

Physics of transition metal based superconductors

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1. Background and purpose of proposed research period

The high- T_c cuprate is still providing many challenging topics related to the strongly correlated electron system. Most of unresolved phenomena, e.g., stripe state, charge inhomogeneity, two gaps in the momentum space, and peculiar softening of phonon mode, might originate from the charge dynamics of strongly correlated electrons. By understanding mechanism behind these phenomena, we will obtain new concepts on condensed matter physics and will contribute to basic science.

Two years ago, a new superconductor based on iron was discovered in Japan. Not only by its high transition temperature but also by huge variety of element combinations, this newly discovered material becomes the most intriguing subject of condensed matter physics. Mechanism of superconductivity induced by the electronic states composed of iron d -orbital and arsenic p -orbital is not yet clarified. However, by solving this puzzle, we can expect higher critical temperature and new aspects on material science.

Progresses of these subjects are rapidly published in the on-line archive day by day. The number of papers is more than 200 per month, which are too many to be caught up. In this workshop, we aimed to exchange the latest results on these interesting materials among experimentalists and theorists and to clarify mechanism of electronic states and various properties of cuprates and iron-based superconductors.

2. Proposed plan

In this workshop, we planned to discuss various results obtained by different spectroscopy techniques, e.g., neutron, X-ray, Raman, angle resolved photoemission spectroscopy (ARPES), nuclear magnetic resonance (NMR), muon spin resonance (μ -SR) and scanning tunneling microscopy (STM), since those techniques are complementary each other. In addition, two different transition metal based superconductors are discussed in the same workshop, since most researchers are interested in both ones. This type of workshop has not been organized so far, and must be important, since IMR is the leading institution in the research field of inelastic neutron and resonant inelastic x-ray scattering on these superconductors. The Workshop is supported also by 1) Collaborative Research Project, IMR, Tohoku University, 2) Grant-in-Aid for Specially Promoted Research in MEXT, Japan, "Development of the 4 Space Access Neutron Spectrometer (4SEASONS) and Elucidation of the Mechanism of Oxide High- T_c Superconductivity", 3) Research Group for Dynamical Structure of Condensed Matter, Spring-8.

3. Results and discussions

In the workshop, 70 scientists including 12 from abroad participated and 38 invited talks were presented. All talks are categorized as follows; 22 talks on iron-based superconductors and 16 talks on cuprates, 30 experimental works and 8 theoretical ones. All speakers presented many new results and overviews on high- T_c cuprates, iron-based new superconductors. The former half is focused on the iron-based superconductors and the latter half is done on the cuprates.

Regarding the iron-based superconductors, Fermi surface nesting, symmetry of superconducting (SC) order parameter, and magnitude of magnetic moment in the spin-density-wave (SDW) state were discussed from various viewpoints. This system has multiple Fermi surfaces (FSs) around Γ - and M-points, which are observed by ARPES. Some theoretical studies reported that the spin fluctuation between those separated FSs stabilizes s_{\pm} -wave symmetry, which is clearly shown by the STM study in the 1111-system. On the other hand, in the magnetic phases of the 1111- and the 122-systems, theoretical study claims that the electron-electron interaction can stabilize another type of magnetic order not yet observed in the neutron measurements. The contradiction between theory and experiment is still under debate. The spin-wave

excitation is clearly observed by the neutron scattering measurement, even though the magnetic state of this system is metallic. In addition, anomalous phonon mode and magnetic resonance mode are reported.

In the cuprates, the peculiar charge dynamics as stripe state, origin of pseudo-gap, and correlation between spatial inhomogeneity and T_c were discussed from various viewpoints of different types of spectroscopy measurements. The stripe state was examined by neutron and X-ray scattering studies. The ARPES studies reported that the pseudo-gap around $(\pi,0)$ point is different from the SC gap around $(\pi/2,\pi/2)$ point, i.e. two-gap state. Although the two-gap state might be clarified in terms of the resonating valence bond theory, it is still under debate. The in-plane spatial inhomogeneity was reported by the STM study. The NMR and the ARPES studies are contradict each other about the charge imbalance in the multi-layered cuprates. This must be verified in near future.

4. Summary and perspective

Due to the rapid development of spectroscopy methods that measure spin, charge and electron excitations, we organized the workshop that promotes complementary studies on the high- T_c cuprates and the iron-based superconductors. Such a workshop seems to be unique and be indicating a new direction. Actually, one symposium closely related to the present workshop will be held in the Japan Physical Society meeting. A booklet of the copies of presentation at the workshop is available on request.

Program

June 24 (Wed)

13:20-13:30 Opening

Chair: S. Maekawa (Tohoku)

13:30-13:55 H. Eisaki (AIST)

Transport properties of LnFeAsO_{1-y} superconductors

13:55-14:20 M. Sato (Nagoya)

Various kinds of studies on the superconducting symmetry of Fe-As systems

14:20-14:45 Y. Takano (NIMS)

Superconductivity in FeSe and FeTe

Break

Chair: H. Eisaki (AIST)

15:00-15:25 N. L. Wang (Institute of Physics, China)

Optical spectroscopy study on Fe- and Ni-based pnictide superconductors

15:25-15:50 A. Fujimori (Tokyo)

Angle-resolved photoemission spectroscopy of
Fe pnictide superconductors

15:50-16:15 S. Shin (ISSP)

Laser-ARPES on $(\text{Ba}_{1-x}\text{K}_x)\text{Fe}_2\text{As}_2$

Break

Chair: T. Tohyama (Kyoto)

16:30-16:55 T. Fukuda (JAEA/Spring-8)

Phonon properties on iron-based new superconductors

16:55-17:20 R. Arita (Tokyo)

Does Fermi surface nesting favor an s_{\pm} - pairing in iron-based
superconductors ?

