Report of MERIT Long-Term Dispatch

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Overview

I stayed and studied at the Max Planck Institute for Solid State Research in Stuttgart form 20th, June to 21th, July. During the stay, I worked on single crystal synthesis of antiperovskite Sr_3PbO with collaborators, Juergen Nuss and Claus Muehle, for further measurements of my research.

Background

I have measured magnetotransport, bulk magnetic susceptibility and NMR of antiperovskite Sr_3PbO. The samples for these measurements have been offered by Max Planck Institute for Solid State Research which I visited for this Long-Term Dispatch. We have revealed that Sr_3PbO has extremely light effective mass which is consistent with the presence of three dimensional Dirac electrons by magnetotransport measurements. NMR spin lattice relaxation rate of Sr_3PbO shows anomalous temperature dependence which also reflects linear dispersion of three-dimensional Dirac electrons.

However, we have difficulty in exploring giant orbital diamagnetism of Dirac electrons by bulk magnetic susceptibility and NMR measurements. First, the samples sometimes contain magnetic impurity. Second, NMR peak is not sharp but broad due to the inhomogeneity of carrier density in the samples. In this Long-Term Dispatch, I tried to solve these problems with collaborators who have technique in material synthesis.

Research

During the stay in Stuttgart, I synthesized single crystals of antiperovskite Sr_3PbO with collaborators, Juergen Nuss and Claus Muehle. They have chemistry background and are experts on crystal synthesis and crystal structure analysis. To realize higher quality single crystals than before, we merged their chemical knowledge and my physical knowledge about synthesis of high purity samples for physical property measurements.

We need low carrier density and homogeneous samples for my research. We have to be very careful not to contaminate chemical agents and tools. We shared the knowledge about synthesis of high purity crystals and worked on the synthesis. For example, we distill Sr metal to remove oxides and hydroxides and use higher purity lead oxide. We

seriously wash tools which may touch chemical agents.

To optimize the condition for single crystal growth, we tried various crucibles and temperature sequences. It takes at least about 10 days to complete one synthesis sequence. Although we could not try many kinds of conditions, I estimated carrier density by magnetic susceptibility measurements and feedback this information to the synthesis. During the stay, we roughly found out what temperature sequences give larger or lower carrier density crystals. We will keep contact in proceeding this project and continue to make larger single crystals by longer time and to optimize temperature sequence in more detail.

Life during the stay

Stuttgart is located in southwest part of Germany and the next largest city to Munich in southern part of Germany. The weather of summer is much better in Stuttgart than in Japan. It is not humid in the daytime and cool at night. I do not need an air-conditioner. (Actually, usual rooms do not have air-conditioner unlike Japan.)

I stayed in the guesthouse of Max Planck Institute. This is located at a useful place, next to the institute. I can walk to the institute in 30 seconds. I have used a canteen for lunch. It closes at 16:00, so I cooked dinner in a shared kitchen of the guesthouse. Germany sausages and beer tastes very good. Many kinds of beer are available in supermarkets. I often drank white beer which is difficult to get in Japan. However, Germany dishes do not have a lot of variations (at least in the canteen), so I bought Japanese seasonings such as soy sauce in an Asian supermarket and used them to cook dinner.

Students and scientists in the institute were very kind to me. They invited me to football practice for a tournament in the institute and I really enjoyed it. Unfortunately, I could not attend the tournament itself which will be held after I left Stuttgart. I am looking forward to hearing the result by my colleagues.

Acknowledgements

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