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Search for electronic nematicity in the cuprate superconductor Bi2212 using ARPES

Suguru Nakata[1,*], Masafumi Horio[1], Keisuke Koshiishi[1], Kenata Hagiwara[1], Chun Lin[1], Kanta Ono[2], Hiroshi Kumigashira[2], Dongjoon Song[3], Yoshiyuki Yoshida[3], Hiroshi Eisaki[3] and Atsushi Fujimori[1]

[1]Department of Physics, University of Tokyo, Tokyo 113-0033, Japan

[2]Photon Factory, 1-1 Oho, Tsukuba, 305-0801, Japan

[3]National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, 305-8568

1 Introduction

Electronic nematicity arises from a phase transition which does not break the translational symmetry but breaks the fourfold rotational symmetry of the electronic system. This concept has originally been used in the field of liquid crystals. Recently, it has been observed in several correlated systems including the ruthenate $Sr_3Ru_2O_7$ [1], the heavy fermion compound URu_2Si_2 [2], the semiconductor heterostructures GaAs/$Al_xGa_{1-x}As$ [3] and the topological superconductor $Cu_xBi_2Se_3$ [4]. In cuprate superconductors, too, nematicity has been discussed as a key candidate to understand the pseudogap state, which is one of the most significant and controversial issues in condensed-matter physics [5-7]. From the experimental perspective, evidence for electronic nematicity appeared in $YBa_2Cu_3O_{6+x}$ from transport [8], Nernst coefficient [9,10], neutron scattering [11], and magnetic susceptibility [12] measurements, and in $Bi_2SrCaCu_2O_{8+\delta}$ from resistivity measurement [13].

Electronic nematicity has been discussed also in Fe-based superconductors [14] and studied by angle-resolved photoemission spectroscopy (ARPES) [15-17], which is the most direct way to reveal the electronic structure. However, at present, there has been no report that reveals the electronic nematicity in cuprates by ARPES. We performed ARPES measurements in order to study the possible electronic nematicity in cuprates. Furthermore, by using ARPES one can investigate whether the electronic nematicity is specific to the pseudogap state or persists also in the superconducting state since.

2 Experiment

Optimally-doped $Bi_{1.7}Pb_{0.5}Sr_{0.9}CaCu_2O_{8+\delta}$ (Pb-Bi2212) single crystal samples were grown by the floating-zone method. The T_c was 91 K. ARPES measurements were carried out at beamline 28A of Photon Factory. We used linearly polarized light with $h\nu$ = 55 eV. The total energy resolution was set at 10 meV. The samples were cleaved *in-situ* under the pressure of ~ 1.6×10^{-8} Pa and measured at T = 10 K and 100 K. Additionally, mechanical strain was applied in the direction of the Cu-O bond of CuO_2 plane in order to obtain signals of electronic nematicity.

3 Results and Discussion

Figure 1 shows Fermi surface plots determined from momentum distribution curves at the Fermi level measured at 100 K and 10 K. In order to detect the possible anisotropy of the Fermi surface, we have fitted the measured Fermi surface using a tight-binding function with anisotropy between the k_x- and k_y-axes : $\varepsilon(k_x,k_y) = -2t[(1+\delta)\cos k_x+(1-\delta)\cos k_y] - 4t'\cos k_x\cos k_y -2t''(\cos 2k_x+\cos 2k_y) + E_0$, where δ represents the anisotropy. Obtained δ is - 0.4 % at 100 K and – 0.8 % at 10 K.

So far, we have not been able to identify definitive evidence for the electronic nematicity in the pseudogap state due to the limited experimental accuracy. However, one can see a signature of the anisotropy in the superconducting state. When we obtain more precise experimental data, we may be able to discuss the relationship between electronic nematicity and superconductivity because some theoretical calculation showed that electronic nematicity and superconductivity could coexist [18-20]. Further measurements with improved resolution and statistics are necessary in the future.

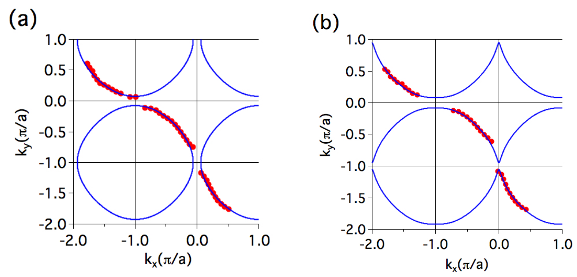

Fig.1 : Fermi surface plots (red points) and fitting curves (blue line) at (a) 100 K, (b) 10 K.

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* nakata@wyvern.phys.s.u-tokyo.ac.jp