Spin-orbit coupling: a small interaction leading to rich physics

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During the last decade, the spin-orbit interaction has played an increasingly crucial role in condensed matter physics, thanks to its relevance as a rich microscopic mechanism from the fundamental point of view and as a driving force for innovative spintronic applications on the technological side. After a general overview on spin-orbit coupling (SOC), I will discuss two non-trivial aspects where this relativistic interaction gives rise to novel and exotic phenomena. First, I will focus on the modelling of (non-magnetic) ferroelectric semiconductors, where SOC leads to a tight link between Rashba spin-splitting, spin-texture and electric polarization, with the appealing perspective of electric-field control of spin-degrees of freedom and long-sought integration of spintronics with ferroelectricity. Second, I will discuss first-principles results for the monolayer of semiconducting NiI_2, where a large symmetric anisotropic exchange, combined with Heisenberg exchange frustration, leads to a spontaneous high-Q antiskyrmion lattice with unique topology and chirality of the spin structure. The anisotropic exchange coupling is therefore put forward as a novel, alternative and robust mechanism that can give rise to topologically non-trivial spin-textures even in centrosymmetric systems.