Search for electronic nematicity in the cuprate superconductor Bi2212 using ARPES

Suguru Nakata1,*, Masafumi Horio1, Keisuke Koshishi1, Kenata Hagiwara1, Chun Lin1, Kanta Ono2, Hirosi Kumigashira2, Dongjoon Song3, Yoshiyuki Yoshida3, Hiroshi Eisaki3 and Atsushi Fujimori1

1Department of Physics, University of Tokyo, Tokyo 113-0033, Japan
2Photon Factory, 1-1 Oho, Tsukuba, 305-0801, Japan
3National 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 Sr2RuO4 [1], the heavy fermion compound URu2Si2 [2], the semiconductor heterostructures GaAs/AlGaAs [3] and the topological superconductor Cu3Bi2Se2 [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 YBa2Cu3O6.5 from transport [8], Nernst coefficient [9,10], neutron scattering [11], and magnetic susceptibility [12] measurements, and in Bi2SrCaCu2O8.5 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 Bi12−xPbxSr20−xCaCu2O6.8±0.2 (Pb-Bi2212) single crystal samples were grown by the floating-zone method. The Tc was 91 K. ARPES measurements were carried out at beamline 28A of Photon Factory. We used linearly polarized light with hν = 55 eV. The total energy resolution was set at 10 meV. The samples were cleaved in-situ under the pressure of ~ 1.6 x 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 CuO2 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 kx- and ky-axes: $ε(k_x,k_y) = -2[(1+δ)cosk_x+(1-δ)cosk_y] - 4t'cosk_xcosk_y - 2t''(cos2k_x+cos2k_y) + E_F$, 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.

References


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