Chiral conduction channels in van der Waals topological magnets

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Recent realizations of a nontrivial quantum anomalous Hall (QAH) and axion insulator states, featuring dissipation-free chiral edge currents, made it apparent that when long-range magnetism and band topology combine the consequences of ubiquitous disorder can be particularly acute and yet surprising. Structural disorder can induce spin correlations even in a non-magnetic system [1], while magnetic doping disorder in topological insulators restricts QAH temperature to the mK range and ultrathin layers. We have recently discovered a new Berry-curvature-driven QAH regime at higher temperatures [2] in the $Mn(Bi,Sb)_2Te_4$ class of van der Waals (vdW) intrinsic topological magnets (ITM), where Mn ions self-organize into a superlattice of Mn monolayers that can be separated on-demand. Robust ferromagnetism of such superlattice opens up a large surface gap, and anomalous Hall conductance reaches an e^2/h quantization plateau when the Fermi level is within this gap, even in the presence of the 2D bulk states. The complex electronic structure and limited tunability of both the electron density and exchange interactions in these bulk materials pose significant challenges in accessing chiral channels. In this talk I will describe a new tuning technique we have developed in ITM towards QAH [3] and our most recent results on inducing chiral spin textures in ITM by disorder control with a reversible intake and release of ionic hydrogen. Our findings offer a scalable strategy to manipulate chiral channels for chiral logic and topological spintronics. *Supported in part by NSF grants DMR-2011738 and HRD-2112550.

References

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Figures

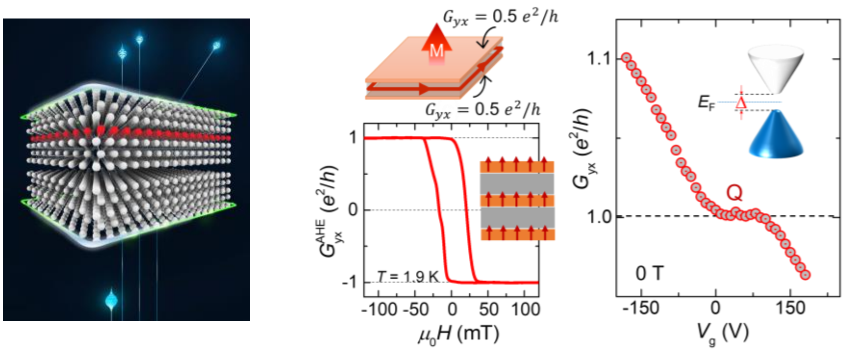

Figure 1: Chiral edge currents and QAH in a self-assembled bulk $MnBi_2Te_4/Bi_2Te_3$ superlattice.

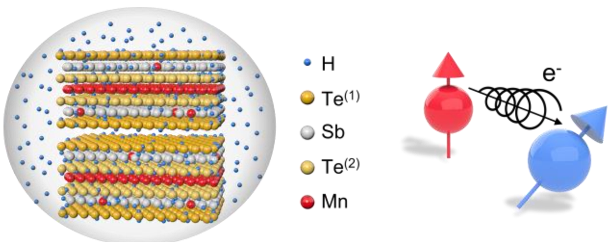

Figure 2: Hydrogenation process of a vdW ITM $MnSb_2Te_4$ that can lead to chiral transport.