Geometrical Spin Filtering in Spin-ARPES Maps from WTe_2

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We demonstrate that an important quantum material WTe_2 exhibits a new type of geometry-induced spin-filtering effect in photoemission [1], stemming from low symmetry that is responsible for its exotic transport properties. Through the laser-driven spin-polarized angle-resolved photoemission (spin-ARPES) Fermi surface mapping, we showcase highly asymmetric spin textures of electrons photoemitted from the surface states of WTe_2. Such asymmetries are not present in the initial state spin textures, which are bound by the time-reversal and crystal lattice mirror plane symmetries. The findings are reproduced qualitatively by theoretical modeling within the one-step model photoemission formalism. The effect could be understood within the free-electron final state model as an interference due to emission from different atomic sites and is a manifestation of time-reversal symmetry breaking by the photoemission process. As such, it cannot be eliminated, but only its magnitude influenced, by special experimental geometries.

WTe_2 is a low symmetry material, with polar surfaces typically denoted as a *top* and a *bottom* surface [2]. Figure 1 (a-d) presents ARPES maps from cleaved WTe_2 single crystals taken with *p*- and *s*-polarized light using cw 6 eV laser. Fig. 1(e-f) shows corresponding spin-ARPES maps taken on two different spots on the *bottom* surface corresponding to two different terrace terminations. Each of the two maps is highly asymmetric, unlike the initial state spin texture, Fig. 1(g). The adjacent terraces are connected by the M_y mirror operation (with additional in-plane sliding) which explains the relation between the two images. We will discuss a microscopic inter-site interference model, which explains the origin of the asymmetric spin-textures, and allows predicting in which cases similar effect will be present. Together with another type of inter-orbital interference [3], these phenomena provide a path to connect the initial and spin-ARPES spin-textures in an effort to provide experimental input for understanding transport properties in novel quantum materials.

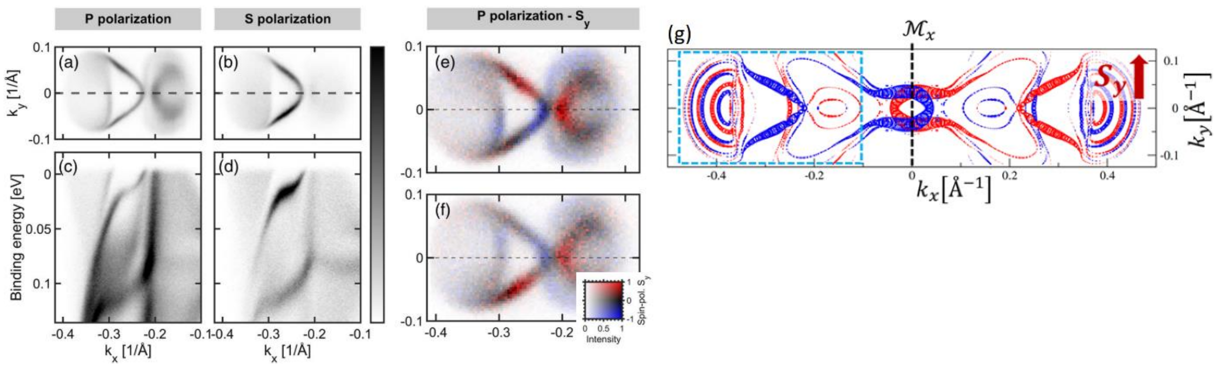

Fig. 1. (a),(b) Spin-integrated laser-ARPES ($h\nu = 6$ eV) Fermi surface maps measured with *p*- and *s*-polarized light. (c-d) Energy dispersions $E(k_x)$ for $k_y = 0$ as indicated by dashed lines in (a) and (b). (e-f) Experimental laser-spin-ARPES 57 × 89 pixel Fermi surface maps taken at two nearby spots on the same cleave using the FOCUS Ferrum spin-detector and MBS A-1 spectrometer with scanning lens. (g) DFT-LAPW surface spin texture.

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