Vortex and Vortex Core Dynamics Imaged by Time Resolved X-ray Microscopy

Bartel Van Waeyenberge

Department of Solid State Science, Ghent University, Ghent, Belgium

The vortex state is the simplest, non-trivial ground state configuration of soft magnetic thin film platelets and an interesting subject for the study of micromagnetism as well as for future applications. The nanometer sized, out-of-plane magnetized vortex core plays a key role in the dynamics of these structures. We have studied the vortex dynamics in micron and submicron Permalloy thin film elements by means of time resolved magnetic X-ray microscopy. The dynamic response was recorded with high spatial (30 nm) and temporal (70 ps) resolution after the application of different excitations: magnetic field pulses, alternating magnetic fields, rotating magnetic fields and spin polarized currents.

These studies have revealed a new reversal mechanism for the out-of-plane vortex core. By the excitation with short bursts of an in-plane alternating field as low as 1.5 mT, the vortex core could be toggled from its up to down state and vice versa [1]. Vortex core switching with different types of excitation has now also been investigated. Experimental data will be presented on vortex core switching resulting from linear, RF magnetic fields, rotating magnetic fields, short magnetic field pulses and spin polarized currents. The switching behaviour was studied for different excitation amplitude and durations.

Additionally, the direct dynamic imaging of the out-of-plane magnetization of the vortex core [2] under different excitations enabled us to evaluate directly the vortex velocity. In this way, the vortex threshold velocity for core switching could be estimated and was compared with analytic and micromagnetic models [3]. We could evaluate the critical vortex velocity for switching [2-5] and detect the deformation of the vortex core profile as the first step in the core reversal mechanism [5]. An advanced pump-and-probe approach at the Scanning Transmission X-ray Microscope enabled us to image the switching transients during the core reversal process.

References

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E-mail corresponding author: Bartel.VanWaeyenberge@UGent.be INVITED