Reports on long-term overseas dispatch

Departments of Advanced materials Sciences
2nd year Master course student in Shibauchi lab, Suguru Hosoi

In this overseas dispatch program, I did experiments with Dr. Clifford Hicks' group at the Max Planck Institute Chemical Physics for Solids in Dresden Germany over about two months, from 6th Feb. to 31st Mar, just after the end of my master thesis work. His group developed the wonderful uniaxial pressure device driven by piezoelectric stacks. One of the main goals for this dispatch is to learn the uniaxial pressure techniques. This uniaxial pressure device can precisely apply the large strain to samples. Strain is new control parameter for controlling phase of matters, which is different from conventional methods such as magnetic fields, chemical substitution, and physical pressure.

MPI-CPFS

In this visit, the plan for experiments was uniaxial pressure study on iron-based superconductors FeSe. Dr. Hicks group previously reports the increase of superconducting transition temperature in Sr_2RuO_4 using their uniaxial pressure devices. Iron-based superconductor FeSe shows superconducting transition in the in-plane anisotropic electronic state "nematic order". We try to elucidate relationships between nematicity and superconductors by measuring strain-dependence of T_c when controlling these anisotropic electronic states by applying external uniaxial strains. My original work is to measure the resistance response to strain induced by piezoelectric stack itself so I preliminary measured the strain-dependence of superconductivity before this dispatch but the changes of T_c were extremely small. Uniaxial pressure device developed in Hicks group can induce about 10 times larger strain than previous methods so in that meaning this device should be really promising for current problem solving.

Basic concept applying strains by piezoelectric stacks is same to my work in Japan, but it was a good opportunity to expand measurable regions because

there are some differences in operation of piezoelectric stacks, methods for measurements, cryostats.

I failed to obtain enough results in these experiments because sample was broken in some-how when applying large strains, which is mainly due to very thin and fragile properties of FeSe. In addition to this, FeSe has structural transition at relatively high temperature 90 K so we had to wait to warm up the system above the structural transition temperature, which means really time-consuming and it is also difficult to evaluate the strains because structural transition induces the orthorhombic strains and twin structures.

We decided to continue uniaxial pressure study after improving the experimental methods. Unfortunately we couldn't do so during this stay so this project continues as the collaboration but I wish I would have another opportunity to visit MPI-CPFS again in some how.

Apart from experiments, there are fortunately two big international conferences during my stay: One is QCNP2017 in Berlin organized by MPI-CPFS and annual meeting of DPG in Dresden. Especially in QCNP2017, there are plenty opportunities to talk with many Ph.D. students and I had really stimulus and precious time. Not limited to this conference, foreign people are much eager to activate the discussion compared to Japanese. I was forced to notice my poor English and lack of experience for discussion when talking with them and these experiences make me strive to self-improvements after the trip.

With members of MPI-CPFS @ Swiss-Saxon

In the end, I really appreciate Dr. Clifford Hicks, Professor Andrew Mackenzie who kindly hosted me, members of MPI-CPFS especially Hicks group, my supervisor Professor Takasada Shibauchi who introduced me to Hicks groups, and kind supports from MERIT program. I am convinced that this wonderful experience provides an import basis for my Ph. D. works.