High-Performance Micromagnetics for Nanostructured Materials and Devices

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Magnetic materials and devices are an inherent part of a host of physical and engineering systems. Micromagnetic and electromagnetic simulations have a significant predictive power and are important for our ability to analyze and design such systems. We present our recent work on the development of high-performance micromagnetic and electromagnetic simulators as well as their use for applications in magnetic material and device analysis and design. We demonstrate a high-performance fast magnetic simulator (FastMag) framework, which solves Landau-Lifshitz-Gilbert type equations for simulating non-linear magnetization dynamics in complex magnetic materials and devices. We show coupled electromagnetic-micromagnetic simulators, which allow accurately accounting for linear and non-linear electromagnetic dynamic phenomena including Eddy currents. The performance of these simulators is based on efficient methods for computing effective magnetic fields, efficient methods for non-linear time integrations, and massive parallelization. Examples of using the developed simulators for applications in magnetic recording, magnetic memories, microwave magnetic materials, and permanent magnets are presented.