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Electronic structure of iron-based superconductor $Sr_4V_2O_6Fe_2As_2$ revealed by angle-resolved photoemission spectroscopy

Kosuke NAKAYAMA[1,*], Tian QIAN[1,2], Pierre RICHARD[2,3], Seigo SOUMA[3], Takafumi SATO[1], Nan XU[2], Yingbo SHI[2], Madhab NEUPANE[4], Yiming XU[4], Xiaoping WANG[2], Hong DING[2], Gang XU[2], Xi DAI[2], Zhong FANG[2], Peng CHEN[2], Haihu WEN[2] and Takashi TAKAHASHI[1]

[1]Department of Physics, Tohoku University, Sendai 980-8578, Japan

[2]Beijing National Laboratory for Condensed Matter Physics, Institute of Physics, Chinese Academy of Sciences, Beijing 100190, China

[3]WPI Research Center, Advanced Institute for Materials Research, Tohoku University, Sendai 980-8577, Japan

[4]Department of Physics, Boston College, Chestnut Hill, Massachusetts 02467, USA

Introduction

The discovery of iron-based high-T_c superconductors (Fe-HTSCs) generated fierce debates on the superconducting mechanism. Several theoretical and experimental investigations strongly suggest the importance of interband scattering between hole and electron pockets connected by the antiferromagnetic wave vector Q = (π, π). However, the recent discovery of $Sr_4V_2O_6Fe_2As_2$ raises a question of the validity of this model. Most band calculations predicted that the band structure of $Sr_4V_2O_6Fe_2As_2$ does not satisfy the interband scattering condition [1,2]. Compared with other Fe-HTSCs, the distinct characteristic of $Sr_4V_2O_6Fe_2As_2$ is the presence of metallic V 3*d* bands. Finite hybridization between the V 3*d* and Fe 3*d* bands changes the band topology and destroys the interband scattering condition [1]. On the other hand, there is an argument that if only the Fe-derived bands are taken into account, the bare susceptibility shows a peak at (π, π) similar to other Fe-HTSCs [2]. Furthermore, it has been pointed out that strong on-site electron correlations would remove V 3*d* states from the Fermi level (E_F) [2]. Thus, it is of particular importance to investigate the electronic structure of $Sr_4V_2O_6Fe_2As_2$.

Results and discussion

We have performed angle-resolved photoemission spectroscopy (ARPES) on $Sr_4V_2O_6Fe_2As_2$ (T_c ~ 37 K) [3]. Figures 1(a) and 1(b) show the ARPES spectra in the vicinity of E_F. We observed hole and electron bands which cross E_F centered at (0, 0) and (π, π) points, respectively. Apparently, the observed hole and electron bands are connected by Q ~ (π, π), suggesting the failure of simple LDA calculations. We adopt a LDA + U approach to understand the band structure of $Sr_4V_2O_6Fe_2As_2$ and compared with the experimental band dispersion along high-symmetry lines as shown in Fig. 1(c). We found that highly dispersive bands near E_F are attributed to Fe 3*d* bands [red curves in Fig. 1(c)]. On the other hand, less dispersive bands around 1 eV correspond to V 3*d* states (white curves) that are pushed away from E_F due to the strong correlation effect. The present ARPES results combined with the LDA + U calculation suggest that the V 3*d* orbitals are in a Mott-insulating state and show an incoherent peak or lower Hubbard band at ~1 eV. The observed band dispersions near E_F are essentially similar to those in other Fe-HTSCs and suggest the importance of the interband scattering for the superconductivity in $Sr_4V_2O_6Fe_2As_2$.

References

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* k.nakayama@arpes.phys.tohoku.ac.jp

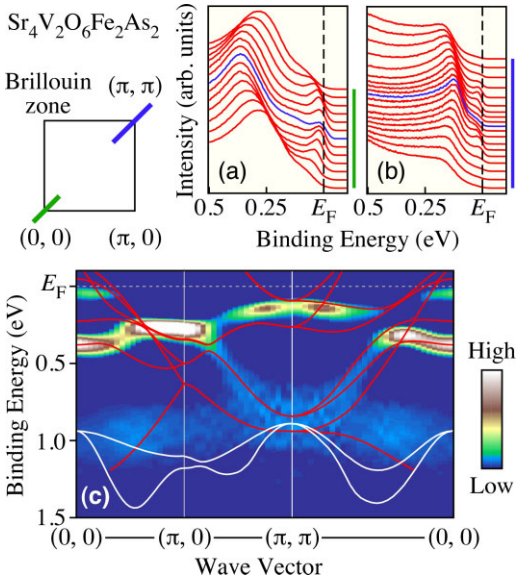

FIG. 1: (a), (b) ARPES spectra measured around (0, 0) and (π, π) points, respectively, at 40 K with $h\nu$ = 80 eV. (c) Second derivative plot of ARPES intensity along high-symmetry lines together with LDA + U band calculations. Red and white curves show the bands derived from Fe 3*d* and V 3*d* states, respectively.