Topological Spintronics: Controlling and Manipulating Spins Using Helical Dirac Fermions

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We provide a perspective on the recent emergence of "topological spintronics," which exploits the helical spin texture of two-dimensional surface states in three-dimensional topological insulators. Spin- and angle-resolved photoemission spectroscopy shows how this spin texture can be engineered using quantum tunneling between surfaces [1] while spin transport devices allow for all electrical measurements of the underlying spin-momentum "locking" [2,3]. In bilayers of a topological insulator and a ferromagnetic metal, spin transfer torque ferromagnetic resonance experiments find evidence for a highly efficient charge- to-spin conversion at room temperature [4]. We also describe more recent experiments that examine spin-pumping at room temperature from both metallic [5] and insulating [6] ferromagnets into topological insulators.

[1] M. Neupane, A. Richardella et al., Nature Communications 5, 3841 (2014).

[2] Luqiao Liu, A. Richardella et al., Phys. Rev. B 91, 235437 (2015).

[3] J. S. Lee, A. Richardella et al., Phys. Rev. B 92, 155312 (2015) .

[4] A. Mellnik, J. S. Lee, A. Richardella et al., Nature 511, 449 (2014).

[5] M. Jamali et al., Nano Letters 10, 7126 (2015).

[6] Hailong Wang et al., submitted.

BIO: Dr. Samarth is Downsbrough Department Head and Professor of Physics at the Pennsylvania State University (PSU). From 1992-1998 he was Assistant Professor of Physics at PSU, and was promoted to Associate Professor in 1998 and to Professor in 2001. He performed his post-doctoral research as a Research Associate and Assistant Faculty Fellow at the University of Notre Dame under Professor Jacek Furdyna (1986-1992). He received this Ph.D. in Physics from Purdue University, also under the direction of Professor Jacek Furdyna (1980-1986). He is a Fellow of the American Physical Society and Fellow of the American Association for the Advancement of Science, a recipient of PSU's Faculty Scholar Medal in the Physical Sciences and received an Outstanding Physics Alumnus Award from Purdue University.

Dr. Samarth has pioneered the epitaxial growth and nanopatterning of a variety of spin-based heterostructures based upon both conventional and magnetic semiconductors and ferromagnetic metals, resulting in fundamental advances in semiconductor spintronics, frustrated magnetic arrays and topological insulators. He has published 225 papers with about 8000 citations and has an h-index of 45.