Shining light on topological insulators and Weyl semimetals

Liang Wu

Department of Physics, University of California, Berkeley, CA, 94720

Email:liangwu@berkeley.edu

The last decade has witnessed an explosion of research investigating the role of topology in band-structure, as exemplified by the wealth of recent works on topological insulators (TIs) and Weyl semimetals (WSMs). In this talk I hope to convince you that optical probes of solids give unique insight into these topological states of matter. First, I will discuss how we can probe the special low-energy electrodynamics of 3D TI thin films of Bi_2Se_3 using time-domain THz spectroscopy[1]. I will then discuss our work following the evolution of the response as a function of magnetic field from a semi-classical transport regime [2] to a quantum regime [3]. In the later case, although DC transport is still semi-classical, we find evidence for Faraday and Kerr rotation angles quantized in units of the fine structure constant [3]. This is consistent with the long-sought "axion electrodynamics" and the topological magneto-electric effect of 3D TIs. Among other aspects this give a purely solid-state measure of the fine structure constant based on a topological invariant [3]. I will also discuss how optics can observe quantized Hall conductance without involving the edge states [3]. Finally, I will present our most recent discovery of the largest 2^{nd} harmonic generation in transition monopnictide Weyl semimetals such as TaAs [4] and talk about a new perspective of nonlinear optics in term of probing the Berry connection/curvature in momentum space [4]. (The focus of my talk will be on Refs. [3, 4].)

1. Wu, *et al, Nat. Phys.* 9, 410-414 (2013).
2. Wu, *et al, Phy. Rev. Lett.* 115, 217602 (2015).
3. Wu, *et al, Science* 354, 1124-1127 (2016).
4. Wu, *et al, Nat. Phys.* (2016). doi:10.1038/nphys3969