Band structure engineering in topological heterostructures

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We will present our recent combined experimental and theoretical results on the band structure engineering in 3D topological insulator (TI) bilayers [1] and superlattices [2]. These studies show how new topologies emerge in complex structures, as compared to the routine Fermi level control by alloying [3, 4]. Furthermore, we will present a direct observation of magnetization direction-dependent spin-orbit coupling-induced gaps in thin film of Fe [5] and relate it to the Weyl-physics in ferromagnets.

Molecular beam epitaxy growth of Sb_2Te_3 and Bi_2Te_3 leads to the *p*-type and *n*-type material respectively, due to the low formation energy of charged vacancies and antisites. Growing one of these materials on top of the other leads to a vertical *p-n* junction where the Fermi level position at the surface can be controlled by the thickness of the two layers [1].

The Bi_1Te_1 stoichiometry results from combining two Bi_2Te_3 quintuple layers with one Bi bilayer in the unit cell. New dual topological properties emerge in such a superlattice, with the material behaving simultaneously as a topological crystalline insulator and a weak topological insulator [2]. This opens up the possibility of controlling the topological protection on different surfaces selectively by breaking respective symmetries.

Encouraged by these results we will propose new vistas to employ topological mechanisms in the design of novel spintronic devices. This encompasses not only TIs, but also Weyl and Dirac phases, where in the intrinsic regime the transport is mediated through the Fermi arc boundary modes. In particular, Weyl nodes are abundant in magnetic materials (including both prototypical ones like Fe and complex ones such as the non-collinear antiferromagnet Mn_3Ge). Exploring their properties, for instance when interfaced with topological insulators, in one of the intriguing future directions in condensed matter research with potential future applications.

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