



Stochastic Actuated Perpendicular Magnetic Tunnel Junctions for Random Number Generation and Modeling

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Bio: ANDREW KENT is a Professor of Physics and the Founding Director of the Center for Quantum Phenomena at New York University. He received a B.Sc. with Distinction in Applied and Engineering Physics at Cornell University and his Ph.D. from Stanford University in Applied Physics. His research interests are in the physics of magnetic nanostructures, nanomagnetic devices, and magnetic information storage. He is a fellow of the American Physical Society (APS) and the Institute of Electrical and Electronic Engineers (IEEE). He received an Honorary Doctorate from the University of Lorraine, France, in 2013, the French Jean d'Alembert Research Fellowship in 2017, and was named professor at the University of Lorraine in 2018.

Abstract: True random number generators (TRNGs) are essential for many computing applications, such as cryptography, neuromorphic systems, and Monte Carlo simulations [1]. However, designing and realizing CMOS TRNGs simultaneously offering high throughput, low energy, and small cell sizes is challenging. Magnetic tunnel junction (MTJ) nanopillar devices provide significant new opportunities, being low power and compact, with the potential for higher throughput, lower energy, and smaller footprints than CMOS-based devices. MTJs can transform magnetic noise generated by thermal fluctuations into stochastic bit streams (two-level resistance fluctuations). This talk will highlight the device physics determining their key characteristics, e.g., speed and energy usage, and provide an overview of different nanomagnetic TRNG device concepts.

I will then discuss our approach using perpendicular magnetic tunnel junctions (pMTJs) actuated with nanosecond and sub-nanosecond pulses — i.e., which operate in the spin-torque ballistic limit [2]. We denote this a stochastic magnetic actuated random transducer (SMART) pMTJ device because the pulse generates a random bit stream on-demand, much like a coin flip. SMART-pMTJs produce truly random bit streams at high rates while being more robust to environmental changes, such as their operating temperature and device-to-device variations, compared to other stochastic nanomagnetic devices [3-5]. By interfacing a pMTJ to an FPGA, we have generated over 1 trillion bits at rates greater than 10 MHz that pass multiple statistical tests for true randomness, including all the NIST tests for random number generators with only one XOR operation [6]. We also use these random bits to generate probability distributions for modeling. Finally, I will discuss opportunities to advance the science and applications of stochastic MTJs.

References

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