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Bulk Topological Insulators and Superconductors: Discovery and the new Frontiers

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While most known phases of matter are characterized by broken symmetries, the discovery of quantum Hall effects (1980s) revealed that there exists an organizational principle based on topology rather than broken symmetry. In the past few years, theory and experiments have suggested that new types of topological states of matter exist in certain bulk insulators without any applied magnetic field. These topological insulators are characterized by a full band gap in their bulk and gap-less conducting edge or surface states protected by time-reversal symmetry. Unlike the quantum Hall systems, the bulk 3D topological insulators can be doped into superconductors and magnets revealing the interplay between topological-order and broken-symmetry-order [Rev. Mod. Phys 82, 3045 (2010)]. In this talk, I will highlight the experimental observations and focus on recent experimental developments on bulk topological insulators. I will then draw connections between the topological physics and their potential applications in electronics and the emergent new frontiers in fundamental physics. Work in collaboration with D. Hsieh, Y. Xia, L. Wray, D. Qian, C.L. Kane, H. Lin, A. Bansil, D. Grauer, R.J. Cava, Y.S. Hor, J. H. Dil, F. Meier, L. Patthey, J. Osterwalder, A.V. Fedorov.