

## Unraveling the Electronic Structure of Altermagnetic MnTe via Photoemission Spectroscopy

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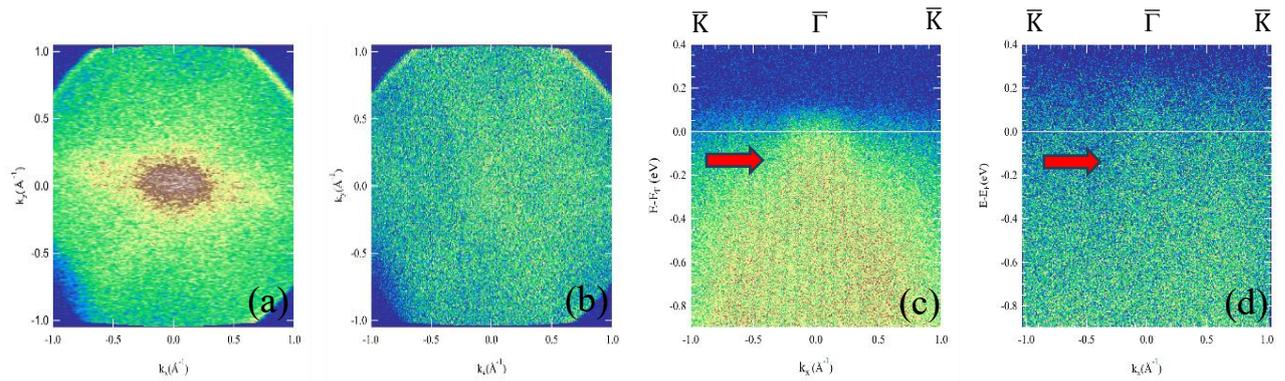
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Despite having zero net magnetization, the recently discovered altermagnetism exhibits spin splitting in the momentum space and has attracted a lot of attention due to its unique magnetic characteristics and possible uses [1]. Antiferromagnetic semiconductor MnTe with the hexagonal NiAs-type structure has garnered a lot of interest lately as a typical altermagnet [2–5].

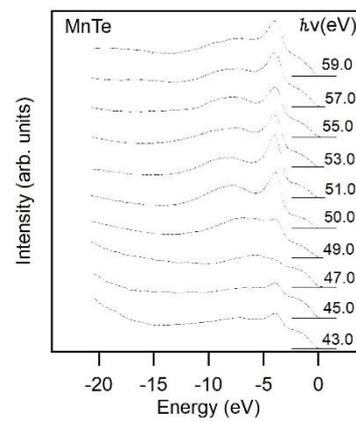
Using polarization-dependent angle-resolved photoemission spectroscopy (ARPES), we have examined the electronic band structure of bulk single-crystalline hexagonal MnTe (0001). MnTe single crystals were synthesized using a solid-state reaction technique and we cut out the (0001) plane of the single crystal. The samples went through multiple cycles of sputtering at 2 kV and 1.5 kV beam energy, followed by annealing at 400°C to provide a clean surface appropriate for ARPES measurements. Surface cleanliness was verified via Auger electron spectroscopy, and the crystalline surface order was confirmed by the presence of sharp hexagonal diffraction patterns in low-energy electron diffraction (LEED) measurements.

The polarization-dependent ARPES measurements were conducted at HiSOR BL-9A using an ASTRAIOS electron analyzer at the photon energy of 40 eV and the sample temperature of 200 K. The polarization direction of the incident light was set by adjusting the undulator magnet configuration. Figures 1(a) and 1(b) present the ARPES intensity maps near the chemical potential in the  $k_x$ - $k_y$  plane, acquired using s- and p-polarization geometries, respectively. Although MnTe is a semiconductor, intrinsic hole doping shifts the chemical potential close to the top of the valence band. The enhanced photoemission intensity observed under s-polarization indicates that the electron wave functions exhibit odd symmetry with respect to the mirror plane, suggesting that the observed valence bands primarily arise from Mn 3d<sub>xy</sub>, Mn 3d<sub>yz</sub>, and Te 5p<sub>y</sub> orbitals. The spectral intensity is strong around the  $\bar{\Gamma}$  point and the ARPES intensity map along the  $\bar{\Gamma}\bar{K}$  direction in Fig. 1(c) reveals the presence of hole-like bands, consistent with theoretical predictions of the band structure [5,6]. The ARPES intensity mapping at the chemical potential in Fig. 1(a) is compatible with the hexagonal (0001) surface.

Figure 2 shows the resonance photoemission spectroscopy (RPES) of MnTe in the Mn 3p-3d excitation region taken at HiSOR BL-1 with changing photon energies from 43 eV up to 59 eV. The Mn 3d-derived spectral intensity is enhanced taken around 51 eV (on-resonance) and is suppressed taken around 47 eV (off-resonance), which is consistent with previous results on polycrystalline MnTe [7]. The leading peak at  $\sim -3$  eV is derived from Mn 3d and the broad peak at  $\sim 8$  eV is charge transfer satellite originated from strong electron correlation [7].



**FIGURE 1.** High-resolution ARPES results on MnTe (0001) single crystal taken at 200K and  $h\nu=40$  eV.  $k_x$ - $k_y$  mapping at the chemical potential with the s-polarization (a) and p-polarization (b) geometries. ARPES intensity map along the  $\bar{\Gamma}\bar{K}$  high symmetry line with the s-polarization (c) and p-polarization (d) geometries.



**FIGURE 2:** The RPES spectrum of MnTe in the Mn 3p-3d excitation region measured at 43-59 eV photon energy.

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