Stochastic Nanomagnets as Natural "p-bits" for Probabilistic Spin Logic (PSL)

Supriyo Datta, Purdue University

Nanomagnets used in memory and logic usually have a large barrier ~ 40-60 kT and require relatively large currents to switch, which limits their practical application. Magnets with smaller barriers would require smaller currents and hence less power, but the practical utility of such magnets has been limited since they do not have a stable magnetization and cannot represent a 0 or a 1. In this talk, we argue that such stochastic nanomagnets (SNM) having thermal stabilities of only a few kT, comprising a few thousand spins, provide a natural probabilistic or "p-bit" for implementing a new kind of logic.

We argue that the natural physics of SNM's mimics the mathematics of *Boltzmann Machines* and can provide the basis for a probabilistic spin logic (PSL) for a wide variety of low power computing applications. To illustrate the power and versatility of PSL we will show how it can be used to; (1) implement any given truth table reliably and reconfigurably (examples: AND, OR, XOR gates and character recognition); (2) solve difficult optimization problems (example: traveling salesman problem); and (3) implement relatively large logic operations by connecting basic PSL blocks in a directed manner (examples: 4-bit multipliers and 32-bit adders).

BIO: Supriyo Datta received his B.Tech. from the Indian Institute of Technology, Kharagpur in 1975 and his M.S. and Ph.D. from the University of Illinois at Urbana-Champaign in 1977 and 1979 working on ultrasonics. Since 1985 he has focused on current flow in nanoscale electronic devices and the approach pioneered by his group for the description of quantum transport, combining the non-equilibrium Green function (NEGF) formalism of manybody physics with the Landauer formalism from mesoscopic physics, has been widely adopted in the field of nanoelectronics. This is described in his books Electronic Transport in Mesoscopic Systems (Cambridge 1995) and Quantum Transport: Atom to Transistor (Cambridge 2005). His latest book Lessons from Nanoelectronics: A New Perspective on Transport (World Scientific 2012) tries to make the insights gained from nanoelectronics accessible to a broad audience irrespective of their specialization. Datta is also known for several important conceptual proposals that have subsequently been demonstrated experimentally in diverse areas including molecular electronics, negative capacitance devices, and spin electronics.