Superconducting proximity effect to probe the topological protection of edge states in Bismuth nanowires

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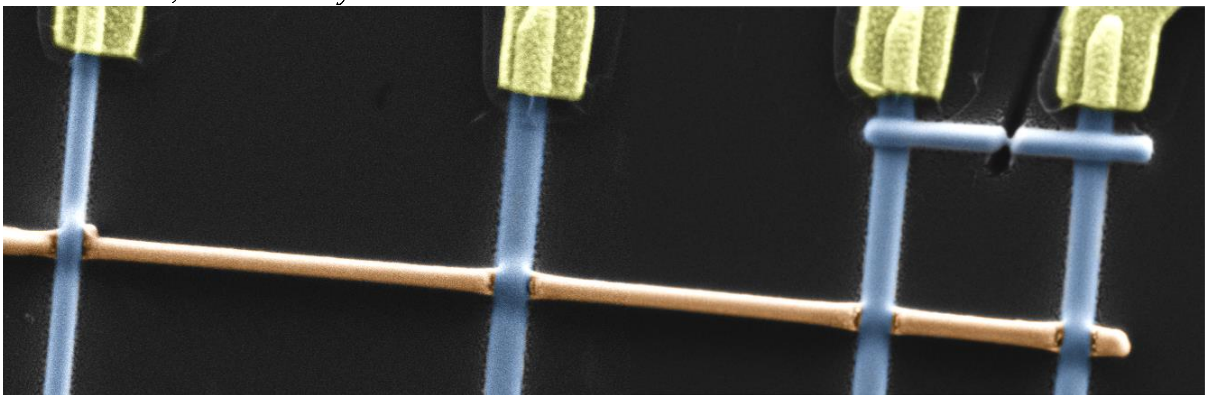

Reducing the size of a conductor usually decreases its conductivity because of the enhanced effect of disorder in low dimensions, leading to diffusive transport and to weak, or even strong localization. Notable exceptions occur when topology provides protection against disorder, such as in the Quantum Hall effect or the recently discovered Quantum Spin Hall effect in two-dimensional Topological Insulators. In the latter, crystalline symmetry combined with high spin-orbit coupling generate band inversion and one-dimensional chiral edge states with perfect spin-momentum locking, that theoretically precludes backscattering along the edges. However, since the first evidences of edge state currents, both in the normal and superconducting-proximitised states, demonstrating the robustness of ballistic conduction and spin polarization in the one-dimensional edge states has remained a challenge. In this talk, I will present a direct signature of ballistic 1D transport along the topological surfaces of a single crystal bismuth nanowire connected to superconducting electrodes. This signature was obtained by exploiting the extreme sensitivity of the relation between the Josephson current flowing through a nanostructure and the superconducting phase difference at its ends, the "current-phase relation" (CPR). The sharp sawtooth-shaped CPR we find demonstrates that transport occurs ballistically along two edges of the nanowire, and confirms the predicted nearly perfect transmission of Cooper pairs through Quantum Spin Hall edge states. I will then describe our recent measurement of the high frequency response of the Bismuth nanowire inserted in a superconducting ring, a setup ideal to probe the topological protection of the edge states.

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