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Spin Texture Control and Magnetic Gap Engineering in a Ferromagnetic Insulator-Topological Insulator Sandwiched Heterostructure.

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The interplay between topology and magnetism in quantum materials gives rise to novel quantum phases, characterized by topologically protected surface states with non-trivial electronic band structures and complex spin textures. One of the most compelling outcomes of this interplay is the quantum anomalous Hall effect (QAHE)¹, where a single chiral edge mode enables dissipationless electron transport. Realizing QAHE requires a magnetic exchange gap to open at the Dirac point (DP) of a topological insulator's surface states. The ferromagnetic insulator –topological insulator sandwich heterostructure composed of four-quintuple layer Bi_2Te_3 between two single-septuple layers of MnBi_2Te_4 (MBT/4BT/MBT), has recently been proposed as a magnetic topological insulator (MTI) through proximity-induced magnetization.² A gap of 75 meV and relatively high Curie temperature make it a candidate for realizing the QAHE at elevated temperatures. Despite the prior characterisation of the gap², the spin texture of the exchange-split surface state remains an open, but crucial, question. Additionally, reports exist regarding gap opening in Bi_2Se_3 -family TIs via non-magnetic means,³ and therefore the direct characterization of the MTI spin texture- and the ability to manipulate it with an external magnetic field- would provide an unambiguous origin for the observed gap.

We report characterization of the surface-state spin texture of the MBT/4BT/MBT heterostructure using spin- and angle-resolved photoemission spectroscopy to directly verify that the band gap arises from broken time-reversal symmetry via proximity-driven magnetization. This study reveals a clear spin splitting at the Γ -point and demonstrates direct control of spin state via external magnetic fields, providing an unambiguous verification that the gap arises from exchange splitting rather than non-magnetic origins. The robust magnetic gap and controllable spin texture make this heterostructure a suitable candidate for spintronic applications and magnetic topological quantum phases.

References

- [1] Science 340, 167(2013)
- [2] Advanced Materials 34, 2107520(2022)
- [3] Nature Communications 7, 10559(2016)

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