**Physics and Applications of Spin-Transfer Torques\***

Andrew Kent, Center for Quantum Phenomena, Department of Physics, New York University

The magnetization of a magnetic material can be reversed by electric currents that transport spin angular momentum [1]. This was predicted in magnetic tunnel junctions—two metallic ferromagnetic layers separated by a thin insulating barrier—by John Slonczewski in 1989 and demonstrated experimentally about a decade later. This discovery has had an enormous impact on magnetism research and technology [2], as prior to this the primary means to reorient the magnetization of a magnet was by applying magnetic fields (dating to 1819 and Oersted!). In this talk I will highlight some of the physics and applications enabled by the discovery of spin-transfer torques. This includes recent experiments that create localized spin-wave excitations (magnons droplets) in thin films with uniaxial magnetic anisotropy [3]. Spin-transfer torques also permit study of magnetic analogues of superconductivity, superfluidity and the Josephson effect that promise to increase our understanding of collective quantum effects. They may even enable braiding Majorana fermions [4]. Finally, if time permits, I will discuss spin-torque switching of perpendicularly magnetized magnetic tunnel junctions [5], the basic device used in spin-transfer torque magnetic random access memories.

[1] A. Brataas, A. D. Kent and H. Ohno, “Current-Induced Torques in Magnetic Materials,” Nature Materials **11**, 372 (2012)

[2] A. D. Kent and D. C. Worledge, “A new spin on magnetic memories,” Nature Nanotechnology **10**, 187 (2015)

 [3] D. Backes, F. Macia, S. Bonetti, R. Kukreja, H. Ohldag and A. D. Kent, “Direct Observation of a Localized Magnetic Soliton in a Spin-Transfer Nanocontact,” PRL **115**, 127205 (2015)

[4] Alex Matos-Abiaguea, Javad Shabani, Andrew D. Kent, Geoffrey L. Fatina, Benedikt Scharfa, Igor Ž utić, “Tunable magnetic textures: From Majorana bound states to braiding,” Solid State Communications **262**, 1 (2017)

[5] C. Hahn, G. Wolf, B. Kardasz, S. Watts, M. Pinarbasi, A. D. Kent, “Time-resolved studies of the spin-transfer reversal mechanism in perpendicularly magnetized magnetic tunnel junctions,” Physical Review B **94**, 214432 (2016)

\*Work done in collaboration with Dirk Backes, Gabriel Chaves, Daniel Gopman, Christian Hahn, Jinting Hang, Yuming Hung, Ferran Macia, Daniele Pinna, Laura Rehm, Debangsu Roy, Javad Shabani and Volker Sluka at NYU; Georg Wolf, Bartek Kardasz, Steve Watts and Mustafa Pinarbasi at Spin Transfer Technologies Inc.;and Hendrik Ohldag at SSRL