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Imaging Magnetization Dynamics on the Nanoscale Using X-ray Microscopy

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We aim at time- and spatially resolved imaging of excitations in ferromagnetic materials such as spin waves, the motion of domain walls and the gyration of magnetic vortices and antivortices. Special emphasize is given to the interaction of electrical currents with magnetic inhomogeneities like domains walls and vortices. The spin-polarized current can give rise to a spin torque on spatially inhomogeneous magnetization configurations. With magnetic transmission X-ray microscopy we observe a current-driven oscillation of an individual domain wall on its genuine time scale. In the framework of an analytical model insight into the domain-wall motion and its characteristic damping time is gained by examination of different phase spaces [1]. Current-induced depinning of a domain wall from a pinning site depends on the temporal shape of the current pulse. Apart from resonant excitation of the wall this effect arises from an additional force on the wall due to a fast changing current. Efficient depinning is achieved for rise times smaller than the damping time of the domain wall [2]. Time-resolved X-ray microscopy is used to image the influence of alternating high-density currents on the magnetization dynamics of vortices and antivortices. They behave as two-dimensional oscillators with a gyrotropic eigenmode which can be resonantly excited by spin currents and magnetic fields [3]. It is shown that the two excitation types couple in an opposing sense of rotation in case of resonant antivortex excitation with circular-rotational currents [4]. We report on the experimental observation of purely spin-torque induced antivortex-core reversal. Financial support by the DFG via SFB 668 and via GK 1286 as well as by the City of Hamburg via the Landesexzellenzcluster Nano-Spintronics is gratefully acknowledged. The ALS is supported by the Director, Office of Science, Office of Basic Energy Sciences, of the US Department of Energy.

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