Abstract

Magnetic bandgap fluctuations in the intrinsic quantum anomalous hall insulator $MnBi_2Te_4$

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Van der Waals materials have widely varying electronic properties including topological insulator (TI) behaviour (Bi_2Se_3/Bi_2Te_3), and ferromagnetism in 2D (CrI_3). However, these materials are distinct i.e. they possess topological or magnetic properties but not both. Intrinsic magnetic topological insulators such as $MnBi_2Te_4$ possess both magnetic and topological states,[1] offering the potential for low disorder and large magnetic bandgaps in order to achieve robust magnetic topological phases operating at higher temperatures.[2] By controlling the layer thickness, emergent phenomena such as the quantum anomalous Hall (QAH) effect and axion insulator phases have been realised.[3] Yet, these observations occur at temperatures significantly lower than the Néel temperature of $MnBi_2Te_4$. The origin of such suppression remains an outstanding issue and needs to be overcome in order to improve the temperature at which QAHE is observed.

In this talk I will discuss using low-temperature scanning tunnelling microscopy and spectroscopy to measure the magnetic gap in 5 SL $MnBi_2Te_4$. The magnetic Dirac gap is found to fluctuate spatially, forming regions that are either completely gapless representing metallic puddles or fully gapped regions with gaps above 50 meV. We further demonstrate the hybridization of the chiral edge state with these metallic puddles in the bulk, where puddles serve as conductive pathways that cause dissipation, and therefore, suppress QAHE. Finally, I will demonstrate that a perpendicular magnetic field well below the spin-flop transition is able to restore the magnetic gap in these puddle regions, confirming they originate from magnetic surface disorder. This offers key insight into the importance of mitigating magnetic disorder so that QAHE and lossless transport applications can be realised at elevated temperatures.

References:

[1] M. M. Otrokov et al., Nature 576, 416 (2019)
[2] M. M. Otrokov et al., Physical Review Letters 122, 107202 (2019)
[3] Y. Deng et al., Science 367, 895 (2020)