Numerical Eigenspectrum of Linearized Dynamics near the Metastable and Saddle Energy States of Nanodisks with Perpendicularly Magnetic Anisotropy

Gabriel David Chaves,[1] Daniel L. Stein,[2,3] Andrew D. Kent,[3] Corrado C. M. Capriata,[4] and B. Gunnar Malm[5]

[1] *Institute of Molecular Physics, Polish Academy of Sciences*

[2] *Courant Institute of Mathematical Sciences*

[3] *Department of Physics, New York University*

[4] *Université Grenoble Alpes, CEA, CNRS, Grenoble-INP, SPINTEC*

[5] *Division of Electronics and Embedded Systems, KTH*

Nanodisks with PMA are basic building blocks for MTJ devices [1]. Understanding their dynamics allows to estimate real device properties. A critical quantity for these is the rate of switching between the two lowest metastable configurations, Γ. It follows an Arrhenius law: $\Gamma = \Gamma_0 e^{-\frac{\Delta E}{k_B T_R}}$, where ΔE is the energy barrier between the two states, T_R is the operating temperature, and Γ_0 is the prefactor. In this work, we focus on the numerical estimates of the rate prefactor Γ_0 for the magnetization reversal on PMA nanodisks [2].

We first present one dimensional analytical profiles that describe the transition between macrospin switching and a domain wall mediated switching. The String Method for the Study of Rare Events [3] confirms that these analytical expressions describe well the transition the transition state for thermally induced magnetization reversal [2]. The rate prefactor is obtained using Transition State Theory:

$$\Gamma_0 = \frac{\lambda_{s,0}}{2\pi}\sqrt{\frac{\prod \lambda_{ms,i}}{\prod \lambda_{s,i}}},$$

where $\lambda_{ms,i}$ and $\lambda_{s,i}$ are the eigenvalues of the linearized dynamics at the metastable and stable states, respectively. A direct numerical evaluation of the determinant, $\prod \lambda_{\cdot,i}$, is not possible because the Nyquist frequency of the discretization imposes an upper limit of available eigenvalues. Here, we follow [4] and use mathematical theorems [5,6] that simplify the determinants to simple evaluations of functions at the boundaries.

References:

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