Towards Faster and More Reliable 3-D Micromagnetic Device Simulation


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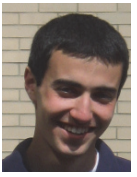
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The emergence of technologies that use nanometer-scale 3-D magnetic structures to implement new logic and memory devices has increased the need for device simulators that can predict the behavior of these devices both accurately and within a reasonable period of time. Fig. 1 shows three snapshots of the state of a magnetic logic device as it transitions from a high- to low-resistance state while Fig. 2 illustrates the final structure of the domain wall for each of the three dimensions. A simulator should be able to illustrate how these fields evolve in three spatial dimensions over time, allow probing of the structure at different points from different perspectives **and** produce results in a reasonable amount of time.

Although the applied physics principles and underlying mathematics is fairly well understood, there is a scarcity of general purpose tools that can simulate arbitrary complex 3-D magnetic structures within a time period that allows thorough exploration prior to fabricating a device in the clean room. Our own research has been with respect to predicting the behavior of novel magnetic logic and memory devices being designed within CSSI, but we have also "hit the wall" with respect to the computational challenges of the associated micro magnetic simulation. Specifically, simulation with a single set of parameters can require days, so exploring several dozen "what-if" scenarios is not practical.

To address this issue, a more robust simulator is being developed to tackle novel geometries with much greater speed and reliability than existing tools. The approach will primarily make use of techniques that have been used to speed up circuit simulators (including parallelism) but we also plan to explore aspects of the underlying quantum effects which might lead to more reliable and faster numerical techniques of solving the underlying differential equations. We are also looking into methods of navigating field structures using techniques based upon graphic-intensive gaming interfaces.

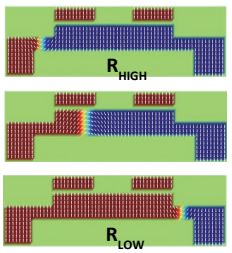

Fig. 1: Magnetic domain wall motion

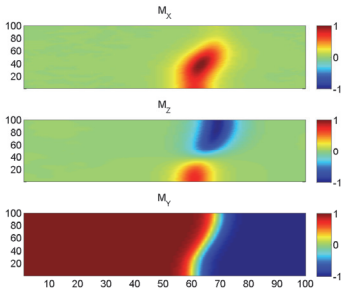

Fig 2: Magnetic wall domain structure