（別紙様式５）

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

氏　　名	穴井　啓太郎
所属部局	工学系研究科　　物理工学専攻
受入先	University of Mainz
日程	西暦 2024 年　6 月　1 日　～　西暦 2024 年　7 月　31 日

This report will be seen on the website, and my research topic during the stay contains what is not published yet, so I do not report the details of my research here.

I visited the Johannes Gutenberg University of Mainz in Germany during June and July. I joined the group of Prof. Peter van Loock, who is a well-known theorist of quantum optics. His group members also study works related to quantum optics. For example, they study topics such as optical quantum computing, optical quantum communication, and optical quantum sensing.

First, I will explain why I wanted to join his group. In Japan, I implement experiments on quantum optics. Now, I am planning to implement my new experiment, and I visited his group because I wanted to discuss my experiment and build up the theory about it.

Here, I roughly introduce my research topic during the stay. I am studying the optical quantum computer. The “quantum computer” is a new computer that utilizes one of laws of the physics, quantum dynamics. I am trying to make this type of computer by using light. However, we cannot exploit the full potential of the quantum computer because we cannot handle a large experimental setup and we cannot fully deal with the experimental noise. Then, there are two choices about the research. One choice is to try to make the perfect computer by dealing with the problems above. The second choice is, by allowing the problems above, seeking practical algorithms and applications which is useful and can be implemented with the current technology. I am investigating the second choice. Especially, I am now studying to utilize the power of machine learning for the optical quantum computer. During my stay, I discussed such a “quantum machine learning” method. I believe that this method will not only demonstrate the power of current optical quantum computers but also help the future development of it.

Then, I write the way of everyday research in his group. The group has a regular meeting once a week, so most members come to the office when the meeting is held. During the meeting, Prof. Peter asks members about their research's current results and problems. However, other than the day of the meeting, some people always come to the office and others do not. I think the absence of members is a big difference between the theoretical group like Prof. Peter’s group and the experimental group like our group in Japan. In addition to such group meetings, we also have a seminar. In the seminar, a researcher from all over the world are invited to the university, and they talk about their research topic. There are various topics such as quantum communications and topological phase transitions. Their talk is also impressive to me, and I realize the variety of quantum technology.

Besides the meetings and lectures, I often discuss with Prof. Peter in his office. When I wanted to discuss something with him, I first contacted him through email and attached the day of the meeting. Then, I went to his office and we discussed using the whiteboard, the PC, etc. When I asked him questions, he always gave me very constructive comments and meaningful insights. Even if I was not familiar with what he said, he taught me very clearly and kindly in various ways such as using simple examples of phenomena. Hence, I can understand what he wants to say and I can improve my research with his knowledge.

I would also like to write the daily life in Germany. I feel that the temperature and humidity are low in Germany compared to Japan, so I feel comfortable there. There are a lot of bus and tram stations around the city, and they are

the main tool of travel. When we ride on them, there are no ticket gates. In Germany, we can buy a “Deutschland ticket” which costs 49 Euros per month. We can ride on most of the buses, trams, and railways if we have a ticket. I hear that beer and sausages are delicious in Germany, so I often go to the restaurant and eat them. The number of people seems to be not so high compared to Tokyo, but there are a lot of people during the festival called “Mainzer Johannisnacht.” During the festival, there are a lot of food and attractions. I feel that the scale of the festival is larger in Germany compared to Japan, and it is a very fun event. The other things are not so different from Japan, and it is easy for us to live.

Finally, I appreciate Prof. Peter van Loock for allowing me to join his group and discuss a lot, Shuntaro Takeda (my supervisor) to support my studying abroad, and the FoPM program to give me an opportunity to study abroad. It was a meaningful study for me.

1. The building of the Institute for Physics at the University of Mainz.