Ultrafast switching of magnetic elements using a rotating field

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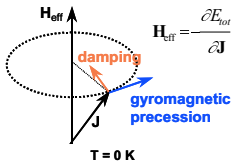
MOTIVATION

Magnetic switching of small particles and thin films becomes increasingly important. Numerical micromagnetics is an essential tool to optimize magnetic storage media and sensors. The application of these devices requires a profound knowledge of the reversal mechanism. The differences of the magnetisattion reversal processes under a constant unidirectional field and under rotational fields are studied using a 3D hybrid finite element/boundary element micromagnetic model. Thermal fluctuations, defects and other forms of disorder as well as eddy currents occurring during the fast switching process are not included in the simulations.

MICROMAGNETIC FRAMEWORK - FE MODEL

Landau-Lifshitz-Gilbert equation:

$$\frac{\partial \mathbf{J}}{\partial t} = -|\gamma|(\mathbf{J} \times \mathbf{H}_{\text{eff}}) + \frac{\alpha}{J_s}\left(\mathbf{J} \times \frac{\partial \mathbf{J}}{\partial t}\right)$$

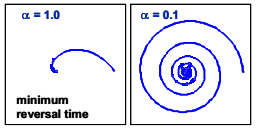


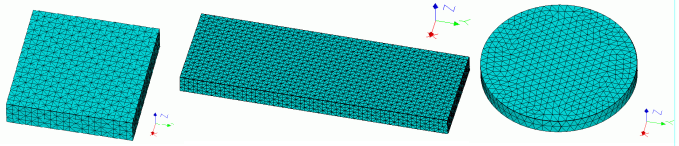
Intrinsic magnetic properties:

$Ni_{80}Fe_{20}$
J_s=1.00 T, K_1= 0, A=13 pJ/m

Co, single and polycrystalline
J_s=1.76 T, K_1=0.45 MJ/m^3, A=13 pJ/m

α = 1.00, 0.10, 0.02
Finite element size: ~ 2.5 - 5 nm





square
100x100x20 nm^3
8960/64000 elements

rectangular
100x300x20 nm^3
21760/96000

dot
d100x20 nm^3
8276/85797 elements

Magnetic field profiles: ← constant reversed field or H(t)

↻ constant rotational field at 1Ghz or 10 GHz

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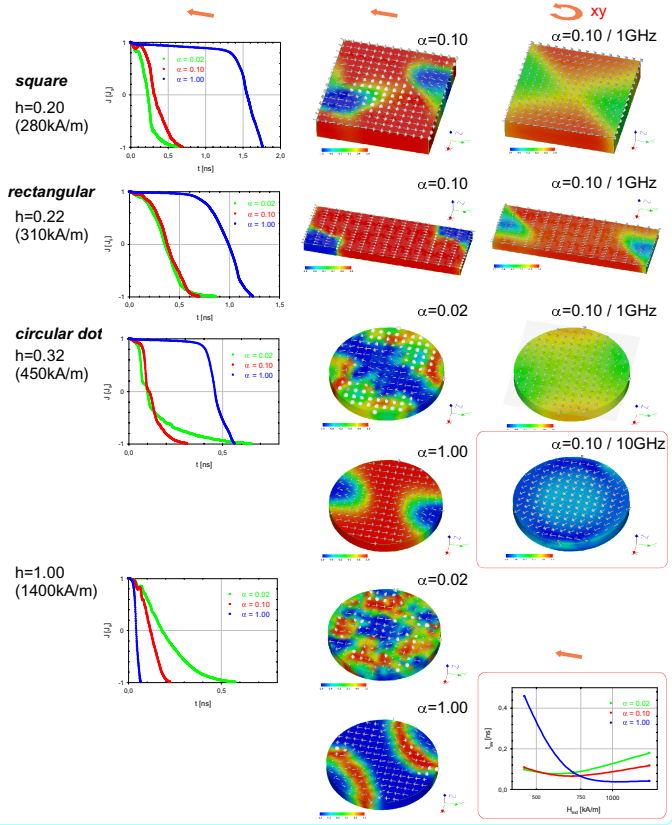
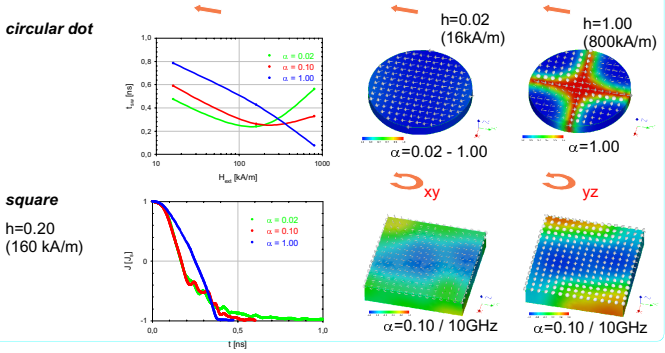
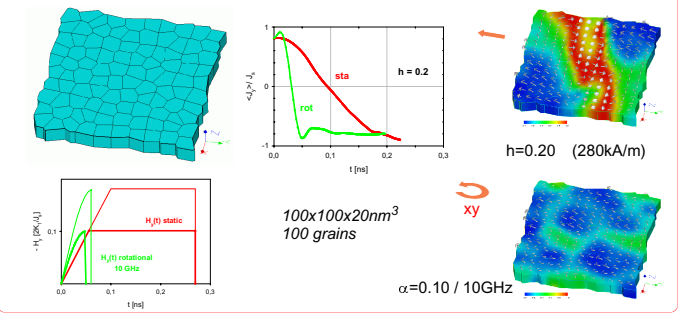
SWITCHING OF UNIAXIAL CO-NANOELEMENTS



SWITCHING OF NI80FE20 NANOELEMENTS



SWITCHING OF GRANULAR CO-NANOELEMENTS



SUMMARY

In nanostructured magnets the switching fields and times are controlled by the geometric shape of the magnets, the intrinsic properties and the orientation and strength of the applied field. The damping parameter α(H) drastically influences the critical switching field and time.