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GMAG Dissertation Award Talk: All Spin Logic – Multimagnet Networks interacting via Spin currents[1]

SRIKANT SRINIVASAN, School of Electrical and Computer Engineering, Purdue University

Digital logic circuits have traditionally been based on storing information as charge on capacitors, and the stored information is transferred by controlling the flow of charge. However, electrons carry both charge and spin, the latter being responsible for magnetic phenomena. In the last few decades, there has been a significant improvement in our ability to control spins and their interaction with magnets. All Spin Logic (ASL) represents a new approach to information processing where spins and magnets now mirror the roles of charges and capacitors in conventional logic circuits. In this talk I first present a model [1] that couples non-collinear spin transport with magnet-dynamics to predict the switching behavior of the basic ASL device. This model is based on established physics and is benchmarked against available experimental data that demonstrate spin-torque switching in lateral structures. Next, the model is extended to simulate multi-magnet networks coupled with spin transport channels. The simulations suggest ASL devices have the essential characteristics for building logic circuits. In particular, (1) the example of an ASL ring oscillator [2, 3] is used to provide a clear signature of directed information transfer in cascaded ASL devices without the need for external control circuitry and (2) a simulated NAND [4] gate with fan-out of 2 suggests that ASL can implement universal logic and drive subsequent stages. Finally I will discuss how ASL based circuits could also have potential use in the design of neuromorphic circuits suitable for hybrid analog/digital information processing because of the natural mapping of ASL devices to neurons [4].

[1] B. Behin-Aein, A. Sarkar, S. Srinivasan, and S. Datta, "Switching Energy-Delay of All-Spin Logic devices," *Appl. Phys. Lett.*, 98, 123510 (2011).
[2] S. Srinivasan, A. Sarkar, B. Behin-Aein, and S. Datta, "All Spin Logic Device with Inbuilt Non-reciprocity," *IEEE Trans. Magn.*, 47, 10 (2011).
[3] S. Srinivasan, A. Sarkar, B. Behin-Aein and S. Datta, "Unidirectional Information transfer with cascaded All Spin Logic devices: A Ring Oscillator," *IEEE Device Research Conference* (2011).
[4] A. Sarkar, S. Srinivasan, B. Behin-Aein and S. Datta, "Multimagnet networks interacting via spin currents" *IEEE International Electron Devices Meeting* 2011. (to appear).

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