

5-10 Elucidation of Electronic Excitation in Novel High- T_c Superconductor — Resonant Inelastic X-ray Scattering Study of Iron-Pnictide Superconductor —

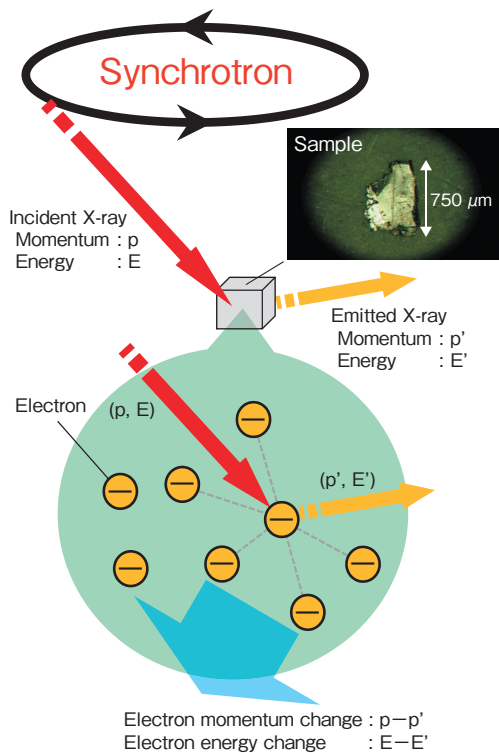


Fig.5-21 Schematic representation of RIXS

Systematic inspection of the momentum change and energy loss of X-rays in scattering enables us to study the momentum-dependent electronic excitation spectra.

Quantum beams such as neutron beams and X-rays have been extensively used to clarify elementary excitations in various strongly correlated electron systems. A lot of studies using quantum beams have been intensively carried out for the recently discovered iron-pnictide high- T_c superconductors, to elucidate their superconducting mechanism.

Recently, resonant inelastic X-ray scattering (RIXS) utilizing the hard X-rays at transition-metal K -edges has become a unique technique to observe momentum-dependent charge excitation spectra of strongly correlated electrons. In K -edge RIXS, the incident X-ray with the $1s$ - $4p$ absorption energy resonantly excites the $1s$ electron to the $4p$ state. In the final state, the excited $4p$ electron returns to the $1s$ state, emitting an X-ray, where the emitted X-ray loses momentum and energy in amounts equal to those transferred to the correlated electrons (Fig.5-21).

We recently succeeded in the first observation of RIXS for a typical iron-pnictide high- T_c superconductor PrFeAsO_{1-y} . The experimentally observed and theoretically calculated

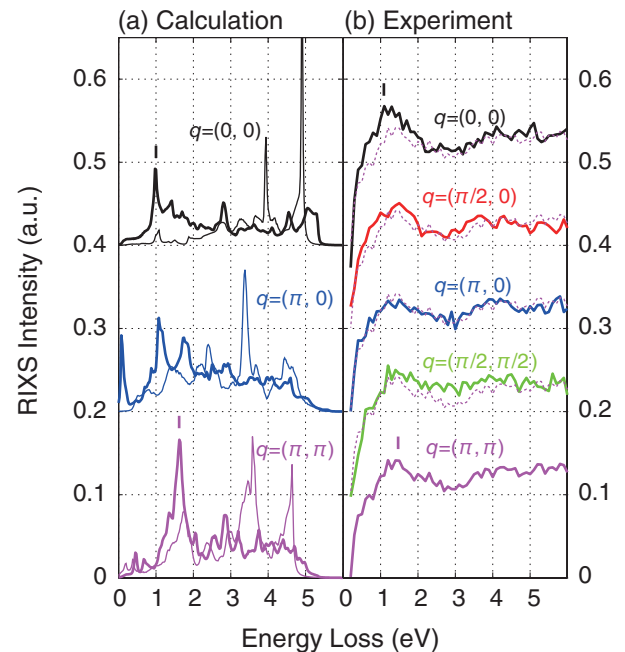


Fig.5-22 Calculated and experimental spectra

Theoretical calculation (left) was performed for non-magnetic and magnetic ground states (thin and thick lines, respectively). The experimental spectrum (right) at $q=(\pi,\pi)$ (dashed line) is overlaid with the spectra at other momenta.

RIXS spectra for various X-ray momentum changes q 's are displayed in Fig.5-22. We found a characteristic momentum-dependent low-energy feature around 1-2 eV, as indicated by the ticks in the right panel of Fig.5-22. To analyze the spectral properties, we also performed a theoretical calculation (left panel of Fig.5-22). From comparison between the calculated and experimental spectra, spectral shape and momentum dependence obtained experimentally agree well with the calculation by assuming the magnetically ordered state rather than the non-magnetic state. This suggests that at least short-range local magnetic correlations exist, consistently with other experiments. By further analysis, we also succeeded in verifying that the local Coulomb repulsion among the Fe $3d$ electrons should be intermediately strong (2-3 eV) in the present iron-pnictide superconductor. This evaluation of electron correlation could play a key role in discussions of the microscopic mechanisms of the iron-pnictide high- T_c superconductivity.

Reference

Jarrige, I., Nomura, T. et al., Resonant Inelastic X-ray Scattering Study of Charge Excitations in Superconducting and Nonsuperconducting PrFeAsO_{1-y} , Physical Review B, vol.86, issue 11, 2012, p.115104-1-115104-4.