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THE BREAKING OF THE VORTEX POLARITY SWITCHING SYMMETRY BY THE SURFACE ANISOTROPY

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The ultrafast manipulation of the complex magnetization dynamics is crucial for the physics of nanomagnetism, in particular, for the nonvolatile magnetic random-access memories. One of the promising candidate is the vortex state nanoparticle, in which vortex core magnetization, the so-called vortex polarity, can be considered as a bit of information.

We study the vortex polarity switching in nanodisks in the Heisenberg easy-plane ferromagnet both analytically and numerically [1], using the spin-lattice simulations. Without the surface anisotropy the switching occurs with a Bloch line scenario: there is no qualitative difference between 2D and 3D simulation. The switching scenario is drastically changed in presence of the surface anisotropy on the face surfaces of the sample. It breaks the symmetry with respect to the thickness coordinate. In the sample with the easy-plane surface anisotropy the vortex width becomes barrel-shaped (see Fig. 1a, curves EP1 and EP2 for strong and weak surface anisotropy respectively) and pillow-shaped for easy-axis case (see Fig. 1a, curves EA). The reduced vortex width has a form

$$w(z) = 1 - \frac{\kappa\Omega\cosh\Omega z}{\kappa\Omega\cosh 0.5\Omega L + 4\sinh 0.5\Omega L},$$

with κ being a ratio between surface and bulk anisotropy coefficients, $\Omega = 1/(\ell\zeta(3))$, ℓ being the magnetic length, $\zeta(x)$ being Riemann Zeta function and L being the sample's thickness.

The static perpendicular magnetic field directed opposite to the initial vortex polarity causes the change of the vortex width shape to the opposite. When fields grow, it leads to creation of two Bloch points during vortex polarity reversal. The direction of the Bloch Points propagation depends on the type of the surface anisotropy: from the face surfaces for the easy-axis one and from the center of the disk axis for the easy-plane one.

Our theoretical conclusions are in a good agreement with spin-lattice simulations.

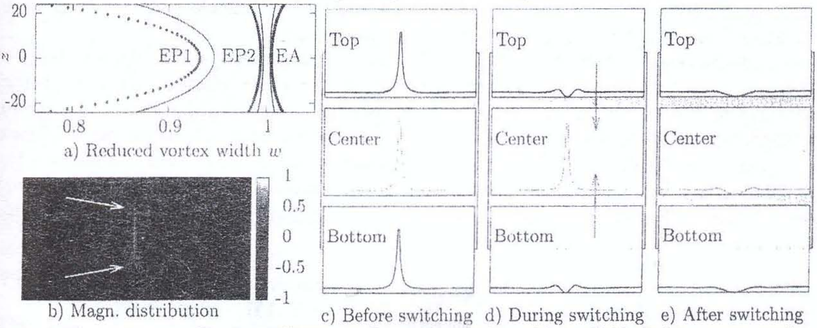

Fig. 1. a) The vortex profile for different surface anisotropies without field. Points correspond to spin-lattice simulations and solid lines to theory. b) The magnetization distribution during Bloch points propagation (easy-axis surface anisotropy). Bloch points are shown by arrows. c-e) Shape of vortices along axis of the nanodot (easy-axis surface anisotropy): before, during and after switching. Arrows show the direction of Bloch point's propagation.

[1] http://www.rz.uni-bayreuth.de Computing Center of Bayreuth University