Spin-orbitronics, a new direction for spintronics

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Classical spintronic devices use the exchange interaction between conduction electron spins and local spins in magnetic materials to create spin-polarized currents or to manipulate nanomagnets by spin transfer from spin-polarized currents. A novel direction of spintronics – that can be called **spin-orbitronics** - exploits the Spin-Orbit Coupling (SOC) in nonmagnetic materials instead of the exchange interaction in magnetic materials to generate, detect or exploit spin-polarized currents. This opens the way to spin devices made of only nonmagnetic materials and operated without magnetic fields. Spin-orbit coupling can also be used in magnetic materials to create new types of topological objects as the magnetic skyrmions or the Dzyaloshinskii-Moriya domain walls. After a **simple introduction on spintronics and some of its applications**, I will review **recent advances in two directions of spin-orbitronics**:

a) **Magnetic skyrmions: Magnetic skyrmions:** The magnetic skyrmions are topologically-protected localized spin windings that exhibit fascinating physical properties and present large potential in highly energy efficient applications for the storage and processing of information. Up to now however they had been observed only at low temperature in a few exotic materials and ultra-thin films. I will show that they can be found at room temperature in multilayers in which the symmetry breaking by interfaces induces strong Dzyaloshinskii-Moriya Interactions (DMI). These findings open the road to room-temperature skyrmion spintronics.
b) **Conversion between charge and spin currents by SOC:** I will present a review of spin-orbit effects allowing the conversion of charge current into spin current (or vice-versa), by the Spin Hall Effect in bulk materials or by similar effects in two dimensional electron gas at Rashba interfaces or the surface of topological insulators. I will discuss the motion of magnetic domain walls and switching of nanomagnets by the resulting current-induced SOC torques.