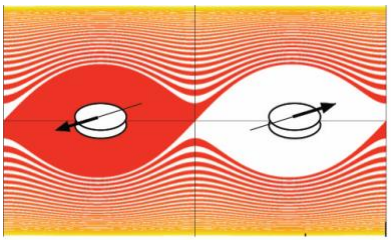
Professeur invité sur le plateau de Saclay dans le cadre du LabEx NanoSaclay

"Probabilistic Aspects of Deterministic Magnetization Dynamics in Single-Domain Nanomagnets"



Abstract:
Single-domain nanomagnets occupy a central position in the research on magnetic phenomena and applications at submicrometer scales, such as coherent magnetization switching, current-induced magnetic torques, and nanomagnet logic. Fundamental as well as application-oriented research in the area of magnetization dynamics this field revolves around the central question: how can one drive a nanomagnet to a prescribed final magnetization state? The simplest answer, which is to apply a sufficiently large magnetic field that destroys all magnetic energy minima except one, is at the core of the classical Stoner- Wohlfarth model. However, this strategy is unsatisfactory in many respects, and the search for more advanced alternatives has become the key issue in recent years, in relation, for example, to precessional or spin-torque-driven magnetization switching. The answer to this question is far from trivial. A striking feature comes from the weakly dissipative nature of magnetization dynamics. In presence of multiple stable states, sensitivity to initial conditions introduces probabilistic aspects in an otherwise purely deterministic dynamics. In the first part of the talk, we introduce these weakly dissipative (quasi-probabilistic) systems by stressing their general nature. Indeed, these systems are encountered in such fields as celestial mechanics, dynamics of charged particles and propagation of electromagnetic waves. We also discuss how the description of this system can be given in terms of Gibbs-type ensembles and the associated phase-flow. In the second part of the talk, we discuss a theoretical analysis of one special case, relevant to magnetic technologies. We demonstrate that in a single-domain nanomagnet, the probability P to relax to one of the two stable equilibrium state can be tuned to any desired value between 0 and 1 by applying a small transverse magnetic field. The transverse field neither breaks the mirror symmetry of the energy function nor introduces any important distortion in the energy profile. Nevertheless, it is enough to alter the effect of the weak dissipative part in a way that drastically modifies the relaxation probabilities. In the last part of the talk we will illustrate the relevance of the presented theory in the problems of field-driven and spin-torque driven precessional (ballistic) switching. Using a combination of analytical and numerical techniques, it is shown that the use of appropriate transverse fields greatly improve the switching reliability. Finally we discuss how the analytical prediction could be exploited to devise novel methods for the measurement of the magnetization damping constant.

***** IMPORTANT *****

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