論文の内容の要旨

論文題目 Neutron scattering study of antiferromagnetic correlation in the iron pnictide $BaFe_2As_2$
(鉄ニクタイド化合物 $BaFe_2As_2$ における反強磁性相関の中性子散乱による研究)

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The superconductivity in LaFeAsOF with transition temperature (T_c) $\sim$ 26 K was discovered by Kamihara *et al.* in 2008 [1]. Promoted by the discovery, material scientists one after another found several types of iron-pnictide superconductors having similar Fe and pnictide layers, such as $Ba(Fe,Co)_2As_2$, LiFeAs and Fe(Se,Te). A parent compound $BaFe_2As_2$ shows structural transition from tetragonal to orthorhombic symmetry and antiferromagnetic transition near $T = 140$ K [2]. By a variety of the parameters as electron- or hole-doping, pressure and homologous element substitution, the two transition are suppressed and superconductivity is induced [3]. In the almost all iron-pnictides superconductors, an antiferromagnetic phase is adjecent to the superconducting phase as in $BaFe_2As_2$. The conventional theory of phonon-mediated superconductivity has difficulty to explain the higher superconducting transition temperatures. Instead, magnetic fluctuation can be a candidate for the glue of electron cooper pairs [4, 5]. Therefore, to solve the mistery of the high T_c, the magnetic correlation in superconducting and the neighbour phase need to be specified. The suitable technique to measure magnetic fluctuation is the neutron scattering. In this study, doping dependence of antiferromagnetic correlation in the iron pnictide $BaFe_2As_2$ was investigated by neutron scattering. The study mainly consist of two topics: 1) Relation between antiferromagnetic fluctuation and superconductivity in $Ba(Fe,Co)_2As_2$. 2) Origin of normal state in-plane mangetic fluctuation anisotropy in $Ba(Fe,Co)_2As_2$.

In optimally electron-doped superconductor $Ba(Fe_{0.94}Co_{0.06})_2As_2$, other groups found ahead of us that antiferromagnetic fluctuation is enhanced in the superconducting phase [6], and that the normal state antiferromagnetic fluctuation agrees with an itinerant spin fluctuation theory [7, 8]. These researches show that the superconductivity have something to do with the itinerant antiferromangetic fluctuation. But, without observation of fluctuation in neighboring non-superconductors, further discussion will be faced with difficulty. We investigated spin dynamics in single crystals by inelastic neutron scattering over the range from undoped to the overdoped regime in electron-doped $Ba(Fe_{1-x}Co_x)_2As_2$ ($x = 0, 0.06$ and 0.24). Damped magnetic fluctuations in the paramagnetic state of the parent compound $x = 0$ that share a remarkable similarity with those in the normal state of the optimally doped compound $x = 0.06$. It is clear that trigger of the antiferromagnetic transition in the parent compound is not divergence of the spin fluctuation. If the trigger is removed, the flucuation will be kept in low temperature and superconductivity may emerge. For the heavily overdoped of nonsuperconducting compound $x = 0.24$ the magnetic scattering disappears, which could be attributed to the absence of a hole Fermi surface pocket observed by photoemission [9]. This indicate that the spin fluctuation originate from Fermi surface nesting between the electron and hole pockets.

In $Ba(Fe_{0.935}Co_{0.065})_2As_2$, the low energy antiferromagnetic spin fluctuation measured by neutron scattering [10] shows different in-plane peak widths in the transversal and longitudinal directions even in the tetragonal normal state. Together with the anisotropic behavior observed in electronic resistivity, elastic constant, SI-STM, etc. [11], the anisotropic spin fluctuation spectra were sometimes referred to as an outcome of spontaneous rotational symmetry breaking into C_2 due to spin or electronic nematicity. On the other hand, Park *et al.* [12] suggested that a proper Fermi surface nesting calculation with multi-band charactors can reproduce the spectra without accounting for those extra symmetry breaking origins. They also predicted that the in-plane anisotropy is smaller in the parent compound $BaFe_2As_2$. This is in striking contrast to the larger anisotropy expected for the nematic order. To clearify the origin of the in-plane anisotropy fluctuation, we investigated the doping dependence of the low energy spin fluctuation in the wide composition of $Ba(Fe_{1-x}Co_x)_2As_2$ ($x = 0$, 0.045 and 0.06) crystals. Neutron scattering experiments were performed using ISSP-GPTAS installed at JRR-3 and HB-3 at HFIR. The final neutron energy was selected as $E_f = 14.7$ meV. The electron-doping and temperature dependence of the anisotropy was investigated by the longitudinal (Q // [110]) and transverse (Q // $[\bar{1}10]$) scans through the inelastic magnetic peak at $Q = (1/2\ 1/2\ 0)$ and the energy transfer of 10 meV, and at $Q = (3/2\ 3/2\ 0)$ and 28 meV in the normal states. From the measurements, three characteristic results were obtained: a) The anisotropy is larger in the doped ($x = 0.045$ and 0.06) compounds at $T = 180$ K, and just above the structural or superconducting transition temperatures, too. b) The anisotropy is larger at higher energies. c) The anisotropy is only weakly termperature dependent and is preserved even at high temperatures. a) and c) support the Fermi surface nesting picture. b) is at least different from the character of $YBa_2Cu_3O_{6.45}$, which is thought be a nematic compound [13]. The results indicate that the in-plane anisotropy of the spin fluctuation is well explained by Fermi surface nesting picture with multi-band charactors

In addition to the main two topics, the study includes other research topics such as suppression of antiferromagnetism and structure transition in underdoped $BaFe_2(As,P)_2$, and magnetic excitation in $BaFe_2(As_{0.92}P_{0.08})_2$. The peculiarity of this study is the measurements of doping dependence. By focusing the difference between the various doping levels, antiferromagnetic correlation in the iron pnictide $BaFe_2As_2$ was made clear by neutron scattering technique.

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