MAGNETIZATION DYNAMICS OF CURRENT- AND FIELD-DRIVEN DOMAIN WALLS AND VORTICES

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The discovery that a spin-polarized current traversing a ferromagnetic sample can alter its magnetization has opened up interesting fields of research as it has possible applications in future memory devices. In experiments the discrimination between spin-torque-driven dynamics and the dynamics driven by the magnetic field accompanying the current flow is still an open problem. Using analytical calculations, micromagnetic simulations, and magnetic X-ray microscopy we investigated the interaction between a spin-polarized current and the magnetization. [1-4]
In our theoretical investigations we focused on two analytically feasible magnetization patterns, i.e., a vortex in a thin-film element and a Néel wall that is confined in a constriction. Starting from the micromagnetic equation of motion extended by the current-induced spin torque introduced by Zhang and Li [5] we derived an analytical expression for the response of both patterns to a temporally varying current. The Oersted field was included in the calculations by introducing a spatially homogeneous magnetic field perpendicular to the current. We found that both systems can be well described as quasiparticles in a harmonic confining potential. The results are compared to numerical results with good accordance.
The experimental investigations of the vortex structure were performed at the STXM microscope at the Advanced Light Source in Berkeley, CA. The structure was excited with an alternating current and its response was detected with the help of the microscope. Current-induced vortex gyrations with a vortex velocity of up to 100 m/s were observed. The high temporal resolution of about 100 ps allowed us to measure the phase between the applied current and the vortex deflection. Theoretically we found that the phase shift between the exciting current and the vortex deflection depends on the source of excitation, i.e., field or spin torque. From the comparison between theoretical and experimental results we were able to determine the ratio between the spin-torque and the Oersted-field induced motion of the vortex.
The investigations of the Néel walls were conducted at the XM-1 microscope at the Advanced Light Source in Berkeley, CA using pulsed excitations with pump and probe measurements. The sub 100 ps time resolution of this microscope allows us to trace the oscillations of the wall in the constriction. From these measurements we found that oscillations of the domain wall occur during and after the pulse with velocities of up to 325 m/s. We could unambiguously determine that the major action of the current on the magnetization is mediated by its Oersted field.

[1] B. Krüger et al., Phys. Rev. B **75**, 054421 (2007)
[2] B. Krüger et al., Phys. Rev. B **76**, 224426 (2007)
[3] G. Meier et al., Phys. Rev. Lett. **98**, 187202 (2007)
[4] M. Bolte et al., Phys. Rev. Lett. **100**, 176601 (2008)
[5] Phys. Rev. Lett. **93**, 127204 (2004)