Spinorbitronics

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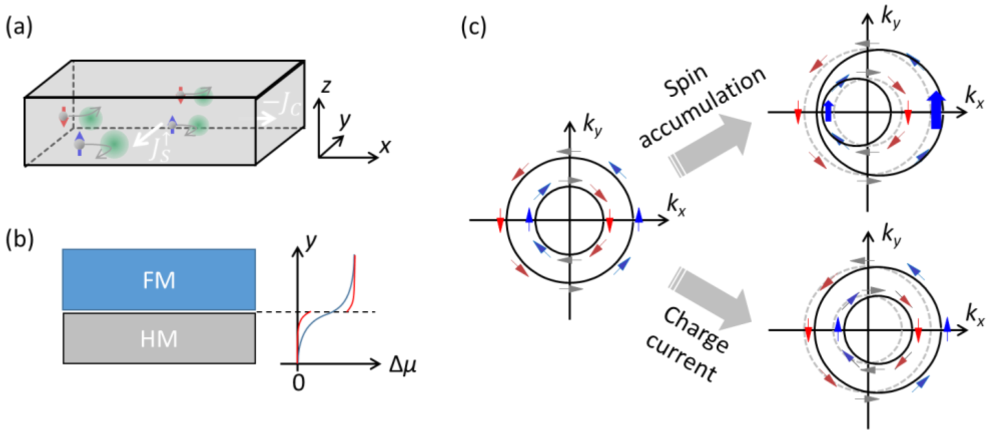
Spintronics evolves along new paths involving non-magnetic materials having large spin-obit coupling (SOC) to generate or detect (pure) spin currents, previously generated by electrical current polarization through a ferromagnetic layer. SOC is a relativistic correction of the quantum mechanics, which considers the magnetic field emerging in an electron rest frame when it moves in electric fields, effectively coupling its spin to its motion ("orbit").

Large SOC can typically be found in 5*d* metals or in peculiar surface states, allowing for example large spin-to-charge current conversion (spin Hall and (Rashba-)Edelstein effects). These heavy metals or these peculiar surface states have other effects: in proximity of magnetic thin films they can burst out the Dzyaloshinskii-Moriya interaction (DMI) leading to the stabilization of chiral magnetic structures (*e.g.* Néel domain walls). Another source of recent interest relies on "non-trivial topologies" resulting from the SOC, either of the band structure (*e.g.* topological insulators), or of the spin textures (see "Skyrmion" talk on Friday 28th).

In this lecture, we will first review the different sources of pure spin current, *i.e.* a spin current which is not accompanied by a charge current (at least not in the same direction), and some of the techniques that can be used to estimate its magnitude. We will concentrate on charge to spin current conversion and discuss the efficiency of the different mechanisms.

In a second part, we will describe how spin currents can be used to move magnetization textures (*e.g.* chiral domain walls) or to switch nanomagnets (*e.g.* MRAM elements). Because the details of the spin textures are crucial to understand their motion, we will start this second part by a brief introduction about the DMI, a SOC-induced antisymmetric exchange.



Different mechanisms related to spin-orbit coupling. (a) *The extrinsic spin Hall effect generates a pure spin current (along y) perpendicular to a charge current (along x). The small grey spheres symbolize the electrons with a red/blue arrow symbolizing their spin.* ***(b)*** *SOC at interfaces is responsible for reduced spin current transmission and discontinuity of the spin accumulation (blue curve without SOC at interface, red with SOC).* ***(c)*** *In a Rashba system, spin and momentum are locked: a charge current is generated by a spin accumulation and reciprocally a spin accumulation is generated by a charge current.*