Chaotic dynamics of a domain wall in magnetic nanostrips

Adrien Pivano, Voicu O. Dolocan

Aix-Marseille University, Marseille, France

IM2NP CNRS, Avenue Escadrille Normandie Niemen, 13397 Marseille, France

Quantifying the dynamics of a transverse magnetic domain wall (TDW) in ferromagnetic nanowires is of vital importance to recently proposed TDW based logic and data storage schemes [1]. In this case, the chaotic motion of a TDW is an undesirable behavior as its dynamics needs to be controlled perfectly. Chaotic systems have also a great interest to encrypt information for secure communication [2]. Some properties of chaotic dynamics, such as random-like behavior and sensitive dependence to initial conditions, are used to encode data.

The aim of this work is to investigate the phenomenon of chaos in a nanomagnetic system and his dependence of the intrinsic properties of the materials like saturation magnetization or damping constant. The nonlinear dynamics of a TDW in a double well potential is studied using micromagnetic simulations and an analytical one dimensional model. The potential can result from intrinsic or extrinsic defects in a nanowire and also can be symmetric or asymmetric. The TDW is displaced by the application of a sinusoidal magnetic field. In this system we observe a rich and complex variety of nonlinear behaviors, ranging from harmonic to chaotic oscillations of the TDW. We quantitatively determine the chaotic nature of the TDW motion using bifurcation diagram, Lyapunov exponent and fractal dimension properties of the strange attractor. For each system we study the dependence of the driving frequency and the amplitude of the magnetic field.

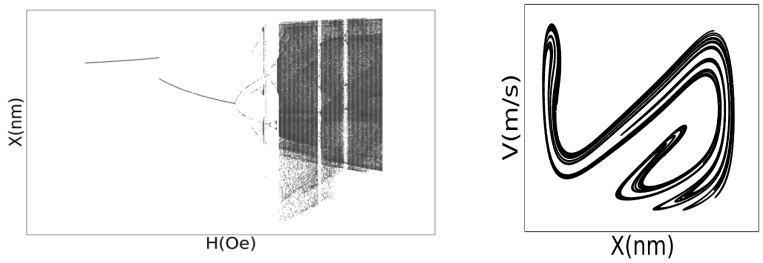

Figure :Bifurcation diagram and strange attractor of the TDW

[1] S. S. P. Parkin, M. Hayashi, L. Thomas, *Magnetic Domain-Wall Racetrack Memory*, Science **320**, 190 (2008).

[2] B. Jovic, *Synchronization Techniques for Chaotic Communication Systems* (Springer, Berlin, 2011)