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Abstract for an Invited Paper
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Breaking time reversal symmetry, quantum anomalous Hall state and dissipationless chiral conduction in topological insulators[1]

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Breaking time reversal symmetry (TRS) in a topological insulator (TI) with ferromagnetic perturbation can lead to many exotic quantum phenomena exhibited by Dirac surface states 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 and topologically non-trivial electronic band structures. In a TI, the ferromagnetic order and TRS breaking is achievable by conventional way, through doping with a magnetic element, or by ferromagnetic proximity coupling. Our experimental studies by both approaches will be discussed. In doped TI van Vleck ferromagnetism was observed. The proximity induced magnetism at the interface was stable, beyond the expected temperature range. We shall describe in a hard ferromagnetic TI system a robust QAH state and dissipationless edge current flow is achieved,[1,2] a major step towards dissipationless electronic applications with no external fields, making such devices more amenable for metrology and spintronics applications. Our study of the gate and temperature dependences of local and nonlocal magnetoresistance, may elucidate the causes of the dissipative edge channels and the need for very low temperature to observe QAH. In close collaboration with: CuiZu Chang,[2,3] Ferhat Katmis, [1.2,3] Peng Wei. [1,2,3] ; From Nuclear Eng. Dept. MIT, M. Li, J. Li; From Penn State U, W-W. Zhao, D. Y. Kim, C-x. Liu, J. K. Jain, M. H. W. Chan; From Oakridge National Lab, V. Lauter; From Northeastern U., B. A. Assaf, M. E. Jamer, D. Heiman; From Argonne Lab, J. W. Freeland; From Ruhr-Universitaet Bochum (Germany), F. S. Nogueira, I. Eremin; From Saha Institute of Nuclear Physics (India), B. Satpati. References:

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2. C-Z Chang et al., Nat. Matl 13, 473 (2015), Phys. Rev. Lett. 115, 057206 (2015)

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