INTERNSHIP PROPOSAL

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Thesis possibility after internship: YES
Funding: YES

Revealing topological helical edge states in the second order topological insulator BiBr

One of the greatest recent achievement in Condensed matter physics is the discovery of a new class of materials, Topological Insulators (TI), whose bulk is insulating, while the edges conduct current in a quasi-ideal way. In particular, the 1D edges of 2DTI realize the Quantum Spin Hall state, where current is carried dissipationlessly by two counter-propagating ballistic edge states with a spin orientation locked to that of the propagation direction (a helical edge state). This opens many possibilities, ranging from dissipationless charge and spin transport at room temperature to new avenues for quantum computing. We are investigating charge and spin currents in a newly discovered class of TIs, Second Order Topological Insulators (SOTIs), which are three-dimensional crystals with insulating bulk and surfaces, but perfectly conducting (topologically protected) one-dimensional helical "hinge" states. Unfortunately, the expected topological protection has turned out to be less robust than anticipated, notably due to the existence of conduction in the bulk and surface. This complicates the fundamental study of the edge states, and motivates the search for different TIs with a reduced contribution of the non-topological bulk states. Among newly discovered TIs, Bi4Br4 appears to be a very promising material, with a large bulk gap, and strong experimental indications of a Second Order Topological Insulator (SOTI) character.

Our work on this material is focused on evidencing these hinge states in low-temperature transport experiments by investigating the modulation of quantum interferences with magnetic field and gate voltage and use Josephson interferometry in hybrid Josephson junctions. We have already found signatures of phase coherence in µm-sized samples with surprisingly large characteristic fields, and a strongly anisotropic behavior. These results suggests that transport in the Bi4Br4 flakes is mediated by 1D ballistic channels, which scatter only in the region under the metallic electrodes. The student will participate to the fabrication of junctions on BiBr with superconducting contacts and to their measurement at very low temperature. The internship may be continued into a PhD.

<u>Methods and techniques:</u>
The experiments will combine different techniques available in our group:
1-Nanofabrication using conventional technique, as well as a focused ion beam to shape the crystalline samples for transport measurements and contact them with superconducting electrodes.
2 – Characterization of the samples with AFM, SEM observation and possibly STEM.
3 - Low temperature magnetotransport measurements in a cryo-free dilution refrigerator equipped with a 3-axis magnet.

Condensed Matter Physics:	YES	Soft Matter and Biological Physics:	NO
Quantum Physics:	YES	Theoretical Physics:	YES