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Magnetic vortex core reversal in Heisenberg magnets with surface anisotropy

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We consider a 3D Heisenberg magnet with Néel surface anisotropy (SA) in the vortex state. Under the action of the DC transversal magnetic field applied, the heavy vortex (polarized opposite to the field direction) becomes unstable and when the field reaches some threshold amplitude, polarity reversal occurs.

In the present work we show that without SA the switching occurs symmetrically in z-direction via the planar vortex mechanism [1], while the SA breaks the symmetry which results in the Bloch point mediated switching scenario. In contrast to the switching in magnets with dipolar interaction, where the polarity reversal is typically mediated by one Bloch point [2], we show that the switching in magnets with SA is accompanied by symmetrical nucleation of Bloch points. Using spin-lattice simulation [3] we show that the Bloch points nucleation scenario depends on the sign of the SA. For the easy-normal SA the effective anisotropy coefficient per lattice site on the face surfaces is smaller than the bulk one and Bloch points appear on the opposite ends of the sample’s axis. For the easy-surface SA they born in the center of the sample’s axis and run in the opposite directions.

The wired-core model is developed to describe the Bloch point-mediated switching process. It extends approach [4] for description of the vortex instability to the 3D case. One assumes that the vortex core in the each lattice plane is formed by the four simulutaneously rotating spins and all other spins are fixed in the vortex state according the adjustment of the external field. In the 3D system spins of the core in the each lattice plane are independent and polarity switching dynamics is reduced to the system of coupled nonlinear oscillators. External field deforms shape of potentials and when the threshold value is reached, the process of the polarity reversal starts form of two waves spreaded in the opposite polarities. Wired-core model allows observe all main features of the full-scale simulations including characteristics of Bloch points motion.