NanoSaclay
Laboratoire d'Excellence en Nanosciences et Nanotechnologies

Séminaire Labex NanoSaclay

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Highly Nonlinear Ferromagnetic Resonance in Nanomagnets

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Abstract:

In the last decades, there has been a renewed interest in Ferromagnetic Resonance (FMR) experiments in connection with the research in the area of magnetic storage and spintronics nanotechnologies.

In classical FMR measurements, magnetization dynamics is excited by a microwave frequency (AC) field applied to a macroscopic ferromagnetic body subject to a sufficiently strong constant magnetic field. At low AC power levels, only the spatially uniform mode of the magnetic precession is excited. When AC power increases above a threshold value, nonlinear coupling of the uniform mode to a continuum of spatially non-uniform spin wave modes gives rise to substantial deviations from spatial uniformity. However, in submicron-scale ferromagnetic bodies, the geometric confinement substantially suppresses the nonlinear spin wave interactions present in bulk ferromagnets. This suppression allows for excitation of large-amplitude quasi-uniform precession of magnetization without simultaneous excitation of other spin wave modes.
In this talk, we present a detailed discussion of nonlinear magnetization dynamics in nanoscale ferromagnetic body subject to spatially uniform microwave external fields. The analysis of magnetization dynamics is carried out by using the classical Landau-Lifshitz (LL) equation. In the case of uniaxial magnets subject to circularly polarized fields, the rotational invariance of the system can be used to obtain a complete analytical theory of spatially uniform magnetization dynamics. This enables to derive analytical formulas for the description of foldover phenomena and other various instabilities process (Hopf and Homoclinic bifurcations). For sufficiently large AC power levels, the spatially uniform modes may become unstable due to their coupling with spatially nonuniform modes. The study of this coupling and the resulting parametric instability is carried out by a spin-wave analysis which generalize to large angle precessions the classical Suhl's spin-wave treatment of parametric instabilities. In the last part of the talk, we will briefly present and discuss recent experimental work on nonlinear FMR to which the presented theory is applicable.

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