Marrying Spintronics with Topological Physics in low dimensional quantum materials

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Abstract

We will present theoretical spin transport features in $MoTe_2$ and WTe_2-based materials which are particularly interesting Quantum Materials [1]. By focusing on the monolayer limit, using DFT-derived tight-binding models, and using both efficient bulk and multi-terminal formalisms and techniques [2,3], I will first discuss the emergence of new forms of intrinsic spin Hall effect (SHE) that produce large and robust in-plane spin polarizations. Quantum transport calculations on realistic device geometries with disorder demonstrate large charge-to-spin interconversion efficiency with gate tunable spin Hall angle as large as $\theta_{xy}\approx 80\%$, and SHE figure of merit $\lambda_s.\theta_{xy}\sim 8\text{-}10$ nm, largely superior to any known SHE material [4]. We will show our theoretical prediction of an unconventional canted quantum spin Hall phase in the monolayer Td-WTe_2, which exhibits hitherto unknown features in other topological materials [5]. The low symmetry of the structure induces a canted spin texture in the yz plane, dictating the spin polarization of topologically protected boundary states. Additionally, the spin Hall conductivity gets quantized ($2e^2/h$) with a spin quantization axis parallel to the canting direction. We also predict the control of the canted QSHE by electric field [6]. We will finally discuss the emerging spin-orbit torque components at interface of van der Waals heterostructures [7]

References

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