High-energy spin fluctuation in low-T_c iron-based superconductor $LaFePO_{0.9}$

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Spin fluctuations are widely believed to play an important role in the superconducting mechanisms of unconventional high temperature superconductors. Spin fluctuations have been observed in iron-based superconductors as well [1]. In the series of iron-based superconductors, the superconductivity appears in the vicinity of an antiferromagnetic (AF) phase and a structural phase transition from tetragonal to orthorhombic phases accompanied by orbital ordering. Therefore, the spin and multi-orbital dynamics are believed to play an important role in the superconducting mechanisms. The spin dynamics have been studied intensively by inelastic neutron scattering (INS), because it is one of the best powerful tools for the study. In the superconducting states, magnetic resonance modes have been commonly observed in the INS spectra of iron-based superconductors so far. According to the doping-dependence, the magnetic resonance energies are proportional to the superconducting gap energies. At the same time, the low-energy spin dynamics are well explained by the Fermi surface nesting model. On the other hand, the magnetic resonance mode nor the spin fluctuation itself has not been observed in the low-T_c iron-based superconductor $LaFePO_{1-y}$[2]. This superconductor $LaFePO_{1-y}$ was discovered as the first superconductor among the iron-based pnictogen compounds [1]. For this system, the low-energy spin dynamics have also been studied by nuclear magnetic resonance, suggesting no AF spin fluctuations. Nevertheless, electron-doped $LaFePO_{1-y}$ shows line-node symmetry revealed by temperature dependence of magnetic penetration depth and thermal conductivity measurements [3]. The line-node symmetry corresponds to a sign-reversing order parameter. It is typically originated by the spin fluctuation. Therefore, no AF spin fluctuation in $LaFePO_{1-y}$ system has been a long standing mystery. Consequently, it was quite important to obtain dynamical information on spin fluctuations of $LaFePO_{0.9}$ in a wide energy range in order to examine the existence of the spin fluctuation on the superconductivity with line-node gap symmetry.

Inelastic neutron scattering measurements have been performed on powder samples of $LaFePO_{0.9}$ with T_c= 5 K and optimally doped $LaFeAsO_{0.918}F_{0.082}$ with T_c= 29 K as a reference. In conclusion, the spin fluctuation has been discovered on this low-T_c $LaFePO_{0.9}$ at 30-50 meV with similar intensity to the optimally doped $LaFeAsO_{0.918}F_{0.082}$ at the normal state, suggesting the universality of the correlation between line-node symmetry and spin fluctuations [4]. However, the observed high energy was very unusual for low-T_c superconductors. This research is expected to trigger a research of searching high energy spin fluctuation in low-T_c superconductors.

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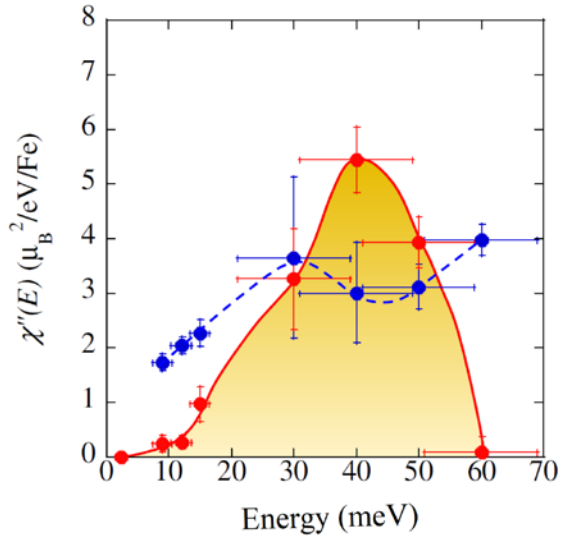

Fig.1. Momentum-integrated dynamical spin susceptibility $\chi''(E)$ for $LaFePO_{0.9}$ (red filled circles) and $LaFeAsO_{0.918}F_{0.082}$ (blue filled circles). All the points were measured at the normal state of T = 30 K [4]. The solid and broken lines are guides for the eye.

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