Fast Switching of Small Magnetic Particles

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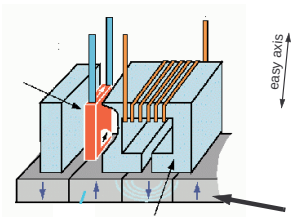
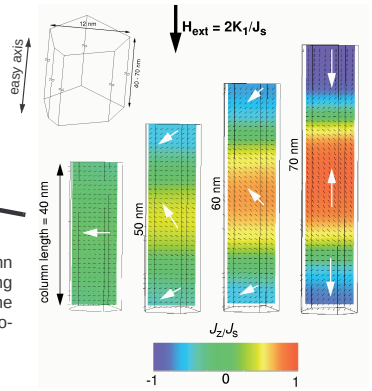
INTRODUCTION

A theoretical understanding of high speed switching of magnetic grains becomes increasingly important as the data rate of magnetic recording media approaches the GHz regime. At such high frequencies gyromagnetic effects and precessional motion dominate the reversal process. In this work we investigate the switching time of a grain of a perpendicular recording medium. For the simulations at zero temperature the Landau-Lifshitz-Gilbert (LLG) equation is integrated numerically using a backward differentiation formula [1]. A hybrid finite element boundary element method [2] is used to solve the strayfield problem. We found that for fields smaller than the Stoner-Wohlfarth nucleation field the switching time decreases with smaller field strengths. Langevin dynamics simulations show that with increasing temperature the switching time decreases.

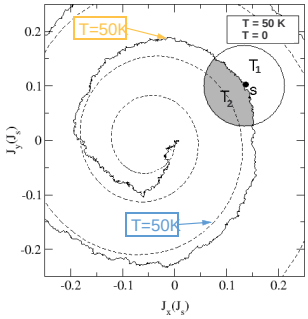
Switching of a Co-grain





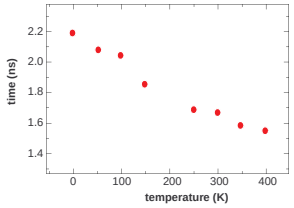
With increasing film thickness (column length) of a perpendicular recording medium the reversal process of one grain becomes more and more inhomogeneous.

Switching at finite temperature



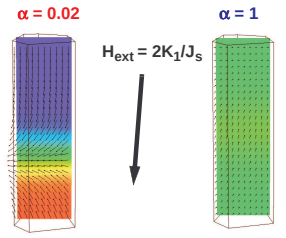
An external field is applied instantaneously to the equilibrium state (**m** parallel to easy axis). The angle between the external field and the easy axis is 1°.

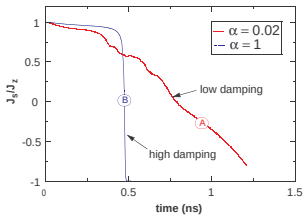
thermal fluctuations
- **perturbation of states**
- **area T1 > T2**
- **states closer to initial state less probable**
- **switches faster**



The switching time decreases with increasing temperature.

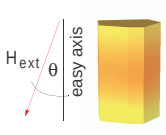
Influence of α



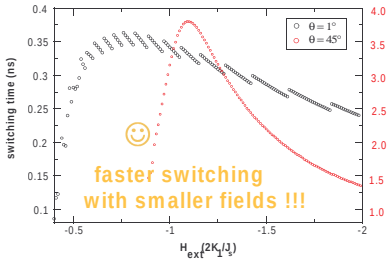


The damping constant changes both the reversal mode and the switching time. With decreasing damping constant more inhomogen-eous states occur during reversal.

Switching time



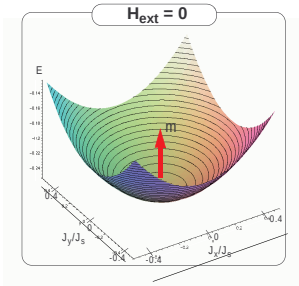
- external field is applied instantaneously to the remanent state.
- Angle of external field and easy axis is either 1° or 45°
- switching time as function of field strength for α=0.01

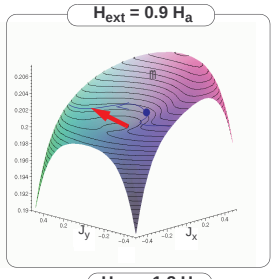


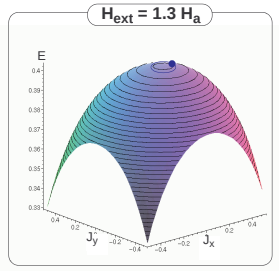
For fields smaller than the anisotropy field the switching time decreases as the external field decreases. If the angle between the external field and the easy axis is changed from 1° to 45° switching occurs 10 times faster.

Fast switching modes

small field
ð fast switching







large field
ð slow switching

[1] S. D. Cohen, A. C. Hindmarsh, CVODE: User Guide, LLNL, Technical Report UCRL-MA-118618, 1994.
[2] D. R. Fredkin, T. R. Koehler, IEEE Trans. Magn. 26 415 (1990) 415

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