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Detecting surface-bulk connectivity in Weyl semimetal TaAs via scanning tunneling microscopy[1]

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Weyl semimetal exhibits a new gapless topological phase, which is characterized by crossings of two non-degenerate bulk bands, called Weyl nodes. The surfaces of these compounds are expected to harbor topologically protected surface states with disjoint Fermi surfaces, Fermi arcs, connecting surface projections of the Weyl nodes with opposing Chern numbers. A distinct feature of topological semimetals such as the Weyl semimetals is surface-bulk connectivity, which is absent from topological insulators, due to the gapless nature of the bulk. Namely, the electrons on the surface Fermi arcs may dive into the Fermi sea of bulk Weyl cones through the surface-projected Weyl cones. Following theoretical predictions of transition metal monopnictides e.g. TaAs as a candidate inversion-symmetry-broken Weyl semimetal, angle-resolved photoemission spectroscopy studies indeed showed the presence of Weyl cones and corresponding Fermi arcs. However, such kinetic aspect of Weyl semimetals had not yet been experimentally verified. While a theoretical proposal suggested quantum oscillations of novel trajectories in thin films as a route to probe such connectivity, an unanticipated alternative, which we exemplified in our present study, turned out to be quasiparticle interference (QPI) of the surface Fermi arcs. In this talk we will describe our scanning tunneling microscopy experiment where we performed a spectroscopic mapping to visualize QPI on TaAs[001] surface. Thanks to the stoichiometric nature of the sample, measuring atomically flat and pristine terraces revealed a rich variety of scattering wave vectors, which can be reproduced with a DFT calculation considering not only the spin texture but also sub-surface distribution of the Fermi arc surface states. Our observation demonstrates the momentum-dependent penetration of the Fermi arcs into the bulk, namely, surface-bulk connectivity in the Weyl semimetal TaAs. Reference: H. Inoue*, A. Gyneis*, Z. Wang, J. Li, S. W. Oh, S. Jiang, N. Ni, B. A. Bernevig and A. Yazdani, "Quasiparticle interference of the Fermi arcs and surface-bulk connectivity of Weyl semimetals," Science **351**, 1184 (2016).

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