Influence of extrinsic properties on magnetism and magnetotransport in Mn doped Bi_2Te_3 topological insulator with self-organized $MnBi_2Te_4$ layers.

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There is a growing interest in magnetic topological insulators (MTIs), which combine the properties of materials exhibiting magnetic order with properties of topological matter. The combination of these features leads to exotic quantum phenomena such as the quantum anomalous Hall effect (QAHE) and the axion insulator phase [1–5].

Among the MTIs one of the systems widely studied is the topological insulator bismuth telluride (Bi_2Te_3) doped with manganese (Mn). Under appropriate growth conditions, Mn ions can form self-organized heterostructures composed of an alternating sequence of $MnBi_2Te_4$ septuple layers (SLs) and *n*-fold Bi_2Te_3 quintuple layers (QLs). The $MnBi_2Te_4/(Bi_2Te_3)_n$ compounds belong to the family of intrinsic MTIs which, compared to dilute MTIs with randomly distributed Mn atoms, can provide more uniform electronic and magnetic properties resulting in larger Dirac mass gap as well as an increase in the QAHE realization temperature [6–8]. The QAHE state has been indeed achieved in crystal flakes with the $MnBi_2Te_4/(Bi_2Te_3)_n$ naturally occurring superlattice at record-high temperature [2]. It became simultaneously clear that the reduction of the influence of extrinsic effects, such as inherent magnetic disorder caused by different locations of Mn dopants and bulk carrier density, is necessary to master the QAHE. In my presentation, I will talk about our recent advances in understanding the role of both of these issues [9,10].

[1] C. X. Liu, S. C. Zhang, and X. L. Qi, *The Quantum Anomalous Hall Effect: Theory and Experiment*, Annu. Rev. Condens. Matter Phys. **7**, 301 (2016).

[2] H. Deng et al., *High-Temperature Quantum Anomalous Hall Regime in a $MnBi_2Te_4/Bi_2Te_3$ Superlattice*, Nat. Phys. **17**, 36 (2021).

[3] S. Grauer, K. M. Fijalkowski, S. Schreyeck, M. Winnerlein, K. Brunner, R. Thomale, C. Gould, and L. W. Molenkamp, *Scaling of the Quantum Anomalous Hall Effect as an Indicator of Axion Electrodynamics*, Phys. Rev. Lett. **118**, 1 (2017).

[4] Y. Deng, Y. Yu, M. Z. Shi, Z. Guo, Z. Xu, J. Wang, X. H. Chen, and Y. Zhang, *Quantum Anomalous Hall Effect in Intrinsic Magnetic Topological Insulator $MnBi_2Te_4$*, Science **367**, 895 (2020).

[5] D. Xiao et al., *Realization of the Axion Insulator State in Quantum Anomalous Hall Sandwich Heterostructures*, Phys. Rev. Lett. **120**, 1 (2018).

[6] M. M. Otrokov, T. V. Menshchikova, I. P. Rusinov, M. G. Vergniory, V. M. Kuznetsov, and E. V. Chulkov, *Magnetic Extension as an Efficient Method for Realizing the Quantum Anomalous Hall State in Topological Insulators*, JETP Lett. (2017).

[7] J. Li, Y. Li, S. Du, Z. Wang, B. L. Gu, S. C. Zhang, K. He, W. Duan, and Y. Xu, *Intrinsic Magnetic Topological Insulators in van Der Waals Layered $MnBi_2Te_4$-Family Materials*, Sci. Adv. **5**, 1 (2019).

[8] H. Chi and J. S. Moodera, *Progress and Prospects in the Quantum Anomalous Hall Effect*, APL Mater. **10**, (2022).

[9] J. Sitnicka et al., *Systemic Consequences of Disorder in Magnetically Self-Organized Topological $MnBi_2Te_4$/(Bi2Te3)$_n$ superlattices*, 2D Mater. (2022).

[10] J. Sitnicka, M. Konczykowski, K. Sobczak, P. Skupiński, K. Grasza, Z. Adamus, A. Reszka, and A. Wołoś, *Fermi Level Dependence of Magnetism and Magnetotransport in the Magnetic Topological Insulators Bi_2Te_3 and $BiSbTe_3$ Containing Self-Organized $MnBi_2Te_4$ Septuple Layers*, arXiv: https://doi.org/10.48550/arXiv.2211.00546 (2022).