Robustness of majority gates based on nanomagnetic logic.

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Nanomagnetic logic (NML) employs dipole-coupled nanomagnets, in order to implement non-volatile logic gates that might overcome the bottlenecks of current CMOS-based technology, especially regarding areal density and power consumption.

In this work we investigate the magnetization reversal of a particular five-magnet majority gate, where the three input dots present slanted edges (Fig. 1). Magnetic force microscopy (MFM) and magneto-optical Kerr effect (MOKE) were used for the measurements, which have been complemented by micromagnetic simulations based on the GPU-accelerated software MuMag3.

The hysteresis loops of the easy axis magnetization under an external clocking field applied along the hard axis were recorded by MOKE magnetometry. The experimental loops have been compared with micromagnetic simulations and MFM observations taken at remanence, in order to understand which magnetic configurations contribute to the shape of the hysteresis loop. A satisfying match between experiments and simulations has been found, giving evidence to the asynchronous switching of the input dots inside the gate, also confirmed by further in-field MFM measurements.

The effect of a small misalignment in the direction of application of the external field H with respect to the hard axis of the gate, which must be taken into account when dealing with nanoscopic devices operation, has been also investigated. The results show that the correctness of the operation of the gate is insured only if the misalignment does not exceed 2°-3°. In order to improve the stability of the gate's logic configuration under the field misalignment, we propose and simulate optimized geometries by increasing the thickness of the dots and a change in their shape.

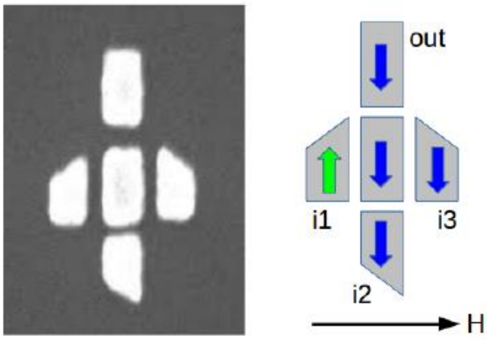

Figure 1. NML slanted-edge Majority gate.