Current induced electronic and nuclear spin polarizations in topological insulators

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Abstract: I will discuss our recent experimental demonstration of electrical current induced electron spin polarization (CIESP) in topological insulators (TI), resulting from the spin-momentum locking of topological surface state (TSS) electrons [1]. Our transport measurements utilize ferromagnets as spin-sensitive voltage probes (so called "spin potentiometry") to measure the spin-dependent electronic chemical potentials. I will discuss how to distinguish such CIESP due to TSS from the CIESP due to surface 2D electron gases (2DEG) with Rashba spin-orbit coupling (SOC) formed by bulk band bending that also exist in many real TI materials. I will then discuss our recent observation of a long-lived persistent electronic spin polarization (persisting for several days at low temperatures) even after removal of the current, a remarkable effect that we attribute to the current-induced nuclear spin polarization (CINSP) [2]. Such a CINSP results from the hyperfine coupling between electronic and nuclear spins revealed in NMR but largely neglected in transport measurements so far. While the exactly mechanisms remain to be understood, the exceptional long lifetime might result from various intriguing situations unique to TIs that may help suppress the nuclear spin relaxation processes operating in conventional metals and semiconductors. The persistent CIESP and CINSP may lead to a "spin battery" or quantum memory for spintronics and quantum information applications. Our studies reveal a rich variety of entities in real topological materials that may play important roles in potential applications in spintronics.

[1] J. Tian et al., Scientific Reports 5, 14293 (2015)

[2] J. Tian et al. Science Advances 3, e1602531 (2017)