Many-body Interactions on the Surface of the Topological Insulators

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Three-dimensional (3D) topological insulators (TIs) have attracted great attention in condensed matter physics for the past decade because of their fascinating fundamental physical properties and promising applications in the "*spintronics*"[1]. The 3D TIs are remarkable because there exist topological surface states (TSSs) with linear Dirac-cone-like dispersion. The TSSs are metallic and the backscattering is reduced due to the helical spin texture, which is robust against weak non-magnetic disorder or crystal defects as far as the topological property is conserved. These unusual physical properties of the TIs would have potential applications in high-speed dissipationless electronic devices such as quantum computers in the future[2]. Based on the Fermi liquid theory, the transport properties are directly related to the quasiparticles (electrons or holes under the influence of the many-body interactions, such as the electron-phonon and electron-electron interactions) near the Fermi level (E_F). Therefore, quantifying these many-body interactions in the TIs is essentially important for spintronic applications.

In this study, we have examined detailed many-body interactions in the prototypical TIs such as Bi_2Se_3 and Bi_2Te_3 using a laser-based high-resolution angle-resolved photoemission spectroscopy (ARPES)[3]. We have done temperature-dependent ARPES measurements with the *s*-polarization geometry. We cleaved the single crystals below 20 K in the ultrahigh vacuum to get clean surfaces. Figures 1(a1) and 1(b1) show the ARPES results of Bi_2Se_3 and Bi_2Te_3. One can see that they are both n-type semiconductors (the conduction band is closer to the Fermi level) and linearly dispersive Dirac-cone-like spectral feature at the $\overline{\Gamma}$ point ($k_{//}=0Å^{-1}$). The high symmetry directions in the surface Brillouin zone can be determined by measuring the Fermi surface (FS) shapes [see Figs. 1(a2) and (b2)]. Figures 1(a3) and (b3) show the enlarged view of selected regions [rectangle box in Figs. 1(a1) and (b1)] near the E_F. The peak positions were obtained by fitting the peak in the momentum distribution curves (MDCs) to a Lorentzian, as illustrated in Figs. 1(a3) and 1(b3) by the solid black line. One can see clearly in Figs. 1(a3) and 1(b3), no band renormalization (so-called kink, which is the whole mark of electron-phonon interaction), indicating weak electron-phonon interaction in the TSS.

In this poster, I will discuss the magnitudes of the electron-phonon and electron-electron interactions in more detail based on the quantitative ARPES lineshape analyses.

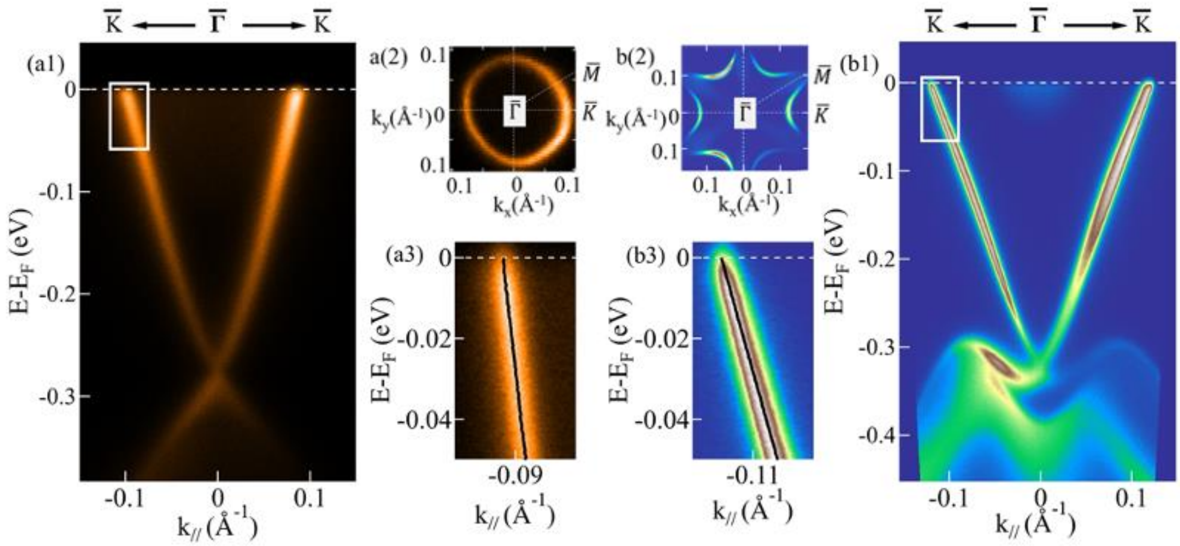

Figure 1. ARPES spectrum measured at 17 K. (a1)-(a3) from Bi_2Se_3 (BS) and (b1)-(b3) from Bi_2Te_3 (BT) respectively. (a1) and (b1) band dispersion along $\overline{\Gamma}$-$\overline{K}$ direction in the surface Brillouin zone. (a2) and (b2) Fermi surface (FS) at E_F. (a3) and (b3) Enlarged view of ARPES spectrum near E_F corresponding to the rectangles in (a1) and (b1), respectively. Solid lines (black) represent peak positions obtained from the MDC lineshape analyses.

References-

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