Thermal Activation in Micromagnetics

R. Dittrich, W. Scholz, T. Schrefl, J. Fidler, D. Suess, H. Forster, V. Tsiantos

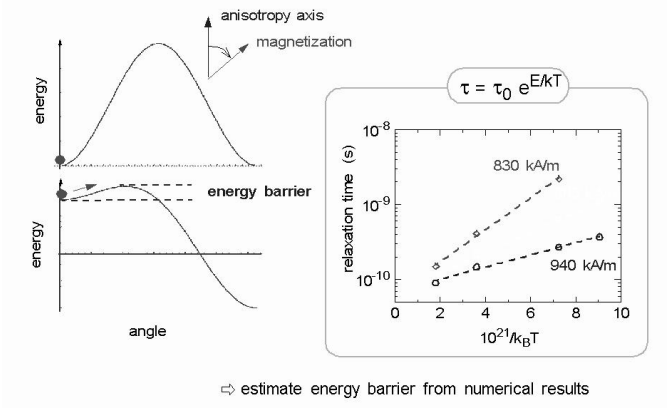
Institut für Angewandte und Technische Physik, Vienna University of Technology

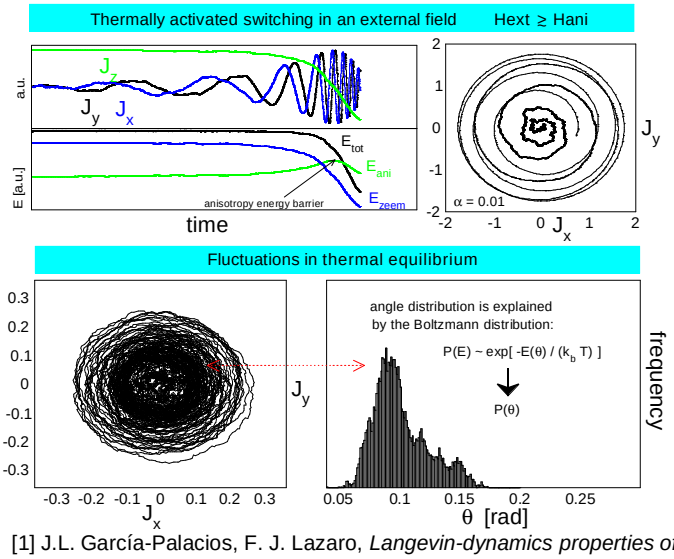
INTRODUCTION

Thermally activated processes become increasingly important in magnetic recording and sensor applications. Thermal stability and fast writing are crucial for ultra high density magnetic recording. With decreasing bit size thermal effects are relevant to high speed switching of the magnetisation in the write process and to the long term stability of the written bit. Short time scale simulations use Langevin dynamics by adding a random thermal field to the effective field and the Heun method [1] for integration of the resulting stochastic differential equation. In order to expand the simulations to larger time scales a novel hybrid Monte Carlo method [2] has been developed allowing a speed up of the simulations of at least an order of magnitude.

STONER-WOHLFARTH PARTICLES

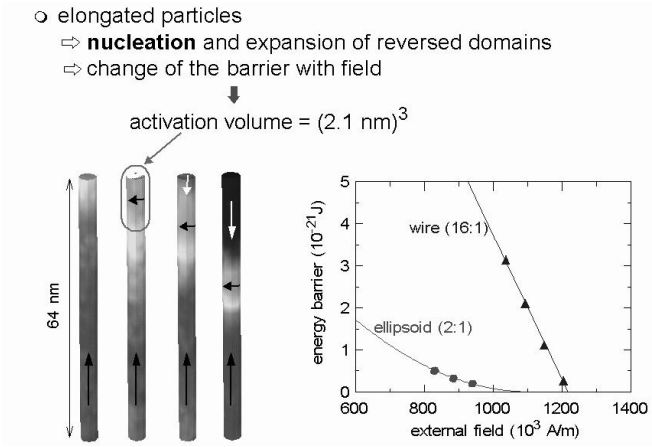
Thermal switching of single domain particles is well described by the Arrhenius-Néel model from which an upper bound of the energy barrier can be obtained.





NANOWIRES

The thermally activated reversal of a Co-nanowire occurs by expansion of a nucleus of reversed magnetisation. The activation volume can be calculated from the slope of E(H) and was found to be independent of the lenght of the nanowire [3].



HYBRID MONTE CARLO

A novel hybrid Monte Carlo method for thermal simulations has been developed. The Hybrid Monte Carlo method [2] samples points in phase space by means of a Markov chain in which stochastic and dynamical transitions alternate. First results indicate a speed up of the computation time of 10 up to 100 as compared to the Heun method. In order to verify the different numerical approaches, thermal equilibrium properties have been calculated. Both methods show the proper Boltzmann distribution of the total energy. Simulations of thermally activated switching processes agree with the results obtained with the Heun method.

[1] J.L. García-Palacios, F. J. Lazaro, *Langevin-dynamics properties of small magnetic particles*, Phys. Rev. B, 58 (1998), pp. 14937-14958.
[2] Radford M. Neal, *Probabilistic Inference Using Markov Chain Monte Carlo Methods,* technical report 1993, University of Toronto
[3] F.L. Li, R.M. Metzger, W.D. Doyle, *Influence of particle size on the magnetic viscosity and activation volume of a-Fe nanowires in alumite films*, IEEE Trans. Magn., 37 (1997), pp. 4423-4439

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