

変革を駆動する先端物理・数学プログラム (FoPM)

国外連携機関長期研修 報告書

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Taking advantage of an opportunity from the FoPM International Research Experience, I spent about two months, from October to December 2024, conducting collaborative research at the Karlsruhe Institute of Technology (KIT) in Germany. I was hosted by Professor Jörg Schmalian at KIT. I am studying condensed matter theory and continued research in this field. His group's research covers a wide range of topics in condensed matter theory, particularly focusing on the theory of superconductivity and transport phenomena. I usually study transport phenomena of electron systems that preserve momentum conservation, and I had previously read some of his papers about it. Because of this, I was interested in his group and was able to contact him through my supervisor.

Although he generously took the time to discuss the research I had done in Japan and gave me an opportunity to present my work in a seminar, I mainly worked on a topic different from my usual research during my stay. We have continued this project as a collaborative research effort after I returned to Japan, so I will not go into details in this report. In short, here is an overview of the main points of my research: I studied how the anomalous Hall effect can be observed in altermagnet, which is a novel class of magnetic materials and has attracted significant attention both experimentally and theoretically. I mainly performed numerical and analytical calculations using specific models, and I examined how the results could be understood through symmetry classification from a broader perspective.

Even though the stay lasted only a little over two months, we were able to achieve certain research results and had a very productive time. I learned a great deal of new knowledge and skills by trying a theme different from my usual work, and I think it was a good experience to step out of my comfort zone and to carry out collaborative research from scratch to a certain degree of completion—of course, with some trial and error. This experience gave me a meta-perspective on research designs from different angles than usual.

The research activities themselves were very fulfilling, but even more valuable was the experience of being in an international environment. His group and other groups, which we often shared lunch with, were truly international. Many of the faculty, post-docs, and graduate students came from various countries other than Germany. Since they had moved to Germany after pursuing careers in their respective countries, I was able to learn about their diverse international perspectives and experiences. Through our discussions about life, experiences, and career paths, not only did I hear fascinating and interesting stories, but I also had the opportunity to view my own career in Japan from a more relative perspective. We often talked about politics, which I think is a particularly different aspect of daily conversation compared to Japan.

Of course, I had expected to spend time in an environment completely different from Japan, and indeed, I did experience many differences in my daily life. Personally, I was not confident in my English and found it difficult to become accustomed to discussions and daily



A picture of Physikshochhaus at KIT, where I spent most of my daytime hours.

conversations in English. I often felt frustrated that I could not easily convey what I wanted to say. Nevertheless, I learned that I could manage, to some extent, even though my English was not perfect. Of course, I cannot emphasize enough that my life in Karlsruhe owed much to the help of Professor Schmalian and the group members.

Living in Karlsruhe also provided me with a wonderful introduction to German and international culture and lifestyles. Karlsruhe, which I was told is one of the sunniest cities in Germany, is a comfortable mid-sized city to live in. It has a very convenient tram system, which I used on a daily basis. On days off, I often took day trips using *Deutschlandticket*, a monthly ticket introduced as part of environmental initiatives supported by government, which allows unlimited use of all local public transport (trams, buses, and regional trains) in Germany. Even though German trains have become infamous in recent years for frequent delays and cancellations (and I experienced several cancellations and countless delays during my stay), certain aspects of the public transport system seem ideal to me. Especially, the public transport system, supported by the federal and local governments, is more integrated than the system in Japan. I was lucky enough to join a once-a-year group trip. We visited the *Schwarzwald* (the Black Forest), a picturesque region near Karlsruhe, and went hiking. I was also able to enjoy authentic Christmas markets, which was a small but delightful highlight of my stay.

Finally, I would like to thank Professor Jörg Schmalian and everyone I met during my time at KIT for their warm welcome and support. I also extend my gratitude to the FoPM program for providing the financial support that made this invaluable experience possible.