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Measurement of intrinsic Dirac fermion cooling of a topological insulator with time- and angle-resolved photoemission spectroscopy

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Three-dimensional topological insulator (TI) is a new phase of matter with exotic surface electronic properties. Even though the bulk states have a bandgap, the surface electrons possess a linear energy-momentum dispersion that is protected by the nontrivial topology of TI to cross the Fermi level. These properties provide a promising platform for new physics and applications in future electronics and computers including high-speed quantum information processing, whose performance depends critically on the dynamics of hot carriers. Unlike the case in graphene, helical Dirac fermions in a TI interact not only with phonons but also with an underlying bulk reservoir of electrons. In this talk, we will present our recent results of time- and angle-resolved photoemission spectroscopy (TrARPES) study of a prototypical TI Bi2Se3. We show that TrARPES is a powerful tool to distinguish the coupled dynamics between these different degrees of freedom. With the combined sub-picosecond time resolution and energy-momentum resolution, we have directly visualized the coupling between surface and bulk electrons through phonons. At low temperature, such coupling is suppressed and the unique cooling of surface Dirac fermions by acoustic phonons is revealed through the power law cooling rate dependence on doping level. The effect on the TrARPES spectra from varying excitation photon energy will also be discussed.