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

INTERNSHIP PROPOSAL

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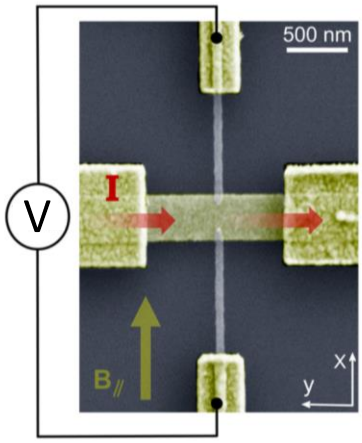
Thesis possibility after internship: YES
Funding: YES (already obtained) If YES, type of funding: Marie Curie ITN (EU)

Spin-charge conversion in topological insulators

The conversion of a conventional charge current into a spin current, carrying not charges but angular momentum, can be done in non-magnetic systems using the spin-orbit coupling. Over the past ten years, the use of this coupling has caused a radical transformation of spin electronics.



Whereas conventional spintronics uses the exchange interaction in a ferromagnet, spin-orbit coupling can now be used to generate or detect spin currents, possibly in absence of any ferromagnetic element. Spin-dependent transport effects can thus be observed in topological insulators.
We will use the spin pumping phenomenon, which takes place at the ferromagnetic resonance, to inject a spin current from a ferromagnet into topological insulators such as HgTe [4] and Sb_2Te_3. The conversion of this spin current into a charge current will be detected electrically (cf. fig., showing an example of nanodevice made in our team). The charge current travels along the horizontal track in the spin-orbit material, generating a spin accumulation, and the vertical ferromagnetic electrodes make it possible to probe this accumulation..) for different experimental parameters: temperature, gate voltage, layer thickness, presence of a tunnel barrier or of a metal layer, stoichiometry of the materials... This will allow studying the physics of spin-orbit coupling in these materials, such as the hybridization of surface states in topological insulators, or the role of interfaces in spin-dependent transport.

Once the optimal systems have been identified, nanodevices will be manufactured to realize this interconversion electrically (see Figure 1), in both possible directions (charge to spin or spin to charge). These devices will also allow studying the Bilinear Magnetoresistance, a novel and intriguing phenomenon leading to symmetry breaking (the electrical resistance of a nanowire is depends on the sign of the applied current). This subject is a rather fundamental research topic, with transport effects specific to spin-orbit coupling appearing in new materials. We already possess the funding via a Marie Skłodowska-Curie Innovative Training Networks (European grant), which also provides for additional funding and European mobility during the PhD.

[1] Vila et al., Physical review letters 120.16, 167201 (2018)

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