

Spin on 2D Topological Quantum Material Devices

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An outstanding feature of topological quantum materials is their unique spin topology in the electronic band structures with novel charge-to-spin conversion effects. Here, we integrated graphene with a topological insulator (TI) in van der Waals heterostructures¹ to engineer proximity-induced spin-charge conversion phenomena. In these heterostructures, we experimentally demonstrate a gate-tunable spin-galvanic effect at room temperature, allowing for efficient conversion of a non-equilibrium spin polarization into a transverse charge current.² Furthermore, in the Weyl semimetal candidate WTe_2 , we observed both conventional³ and unconventional⁴ charge-to-spin conversion effects at room temperature (Fig. 1). Such an unconventional charge-spin conversion can be possible in WTe_2 due to a reduced crystal symmetry combined with its large spin Berry curvature, spin-orbit interaction with a novel spin-texture of the Fermi states. These findings provide an efficient route for realizing all-electrical and gate-tunable spin-orbit phenomenon in topological materials and their heterostructures.

1. Tailoring emergent spin phenomena in Dirac material heterostructures.

D Khokhriakov, A. W. Cummings, K Song, M Vila, B Karpiak, A Dankert, S Roche and SP. Dash.

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2. Gate-tunable Spin-Galvanic Effect in Graphene - Topological insulator van der Waals Heterostructures at Room Temperature. D Khokhriakov, AM Hoque, B Karpiak, SP Dash.

Nature Communication 11, 3657 (2020).

3. Observation of charge to spin conversion in Weyl semimetal at room temperature.

B Zhao, D Khokhriakov, Y Zhang, H Fu, B Karpiak, AM Hoque, X Xu, Y Jiang, B Yan, SP Dash.

Physical Review Research 2 (1), 013286 (2020).

4. Unconventional charge-to-spin conversion Weyl Semimetal WTe_2 .

B Zhao, B Karpiak, D Khokhriakov, A Johansson, AM Hoque, X Xu, Y Jiang, I Mertig, SP Dash.

Advanced Materials, 2000818 (2020).

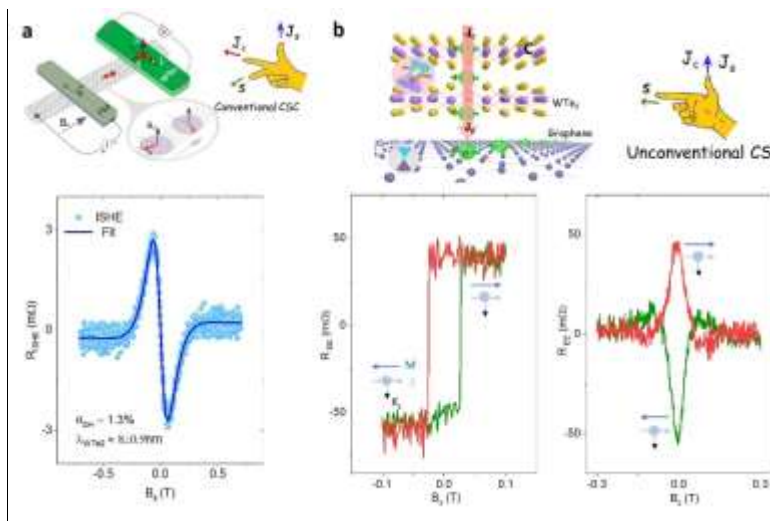


Fig. 1. Charge-to-spin conversion in WTe_2 . **a.** Device geometry and Hanle measurement of conventional charge-to-spin conversion in WTe_2 (Ref. 1). **b.** Measurement of unconventional charge-to-spin conversion in WTe_2 . The measurement of spin-valve and Hanle signals both in parallel and anti-parallel configurations at room temperature show the unconventional nature of charge-to-spin conversion.