The 2020 Around-the-Clock Around-the-Globe Magnetics Conference: Invited speakers information

Name: Mark
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Title of the talk: <u>**Spintronics for neuromorphic computing**</u>

Biography:
Mark Stiles is a NIST Fellow in the Advanced Computing Group in the Physical Measurement Laboratory. He received a M.S./B.S. in Physics from Yale University, and M.S. and Ph.D. degrees in Physics from Cornell University. Following postdoctoral research at AT&T Bell Laboratories, he joined the research staff at NIST. Mark's research has focused on the development of a variety of theoretical methods for predicting the properties of magnetic nanostructures and has recently shifted to neuromorphic computing. He has helped organize numerous conferences and has served the American Physical Society on the Executive Committee of the Division of Condensed Matter Physics and as Chair and on the Executive Committee of the Topical Group on Magnetism. He has also served as a Divisional Associate Editor for Physical Review Letters, served on the Editorial Board of Physical Review Applied, and is an Associate Editor for Reviews of Modern physics. Mark is a Fellow of the American Physical Society and has been awarded the Silver Medal from the Department of Commerce.

Abstract:
Human brains can solve many problems with orders of magnitude more energy efficiency than traditional computers. As the importance of such problems, like image, voice, and video recognition increases, so does the drive to develop computers that approach the energy efficiency of the brain to solve them. Magnetic devices have several properties that make them attractive for such applications. I give a brief overview of the variety of devices and approaches that are under consideration [1,2] and then focus on magnetic tunnel junctions. Based on the ability to read the magnetic state of a tunnel junction through the tunneling magnetoresistance and the ability to electrically control it through spin-transfer and spin-orbit torques, magnetic tunnel junctions are actively being developed for integration into CMOS integrated circuits to provide non-volatile memory. This development makes it feasible to consider other geometries that have different properties. I describe computing schemes based on two such alternative configurations, spin-torque nano-oscillators, which can be excited into an oscillatory state and used in analogy with oscillatory processes in the brain and superparamagnetic tunnel junctions, which thermally fluctuate between states and can be used in analogy to the stochastic process in the brain. Finally, I focus on representative projects for each of these structures from work by

collaborators. The first [3] uses spin-torque nano-oscillators in a reservoir computing scheme and the second [4] uses superparamagnetic tunnel junction for stochastic computing.

References:

[1] J. Grollier, D. Querlioz, M. D. Stiles, “Spintronic Nanodevices for Bioinspired Computing,” Proc. IEEE, 104, 2024 (2016).
[2] J. Grollier, D. Querlioz, K. Y. Camsari, K. Everschor-Sitte, S. Fukami, M. D. Stiles, “Neuromorphic Spintronics,” Nat. Electron. 3, 360 (2020).
[3] J. Torrejon, M. Riou, F. Abreu Araujo, S. Tsunegi, G. Khalsa, D. Querlioz, P. Bortolotti, V. Cros, K. Yakushiji, A. Fukushima, H. Kubota, S. Yuasa, M. D. Stiles and J. Grollier, “Neuromorphic computing with nanoscale spintronic oscillators,” Nature 547, 428 (2017).
[4] M. W. Daniels, A. Madhavan, P. Talatchian, A. Mizrahi, and M. D. Stiles “Energy-efficient stochastic computing with superparamagnetic tunnel junctions,” Phys. Rev. Applied 13, 034016 (2020).