

Electrical control of spin polarization in WTe₂

José Hugo Garcia

Jose H. Garcia, Jinxuan You, Mónica García-Mota, Peter Koval, Pablo Ordejón, Ramón Cuadrado, Matthieu J. Verstraete, Zeila Zanolli, and Stephan Roche

Catalan Institute of Nanoscience and Nanotechnology - ICN2, (CSIC and BIST), Campus UAB, Bellaterra, 08193 Barcelona, Spain

Simune Atomistics S.L., Tolosa Hiribidea, 76, 20018 Donostia-San Sebastian, Spain

Department of Materials Science, Universitat Autònoma de Barcelona, Cerdanyola del Vallès, 08193 Bellaterra, Spain

nanomat/QMAT/CESAM and European Theoretical Spectroscopy Facility Universite de Liege, Allee du 6 Aout 19 (B5a), 4000 Liege, Belgium Dept. of Chemistry, Debye Institute for Nanomaterials Science, and ETSF, Utrecht University, The Netherlands

ICREA–Institutió Catalana de Recerca i Estudis Avançats, 08010 Barcelona, Spain

Josehugo.garcia@icn2.cat

The existence of the quantum spin Hall (QSH) insulator has boosted opportunities for spintronics and quantum metrology, given the ability of topologically protected states to convey spin information over long distances at ultralow dissipation rate. QSH is a manifestation of strong spin-orbit coupling. However, even in time-reversal symmetric systems, the lack of a spin conservation axis in QSH insulators allows backscattering effects for edge states, limiting their ballistic transport. In some situations, the emergence of a phenomenon known as persistent spin texture (PST) enforces spin conservation and favors long spin lifetimes even in the presence of chemical disorder and structural imperfections. Such an effect is deeply rooted in the underlying symmetries of the system and opens promising prospects for spintronics when combined with the manifestation of dissipationless chiral edge states. The recent prediction and experimental observations of a PST-driven canted quantum spin Hall effect in low-symmetry monolayer WTe₂ provide a new ingredient for the use of topological materials in spintronic applications.

This work reports on the possibility of a fully controllable variation of up to 90 degrees rotation of the spin polarization of chiral edge-states, dictating the canted QSH effect, while preserving spin conservation. By combining density functional theory (DFT) with tight-binding methods and quantum transport simulations, we show that the emerging PST can be continuously varied from in-plane to out-of-plane under electric fields below 0.1 V/nm, making this effect experimentally accessible. The experimental confirmation of such fully electrically tunable spin-polarized topological currents would establish a new milestone towards replacing magnetic components in spintronic devices and all-electric spin circuit architectures, as well as optimized resistance quantum standards.

References

- [1] J. H. Garcia, Jinxuan You, Mónica García-Mota, Peter Koval, Pablo Ordejón, Ramón Cuadrado, Matthieu J. Verstraete, Zeila Zanolli, and Stephan Roche. *Physical Review B* 106, L161410 (2022)