Peculiar spin-polarized bands originating from the symmetry of the surface

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Abstract

Generally, the electronic states of opposite spin orientation are considered to be degenerate in nonmagnetic materials due to the presence of both time-reversal symmetry and space-inversion symmetry. In a 2D system such as a crystal surface, the latter symmetry is broken, and the degeneracy is lifted by spin-orbit coupling. This effect, which is called the Rashba-Bychkov (RB) effect [1], produces spin-polarized electronic states even for nonmagnetic materials, and is the key factor for operating a spin field-effect transistor [2] that is one of the most prominent semiconductor spintronics devices. In this talk, we first present peculiar RB effects that originate from the symmetry of the surface, such as the abrupt change of the spin polarization vector to the surface normal direction [3] and the presence of peculiar vortical RB splitting even at a point without time-reversal invariance [4]. Then, we show results on RB systems with peculiar spin structures, in which the backscattering of electron spin with a non-magnetic impurity are considerably suppressed [5], and also discuss the origin of these spin structures based on a combination of the RB effect and the valley degree of freedom. All these novel quantum phenomena are corroborated by the combination of high-resolution photoemission and spin-resolved photoemission measurements, scanning tunneling microscopy, and a state-of-the-art theoretical calculation.

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