Bloch-Point micromagnetic behavior in cylindrical nanowire: from simulation to experimental evidence

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Cylindrical magnetic nanowires are three-dimensional systems (Fig. 1(a)) in which magnetization may be manipulated by spin-polarized currents in order to controllably nucleate, move and pin magnetic domain walls (DWs) in view of three-dimensional storage devices design. These objects can host so-called Bloch-Point walls (BPWs) not subject to the Walker breakdown limitation and which have been reported to reach velocities above 600 m/s under spin-transfer-torque-induced driving force [1]. In order to achieve the desired control of DW motion, the use of chemical modulations have been proposed to introduce effective pinning sites along the wire's axis [2].

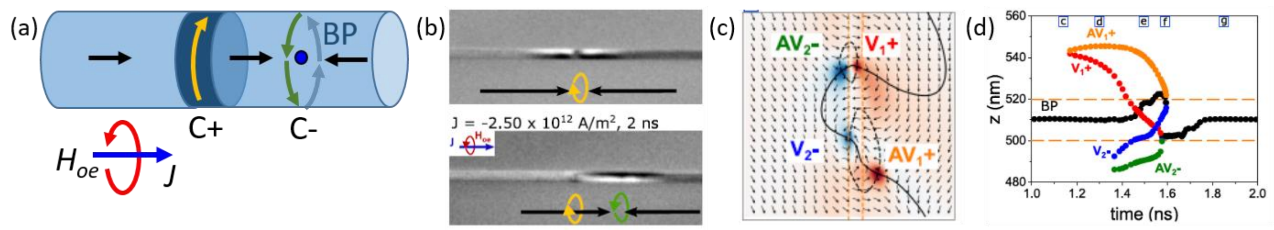

Figure 1: (a) BPW in modulated nanowire, (b) XMCD image of BPW before and after current pulse, (c) micromagnetic image of unrolled wire surface, (d) volume and surface singularities evolution in time.

We study BPW behavior under applied current taking into account related Oersted field using both various theoretical and experimental technics and will provide a complete and realistic picture of the BPW dynamics.

Dynamical behavior of BPWs recently observed using x-ray magnetic imaging measurements [2] (Fig. 1(b)) rose several challenging questions for micromagnetic modeling in particular from topological point of view. It occurs that any BPW transformation or propagation in chemically modulated wire [3] implies complex interplay between volume topological objects (BPs itself) and induced surface objects (vortex and antivortex pairs) (Fig.1(c)). Thus, in order to complete and to go beyond conventional micromagnetic simulations of three-dimensional spin textures we developed the post-processing tool based on vector field singularities analysis (Fig. 1 (d)). This theoretical advancement allowed us to accompany experimental observations and to overcome limitations related to the time resolution in experiments. Indeed, the access to intermediate time steps via simulations give deeper insight of underlying phenomena and provide clues for interpretation of future experimental data.

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References

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