A 2.5D micromagnetic modeling approach for magnetic domain and domain wall studies

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There is a long standing interest in the structure of domains and domain walls in various magnetic material samples. Here, the micromagnetic theory is able to describe how material parameters, excitation conditions and sample geometry influences the magnetization state and its temporal evolution. In the theory, the Landau-Lifshitz (LL) equation describes how the magnetization evolves on a picosecond time scale and a nanometer space scale. Due to its highly non-linear character, one can in most cases only rely on numerical computational schemes to solve the LL-equation. If one aims at structurally investigating domain and domain wall structures in a comprehensive way, large parameter scans need to be undertaken on possibly large samples, which is computationally intensive.

For some geometries, a first possibility to reduce the computational burden is to apply a 2.5D approach. Here, the sample is considered infinite in one direction. Along this direction all material and field quantities are assumed invariant, but still retain their 3D vector character. This makes a 2D discretization of the geometry possible and reduces the computational burden for the evaluation of the magnetic fields, compared to a full 3D description. This approach is particularly valuable as an alternative to the analytics based domain theory which often starts from the same assumptions (A. Hubert and R. Schäfer, *Magnetic domains*, Springer Verlag, Berlin, Heidelberg, New York, 1998).

A second way to accelerate the numerical simulations is to implement the algorithms on Graphical Processing Units (GPUs). In the last years the huge parallel computational power available in this hardware, originally developed for high-speed image rendering, has drastically reduced computation times in various numerical research domains. In this contribution, we present the 2.5D micromagnetic approach and comment on its GPU-specific implementation.