Séminaire SATIE & Institut Farman

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en **amphithéâtre 63**

à l'Ecole Normale Supérieure de Cachan:

"Dynamical Systems Approach to Nonlinear Magnetization Dynamics in Nanomagnets"

Claudio Serpico

Dipartimento di Ingegneria Elettrica,
Università di Napoli "Federico II"
Via Claudio 21, I-80125 Napoli

Claudio Serpico is Associate Professor at the Department of Electrical Engineering, University of Naples "Federico II" . His research interests are in the areas of Micromagnetics, Hysteresis Modeling, Electrodynamics of Materials, Nonlinear Dynamics in Circuits and in Electromagnetic Systems, and Computational Physics. He is Editor of IEEE Transactions on Magnetics in the areas of electromagnetism, computational magnetics, and electromagnetic devices.

Abstract:

Experimental investigations in the area of spintronics have demonstrated that magnetization dynamics in magnetic nanosystems, depending on the excitations conditions, may exhibit a very rich variety of nonlinear phenomena such as switching, self-oscillations, nonlinear resonance, quasiperiodicity, phase locking, and chaos. In this talk, we discuss how these phenomena can be coherently and comprehensively interpreted by using the theory of nonlinear dynamical systems.

The above mentioned nonlinear phenomena are often governed by the evolution of a small number of state variables. Consequently, we concentrate here on the discussion of magnetization dynamics models with two or three state variables. As an archetype of such models, we consider a uniformly magnetized nanomagnet subject to external magnetic fields and spin-polarized currents.Magnetization dynamics is described by a generalized Landau-Lifshitz equation which describes the time evolution of the orientation of magnetization. This is nothing but a nonlinear dynamical system evolving on the surface of the constant-magnetization-magnitude sphere. We shall discuss how basic concepts of the dynamical systems theory, in particular the notion of structural stability and bifurcation, are strictly related to the phenomena observed in experiments. In this respect, the full classification of generic bifurcation conditions for 2D (two state variables) dynamical systems is presented in connection to the Andronov-Pontryagin criterion for structural stability. Of central importance is also the Melnikov-function technique for the study of periodic regimes (self-oscillations) and of the related global bifurcations.

The final part of the talk is devoted to the discussion of two examples of application of the general theory to the magnetization dynamics in nanosystems subject to specific excitation conditions. Firstly, we present the bifurcation diagram of a spin-torque oscillator subject to constant injected currents and constant external magnetic fields. Secondly, we address the problem of synchronization and injection-locking for a spin-valve device subject to time-harmonic external fields or time-

harmonic injected currents, and we discuss what measurable effects are to be expected in correspondence of the characteristic bifurcation patterns predicted by the theory.