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Room Alnot 4-A014, IJL

Solving Combinatorial Optimization Problems Stochastic Magnetic Tunnel Junctions

Can stochastic magnetic tunnel junction arrays solve complex optimization problems better than existing methods? The first part of this talk addresses this question by presenting the Sherrington–Kirkpatrick (SK) spin-glass model, a difficult problem with a known solution in the thermodynamic limit. Remarkably, we show by numerical modeling that coupled macrospins emulating the SK model and evolving according to Landau-Lifshitz Gilbert dynamics can get closer to the true ground state energy than state-of-the-art numerical methods [1].

The second part of my talk will focus on stochastic magnetic tunnel junctions based on perpendicular magnetic tunnel junctions. In contrast to superparamagnetic MTJs, we experiment with magnetically stable perpendicularly magnetized MTJs (pMTJs) and actuate them with nanosecond pulses to make them behave stochastically. We denote this a stochastic magnetic actuated random transducer (SMART) pMTJ device because a pulse generates a random bit stream on-demand, much like a coin flip [2]. SMART-pMTJs produce truly random bit streams at very high rates (>100MHz) [3], while being more robust to environmental changes, such as their operating temperature and device-to-device variations, compared to other stochastic nanomagnetic devices [4,5]. By interfacing a SMART-pMTJ to an FPGA, we have generated over 1 trillion bits at rates greater than 100 MHz that pass multiple statistical tests for true randomness, including all the NIST tests for random number generators with only one XOR operation [6]. Finally, I will discuss opportunities to advance the science and applications of stochastic MTJs toward creating better sources of random numbers and addressing complex optimization problems.

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[3] Ahmed Sidi El Valli, Michael Tsao, J. Darby Smith, Shashank Misra, and Andrew D. Kent. "High-Speed Tunable Generation of Random Number Distributions Using Actuated Perpendicular Magnetic Tunnel Junctions," arXiv:2501.06318

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