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Stochastic Current-Driven Domain-Wall Motion Observed by X-Ray Microscopy

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Transmission x-ray microscopy can directly visualize the influence of a spin-polarized current on the magnetization of micro- and nanostructures. We investigate the stochastic motion of domain walls in curved wires [1] and the motion of vortices in squares [2]. To observe domain-wall motion pulses of nanosecond duration and high current density are send through permalloy wires and either move or deform the domain wall. The current pulses have nanosecond duration and a high current density of up to 1.0 10^{12} A/m^2 and drive the wall either undisturbed, i.e. as a composite particle through the wire or causes structural changes of the magnetization. Repetitive pulse measurements reveal the stochastic nature of current induced domain-wall motion. From the experiments we estimate the ratio between the degree of nonadiabaticity and the Gilbert damping parameter indicating the importance of the nonadiabatic contribution to current driven domain-wall motion. To compare experimental results with theory the spin-torque transfer model of Zhang and Li [3] is implemented in the micromagnetic framework OOMMF [4]. The code is applied to determine the current-induced domain wall velocity using the material parameters of permalloy. The simulations support the interpretation of the experimental results. Sinusoidal high-density currents are applied to micrometer-sized permalloy squares containing ferromagnetic vortices. Spin-torque induced vortex gyration on the nanosecond timescale is observed. The phase of the gyration in structures with different chirality are compared to an analytical model and micromagnetic simulations, considering both alternating spin-polarized currents and the current's Oersted fields. This analysis reveals that spin-torque is the main source of motion. Supported by the DFG via SFB 668 and GK 1286 as well as by the U.S. DOE Contract No. DE-AC02-05-CH11231. References:

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