Imaging spin polarization and orbital symmetry in topological materials

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Topological materials have attracted wide interest in condensed matter physics over the past decade. A key role in their physics is played by spin-orbit interaction, which drives the non-trivial topology of the band structure and generates a spin polarization of the electronic states. Vivid examples include the spin-momentum-locked surface states in topological insulators [1] and unconventional Fermi arcs at the surfaces of topological semimetals [2], which can be probed directly by use of angle-resolved photoelectron spectroscopy (ARPES).

Here we will present recent spin-resolved ARPES experiments on strongly spin-orbit coupled surface states [3-5]. We will show how systematic measurements in dependence of light polarization [3] and photon energy [4] are able to disentangle the properties of the surface state, namely its spin polarization and orbital symmetry, from those of the final-state wave function of the outgoing photoelectron. We will focus, in particular, on recent results for the Weyl semimetal TaP(001) [5], where we used linear dichroism in ARPES to investigate the topological connectivity of the Fermi arcs to the bulk Weyl nodes. Our measurements reveal pronounced switches in the orbital symmetry of the Fermi arcs at the projected Weyl nodes, in good agreement with first-principles calculations, see Figure 1 [5]. These observations enable a precise assignment of Fermi arcs and coexisting trivial surface states, that accomodates the predicted chiral charge of the bulk Weyl points.

As an outlook we will present efforts at PETRA III (DESY, Hamburg) to push spin-ARPES experiments into the soft X-ray photon-energy regime in order to access the spin-dependent bulk electronic structure of topological materials, such as Weyl semimetals.

References

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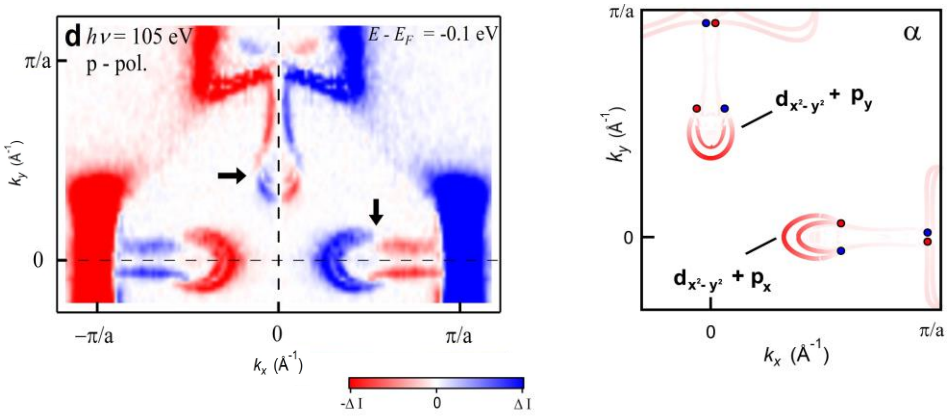

Fig. 1: (left panel) Linear dichroism ARPES data of the Fermi surface in the Weyl semimetal TaP(001) [5]. Pronounced red/blue switches in the dichroism of the Fermi arcs are observed at momenta corresponding to the projected bulk Weyl nodes (arrows). (right panel) Corresponding first-principles calculation of the surface electronic structure evidencing switches in orbital symmetry of the Fermi arcs at the Weyl nodes (red/blue points) [5].