Master 2: ***International Centre for Fundamental Physics***

INTERNSHIP PROPOSAL

Laboratory name: LPS
CNRS identification code:
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Internship location: LPS, Bâtiment 510, Université Paris-Saclay 91405 Orsay
Thesis possibility after internship: YES Funding: Yes

Unveiling topological helical edge states in the bismuth bromide second order topological insulator

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. Bismuth was recently shown to belong to this class of materials, thanks in part to the intriguing behaviour we had detected in bismuth nanowires connected to superconducting electrodes. However, because Bi is a semimetal, topological states were shown to coexist with non-topological ones.

Recently, other materials were proposed as possible members of this topological family. Among them Bi4Br4 is particularly interesting because, in contrast to bismuth, its bulk is a good insulator. We propose during this internship to explore the possible hinge states in this new material using experimental techniques we have developed to reveal hinge states in bismuth. Our goal is to reveal, characterize and exploit the unique properties of these 1D states, in particular the high velocity, ballistic, and dissipationless hinge currents. The superconducting proximity effect and quantum interferences induced by a magnetic field will be used to reveal the spatial distribution of conduction paths, and to test their ballisticity as well as their spatial transverse extension.

These experiments will combine different techniques available in our group:

1-Nanofabrication using a focused ion beam to shape the crystalline samples for transport measurements and contact them with superconducting electrodes.

2- Low temperature magnetotransport measuremenst in a newly acquired cryo-free dilution refrigerator equipped with a 3 axis magnet.

A. Murani et al. *Nat. Com.s* 8, 15941. 2017. A. Murani *et al*, Phys. Rev. Lett. 122, 076802 (2019).
F. Schindler et al. Nat. Phys. 14, 918 (2018).
R. Noguchi et al; arXiv:2002.01134

Mis en forme : Police :11 pt, Français (France)

Condensed Matter Physics: YES Macroscopic Physics and complexity: NO
Quantum Physics: YES Theoretical Physics: YES