Report on MERIT Overseas Dispatch

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Period of visit: 2017/9/28~2017/12/21

Overview

I stayed at Prof. Manfred Sigrist in the Swiss Federal Institute of Technology Zurich (ETH Zurich) in Zurich, Switzerland.

Circumstance

Professor Sigrist is a leading researcher in the study of superconductors in broken centrosymmetric, and time reversal symmetric materials. He is deeply connected with Japanese researchers probably because he used to stay in Japan. Since I wanted to extend my research on nonlinear electric conduction and directional electric conduction to superconducting systems, my supervisor Prof. Nagaosa advised me to stay with him.

Research

After introducing mutual research with the group members, Professor Sigrist suggested me to study the direction dichroism of superconducting critical current. This can be regarded as an ideal diode in which superconducting current flows in one direction and normal current flows in the opposite direction. The target system is Sr2RuO4, chiral p-wave superconductor, which he knows very well. In this material, Cooper pairs responsible for superconductivity have an orbital angular momentum in the c-axis direction, so time reversal symmetry is spontaneously broken. It is expected that a time reversal symmetry breaking with directionality (magnetization etc.) will result in direction-dependent electric conduction by applying a magnetic field in the same direction. Therefore, I calculated the directional and magnetic field dependence of the critical current of the Josephson junction with the magnetic field applied in the c-axis direction. In conventional superconductors, this problem has been well understood microscopically and phenomenologically for a long time but in Sr2RuO4 he taught me that a special term is added at the level of phenomenology. After some simple calculations, it became clear that in order to obtain the direction dichroism of the critical current, it is necessary to introduce structural mirror-symmetry breaking in addition to the magnetic field in the c-axis direction. In addition, in this calculation, we got intuition that the additional term specific to Sr2 RuO4 originates from the topological edge current that is a direct consequence of the topological superconducting state of Sr2RO4. We have

started the microscopic calculation of Josephson current. Unfortunately, I had to go back to Japan during the calculation, but we have decided to keep in touch.

Life

Zurich is located in the central part of Switzerland, a city with a long history surrounded by Lake Zurich and hills, good access to large cities such as Bern and Lausanne, tourist destinations such as the Alps. For the stay within 3 months, you can visit without visa. Concerns about staying may be climate and cost of living. As for the former problem, the temperature is lower by 5 °C than in Tokyo, but no special preparation is required. It is snowing but wind is not as strong as Tokyo, and I did not feel it was so cold. It is necessary to pay attention to the living cost. Prices in Switzerland are quite expensive among Europe, cost for housing and food expenses were heavy burden during my stay. Fortunately, I could receive a support from the recipient about rent while staying. In the university I stayed in a big building of Institute for Theoretical Physics. In addition to condensed matter physics, there are many divisions such as mathematical physics, string theory, particle theory, information theory, etc. Students and staff are divided into mirrored offices of 3-4 people beyond the barrier between fields. Whiteboards and sofas were installed everywhere in the floor, and discussions were constantly being held. Common kitchen space with coffee machines, refrigerators, ranges etc. was also a place of exchange and discussion. In this institution, about 2-5 seminars by external researchers are held every day. Topics range from elementary particle physics to energy issues, to researchers' career development, and to lectures by scientific journal editors. After big seminars, there were small parties with wine, beer, and snacks where they enlarge the circle of their friendship. In the end of the stay it was almost Christmas, so many parties, official and informal, were held. What the most impressive was the diversity of the group members. Excellent young people had gathered not only from the Swiss, but also from all over the world including Spain, Italy, Slovenia, Romania, Armenia, China, United States, Brazil etc. During the lunch, we discussed the Spanish Catalonia issue, China's population policy, the history of the former Soviet Union countries etc, and I was ashamed that I could not talk about politics and culture of Japan. It may be necessary to learn the sense of crisis in the odd situation that there are only Japanese people in universities in Japan.

Acknowledgments

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