Using Topology; From Detecting Dark Matter to making a Giant Spin Hall Effect

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Topological insulators and semimetals are centered around the idea of symmetry demanded electronic structure features resulting in electrons behaving in unusual ways. Here I will briefly outline another quasiparticle state termed the "axionic insulator", which can be formed from magnetic topological insulators, and how we propose to use that state to try and detect dark matter. Magnetic topological insulators can satisfy the Wilzcek criteria for creating dynamical axions in the form of spin wave excitations and with an applied magnetic field the axion mass inside the magnetic TI can be tuned to resonantly couple with dark matter axions in the few meV regime[1]. Also, I will also discuss the use of simple ideas learned from topological physics combined with simple solid state chemistry to realize materials with a giant Spin hall effect. Spin orbit coupled, gapped Dirac anti-crossings create points of large spin Berry curvature and subsequently a large spin Hall effect. This idea can be realized in simple, sputerrable materials which, from an electronic structure point of view, can be thought of as "failed" topological insulators[2], and are highly desirable for spintronic applications.

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[1] David J.E. Marsh, arXiv:1807.08810
[2] S. Yang, APX, 3, 1, 2018