Ferromagnetism, Quantum Anomalous Hall State and Dissipationless Chiral Conduction in Topological Insulators

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A topological insulator (TI) with broken time reversal symmetry (TRS) by ferromagnetic perturbation of their Dirac surface states can display many exotic quantum phenomena including the quantum anomalous Hall (QAH) effect and dissipationless quantized Hall transport. The realization of the QAH effect in realistic materials requires ferromagnetic insulating materials that have topologically non-trivial electronic band structures. In a TI, the ferromagnetic order and TRS breaking is achievable through doping with a magnetic element or via ferromagnetic proximity coupling with a magnetic material. Our experimental success by both approaches showed excellent results along with some unanticipated observations: the proximity induced magnetism in TI exhibited stability far above the expected temperature range. We will discuss the robust QAH state and dissipationless chiral edge current flow achieved in a hard ferromagnetic TI system.\(^{1,2}\) This could be a major step to lead us towards dissipationless electronic applications, making such devices more amenable for metrology and spintronics applications. Furthermore, our study of the gate and temperature dependences of transport measurements may elucidate the causes of the dissipative edge channels and the need for very low temperature to observe QAH.

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Dr. Moodera’s many years of research in the area of spin polarized tunneling led to the breakthrough in observing tunnel magnetoresistance (TMR) at room temperature in magnetic tunnel junctions (1995). This resulted in a huge surge in this area of research, currently one of the most active areas. TMR effect is used in all ultra-high density magnetic data storage since about 2004, as well as for the development of non-volatile magnetic random access memory (MRAM).