17:20-17:45 J. A. Riera (Rosario, Argentina)

Correlated multi-orbital models for superconducting Fe-pnictides

18:00-20:00 Banquet

June 25 (Thu)

Chair: J. Mizuki (JAEA)

9:00-9:25 P. C. Dai (ORNL, USA)

Neutron scattering studies of iron arsenide superconductors

9:25-9:50 D. Reznik (Karlsruhe, Germany)

Effect of magnetism on phonons in 122 pnictides

9:50-10:15 S. Shamoto (JAEA)

Magnetic excitation spectrum in $\text{LaFeAsO}_{1-x}\text{F}_x$ system

Break

Chair: M. Fujita (Tohoku)

10:30-10:55 T. J. Sato (ISSP)

Neutron inelastic scattering study on the BaFe_2As_2 and related
superconducting phases

10:55-11:20 D. Louca (Virginia, USA)

The local atomic structure of superconducting Fe-Se-Te

11:20-11:45 M. Ogata (Tokyo)

'Unscreening' effect on superconductivity in Fe-Pnictides

11:45-12:10 T. Morinari (Kyoto)

Fermi surface topology effect on inter-layer magnetoresistance in layered multi-band systems: Application to $\text{LaFeAsO}_{1-x}\text{F}_x$

Lunch

Chair: M. Sato (Nagoya)

13:30-13:55 K. Ishida (Kyoto)

NMR Studies on $\text{LaFeAs}(\text{O}_{1-x}\text{F}_x)$

13:55-14:20 H. Mukuda (Osaka)

^{57}Fe -NMR study on Fe pnictide superconductors LaFeAsO_{1-y} and $\text{Ba}_{0.6}\text{K}_{0.4}\text{Fe}_2\text{As}_2$

14:20-14:45 H. Kotegawa (Kobe)

NMR and resistivity studies under pressure in Fe-based superconductor FeSe and SrFe_2As_2

Break

Chair: N. L. Wang (Institute of Physics, China)

15:00-15:25 Y. K. Bang (ACTP, Korea)

Resonant impurity scattering on the $\pm s$ -wave state of the iron-based superconductors

15:25-15:50 T. Hanaguri (RIKEN)

Spectroscopic-imaging STM studies on iron-based superconductors

15:50-16:15 N. Miyakawa (Tokyo University of Science)

Point-contact tunneling spectroscopy of NdFeAsO_{1-y} with $T_C \sim 51\text{K}$

Break

Chair: M. Sgrist (ETH, Switzerland)

16:30-16:55 S. Uchida (Tokyo)

Coherence and incoherence in high- T_c cuprates

16:55-17:20 Y. J. Kim (Toronto, Canada)

X-ray scattering study of charge stripes in cuprates

17:20-17:45 K. Ishii (JAEA)

Charge excitations associated with charge order in cuprates

June 26

Chair: T. Hanaguri (RIKEN)

9:00-9:25 S. Tajima (Osaka)

High T_c cuprates as a multi-ordered system

9:25-9:50 Y. Kohsaka (RIKEN)

Visualizing formation of symmetry breaking excitations
in lightly-doped $\text{Ca}_{2-x}\text{Na}_x\text{CuO}_2\text{Cl}_2$

9:50-10:15 K. Kudo (Tohoku)

Magnetic field effects on the local electronic states of Pb-substituted
 $\text{Bi}_2\text{Sr}_2\text{CuO}_{6+\delta}$ studied by the scanning tunneling
microscopy/spectroscopy

Break

Chair: K. Yamada (Tohoku)

10:30-10:55 A. Fujimori (Tokyo)

Pseudogap, Fermi arc, and kink in cuprate superconductors

10:55-11:20 A. Ino (Hiroshima)

Low-energy ARPES study of doping-dependent gap structure in high- T_c
cuprates

11:20-11:45 H. Mukuda (Osaka)

NMR in multilayered cuprate - Phase diagram of CuO_2 plane -

11:45-12:10 M. Mori (Tohoku)

Apical site and electronic states in multi-layered cuprates

Lunch

Chair: Y. Koike (Tohoku)

13:30-13:55 M. Fujita (Tohoku)

Incommensurate spin correlations in single-layered high- T_c cuprates
 $\text{La}_{2-x}\text{Sr}_x\text{CuO}_4$ and $(\text{Bi,Pb})_{2+x}(\text{Sr,Lu})_{2-x}\text{CuO}_{6+\delta}$

13:55-14:20 Y. Tanabe (Tohoku)

Crossover between hole-trapping and Kondo effect in Ni-substituted
 $\text{La}_{2-x}\text{Sr}_x\text{Cu}_{1-y}\text{Ni}_y\text{O}_4$

14:20-14:45 K. Tsutsui (JAEA)

Exact diagonalization study for Ni substitution effect in
d-p model

Break

Chair: M. Arai (JAEA)

15:00-15:25 D. Reznik (Karlsruhe, Germany)

Photoemission kinks and phonons in cuprates

15:25-15:50 P. C. Dai (ORNL, USA)

Dynamic stripes and incommensurate spin excitations in $\text{YBa}_2\text{Cu}_3\text{O}_{6+x}$

15:50-16:15 H. Yamase (NIMS)

Pomeranchuk instability in cuprate superconductors

16:15-16:30 Closing