Spin-orbit-induced spin landscapes of two-dimensional electron states

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Spintronics is the key word to motivate studies of spin-polarized electronic states in solids and at surfaces or interfaces. The use of the electron spin in addition to the electron charge as information carrier – that's the goal for spintronics devices. The generation, manipulation, and detection of spin-polarized currents promise applications in information technology. However, in many materials, the electronic states are spin degenerate. The spin degeneracy may be lifted by two interactions: (i) exchange interaction in magnetically ordered materials, where the magnetization direction is the reference for the alignment of the spin magnetic moments; (ii) spin-orbit interaction (SOI), which is present in all materials but becomes relevant in systems with high atomic number.

In non-ferromagnets, SOI leads to energy splittings of bands with different total angular momentum j but not necessarily to spin-split bands. Only in systems, where inversion symmetry is broken, which is, e.g., the case at surfaces, the bands exhibit a spin-dependent energy splitting, which itself depends on the momentum **k**. This so-called Rashba-type spin splitting was predicted for a two-dimensional electron gas and first experimentally observed in surface states on Au(111) [1]. However, this is a rather general phenomenon for two-dimensional electron states that, due to symmetry reasons, may lead to distinct spin landscapes, e.g., in heavy-metal/semiconductor hybrid systems [2] or transition-metal dichalcogenides [3]. In contrast to this general class of Rashba-type systems, where surface states become spin split by SOI, topological surface states only appear as a consequence of SOI. Here, SOI is responsible for band inversion and formation of a gap, which is then closed by a surface state with Dirac-cone-like energy dispersion and characteristic spin texture, e.g., in topological insulators (e.g. Bi_2Se_3) but also at a simple transition-metal surface such as W(110) [4].

The experimental determination of the spin texture of these spin-split bands is essential to evaluate the potential of a particular material for spintronic applications. Experimental access is provided by spin- and angle-resolved photoemission (ARPES) and inverse photoemission (IPE) for the occupied electronic states below the Fermi energy and the unoccupied electronic states above the Fermi level, respectively. In this talk, examples of SOI-induced spin structures in two-dimensional electron states are presented and discussed. In addition, we show that the experimentally observed spin signals of electronic states are not only influenced by their intrinsic spin polarization but also by the choice of symmetry-breaking experimental parameters in combination with the particular symmetry characters of the involved electron states [5].

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