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Field and Current-Driven Domain Wall Motion in Permalloy Nanowires[1]

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Ferromagnetic nanowires provide a well-defined conduit for domain walls, which may be manipulated and used in a variety of information storage and processing schemes. A domain wall may be displaced by a magnetic field or by an electric current traversing the wall via spin-momentum transfer. Many experiments have focused on the depinning of a domain wall by a current, but few have addressed the subsequent propagation of a depinned wall, whether driven by current [1], field [2,3], or both. Using high-bandwidth scanning Kerr polarimetry, we have studied time-resolved motion of field and current-driven domain walls in Permalloy nanowires. Domain dynamics models predict that above a threshold field, uniform wall translation gives way to turbulent wall motion, a dynamic internal wall structure, and a substantial drop in wall mobility. We have observed this transition at an unexpectedly low field [3], suggesting that in many experiments, wall motion is far more complex than the smooth translation typically assumed. The interaction of a dc current with a propagating domain wall is likewise more complex than existing spin-torque models predict. We find a nonlinear response of the wall velocity to a dc current, with velocity enhancements approaching 40 m/s at a current density of $\sim 6 \times 10^{11}$ A/m^2. The response may be represented by a field-independent linear term, consistent with theory, and a field-dependent nonlinear term that overtakes the linear term at moderate currents. This latter term may arise from the interaction of the current with a vortex in the wall. [1] A. Yamaguchi, *et al.*, *Phys. Rev. Lett.* **92**, 077205 (2004) [2] T. Ono, *et al.*, *Science* **284**, 468 (1999); D. Atkinson, *et al.*, *Nature Mater.* **2**, 85 (2003). [3] G. S. D. Beach, *et al.*, *Nature Mater.* **4**, 741 (2005)

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