Quasi-ballistic transport of spin-helical Dirac fermions in 3D topological insulator quantum wires

V. Labracherie[a], L. Veyrat[b], J. Dufouleur[a], S. Hampel[a], R. Giraud[a,c*]

a. Leibniz Institute for Solid State and Materials Research, IFW Dresden, D-01069 Dresden, Germany
b. Univ. Grenoble Alpes, CNRS, Grenoble INP, Institut Néel, 38000 Grenoble, France
c. Univ. Grenoble Alpes, CNRS, CEA, Grenoble INP, INAC-Spintec, 38000 Grenoble, France

* romain.giraud@cea.fr

Despite strong disorder, the transport of surface Dirac fermions remains quasi-ballistic in narrow (quantum) nanostructures of a 3D topological insulator, as evidenced with Bi_2Se_3 or Bi_2Te_3 nanowires [1,2]. We demonstrate that such a unique behavior for a mesoscopic conductor results from the spin helicity of all quasi-1D surface modes, rather than from the topological nature of a single perfectly-transmitted mode. The weak coupling of spin-helical modes can be revealed by the non-universal behavior of conductance fluctuations [3], and the spin and energy-dependence of transmissions is well captured by both analytical and numerical models. It is further discussed that, under appropriate conditions, such 3D topological insulator quantum wires could be used not only for ballistic spin transport but also as spin filters.

[1] J. Dufouleur *et al.*, Phys. Rev. Lett. **110**, 186806 (2013)
[2] L.A. Jauregui *et al.*, Nat. Nano. **11**, 345 (2016)
[3] J. Dufouleur *et al.*, Sci. Rep. **7**, 45276 (2017)