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Domain-wall dynamics in ferromagnetic nanowires[1]

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Current-induced domain-wall (DW) dynamics is studied in a thin ferromagnetic nanowire. We derive effective equations of motion describing the dynamics of the DW soft modes with or without topological defects. Because the DWs are topological objects with a rigid spin structure, these equations are rather universal. The DW rigidity makes the microscopic details irrelevant, and it allows us to solve the DW dynamics for a very general class of spin Hamiltonians. We show that the DW dynamics is described by simple equations with only four parameters. Based on these equations, we study DW dynamics in a ferromagnetic wire with Dzyaloshinskii-Moriya interaction (DMI). We find spin spiral DW structure and how the critical current required to move the domain wall depends on DMI. We also investigate the DW dynamics driven by time-dependent currents. We find the most efficient (with the lowest Ohmic losses) way to move the DWs by resonant current pulses. In addition, we propose a procedure to unambiguously determine the DW dynamics parameters by all-electric measurements of the time-dependent voltage induced by moving DW. Furthermore, based on the derived DW dynamics equations for the translationally non-invariant nanowires, we show how to make potential magnetic memory nanodevices much more energy efficient.

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