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Isotropic kink in $La_{0.6}Sr_{0.4}MnO_3$ thin films studied by *in situ* angle-resolved photoemission spectroscopy

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In order to reveal the many-body interactions in three-dimensional perovskite manganites, we performed an *in situ* angle-resolved photoemission spectroscopy (ARPES) on $La_{0.6}Sr_{0.4}MnO_3$ (LSMO) and investigated the behavior of quasiparticles. We observed clear kinks throughout the entire hole Fermi surface in the ARPES band dispersion. This isotropic behavior of kinks suggests that polaronic quasiparticles produced by the coupling of electrons with Jahn-Teller phonons play an important role in the ferromagnetic metallic phase of LSMO.

1 Introduction

Perovskite manganese oxides have attracted much attention because of its unusual physical properties, such as colossal magnetoresistance behavior and the half-metallic nature of its ground state. These remarkable properties originate from the complex interplay between the charge, lattice, orbital, and spin degrees of freedom. In order to clarify the origin of these properties of manganites, it is important to understand the detailed electronic band structures and interactions of electrons with various degrees of freedom. For two-dimensional (2D) layered manganites $La_{1.2}Sr_{1.8}Mn_2O_7$, the existence of kink and quasiparticle excitations has been observed using angle-resolved photoemission spectroscopy (ARPES) [1, 2]. The kink in the layered manganites strongly suggests the important underlying physics among 2D strongly correlated oxides. On the other hand, such a kink has not been observed in the ARPES studies on three-dimensional (3D) perovskite manganite $La_{1-x}Sr_xMnO_3$ [3, 4], although relevant many-body interactions in strongly correlated oxides are also expected to be strong in 3D manganites. In this study, we report the first observation of the kink and quasiparticle excitations in 3D manganite $La_{0.6}Sr_{0.4}MnO_3$ (LSMO) thin films by a precise and detailed investigation of 3D electronic structure using *in situ* synchrotron radiation ARPES measurements [5].

2 Experiment

LSMO samples were grown on $SrTiO_3$ (001) substrate by pulsed laser deposition [3, 5] and immediately transferred through ultrahigh vacuum to the ARPES chamber without exposure to air [6]. The *in situ* ARPES measurements were carried out at beamlines BL-28A and BL-2A MUSASHI at the Photon Factory, using circular polarized synchrotron radiation as the excitation light source. The total energy resolution was set to 20 meV at the photon energy of 60 eV.

3 Results and Discussion

Figure 1 show the ARPES intensity plot of the hole band dispersion along the *R-A* direction of LSMO [cut A in Fig. 2(f)]. In the energy dispersion along the *R-A* direction, we have found a clear kink at the binding energy of around 50 meV.

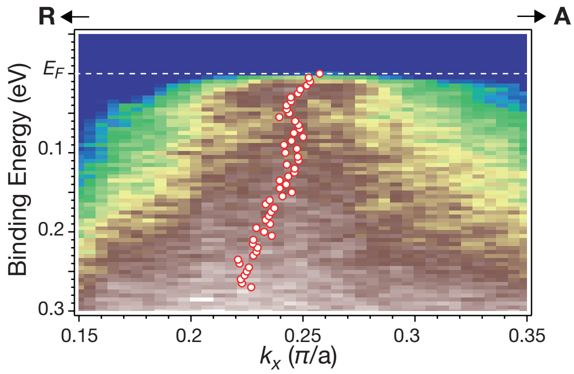

Fig. 1: Intensity map for the band dispersion along the R–A dirction. Open circles indicate the peak positions of momentum distribution curves (MDCs).

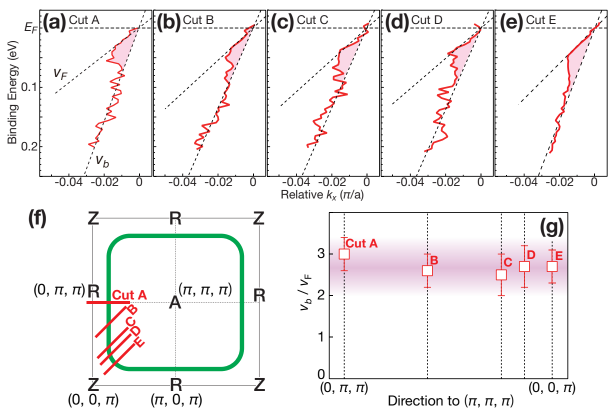

Fig. 2: (a)–(e) Band dispersions obtained from the MDCs along cuts A–E, respectively, in (f), which shows the illustration of the hole Fermi surface together with the measurement cuts (A–E). (g) The values of v_b/v_F obtained from linear fitting of the band dispersion along cuts A–E.

Whether or not the observed kink shows momentum dependence is a crucial issue for identification of relevant many-body interactions. Figure 2 shows the ARPES results along different cuts in the hole Fermi surface. The clear kinks are observed throughout the hole Fermi surface from cuts A to E in Fig. 2(f), and the ratio between the Fermi velocity and the bare-band velocity (v_b/v_F) are estimated to be almost the same values of ~3. This isotropic behavior of kinks is most likely caused by localized bosons coupled with electrons. Therefore, it is reasonably conclude that polaronic quasiparticles produced by the coupling of electrons with Jahn-Teller phonons play an important role in the ferromagnetic metallic phase of LSMO.

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