（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	吉井真央
所属部局	工学系研究科物理工学専攻
受入先	Néel 研究所
日程	西暦 2023 年 8 月 7 日　～　西暦 2023 年 11 月 3 日

As the international Research experience program, I visited Prof. Adolfo G. Grushin's group at the Néel Institute in Grenoble, France.


Cocktail of Chartreuse

Introduction of Grenoble

To begin with, let me briefly introduce about Grenoble. Grenoble is a city in the southeast part of France and famous for its green liqueur, Chartreuse. Since it is close to Switzerland and Italy, it is easier to go to Geneva and Milan rather than going to Paris and Marseille. Also, Grenoble is a part of Alpes. The city is surrounded by mountains of 2000m to 3000m, so we can go hiking easily using one-day tickets for local buses.

From an academic point of view. Grenoble is what Tsukuba in Japan. Along the tram B line, there are many institutes and buildings of universities, so you can find researchers everywhere.

Why I visited Prof. Adolfo

In the PhD course, I've been working on the topological phenomena in quasiperiodic systems. The quasiperiodic system is defined as a system with long-range order without the translational symmetry. On the other hand, Adolfo is an expert on the topological phenomena in the aperiodic systems, and the aperiodic systems is a system without the translational symmetry. As you see, quasiperiodic systems are a special group of aperiodic systems, and they are similar systems in the sense that they don't have the translational symmetry. Therefore, we can find many similarities in method and interest and so on.


Hiking at Moucherotte

Research

During the visit, we mainly studied the physics of Hat tiling using the Kernel Polynomial method (KPM). Hat tiling is a new quasicrystal found in 2023 and an answer to the Einstein problem. Since this is a new tile, little is known about this tile. Adolfo's group had already studied the electronic band structure of this tiling before I arrived at the Néel Institute, so I tried to study the nature of the Hat tiling itself and other physical quantities.

To study the hat tile itself, I started the research by calculating the fractal dimension, scaling exponent and diffraction spectrum numerically. Next, I tried to determine the higher-dimensional periodic structure of Hat tiling. The quasiperiodic system is a system obtained by projecting a higher-dimensional periodic structure in a special manner. If we use this higher-dimensional structure, we can predict the diffraction pattern and other quantities easily. Thus, to understand the Hat tiling, it is necessary to determine the higher-dimensional structure and corresponding projection.

To do that, I read Socolar's paper, but there remain many problems to be solved.

Another project is to understand the optical property of the Hat tiling. To do that, I used KPM, but this method was completely new to me. In addition, there was no package of KPM implemented in the Julia language. Therefore, I first implemented the KPM in Julia and calculated the physical quantities after that. Even though we've not finished writing a paper, we have finished the calculations and collecting data. Thus, the remaining task is to understand the mechanism.

My life in Néel institute

Here, I will explain my life at the Néel Institute with my colleagues. During the visit, I went to the office at 7 am and other PhD students without lectures were also there at 9 am. Until lunchtime, we focus on the research. At lunchtime, we went to the cafeteria of CEA. The price of meals in the cafeteria is low for the students and postdocs, but high for the professors and visitors, so in summer, I also did a picnic with sandwiches. After lunch, we moved to another room to have coffee. We had some conversations sipping coffee until 2 pm. After the coffee break, we played table football and returned to research. Around 5 to 7 pm, we finished the research and went to the bouldering gym together.

Other activities

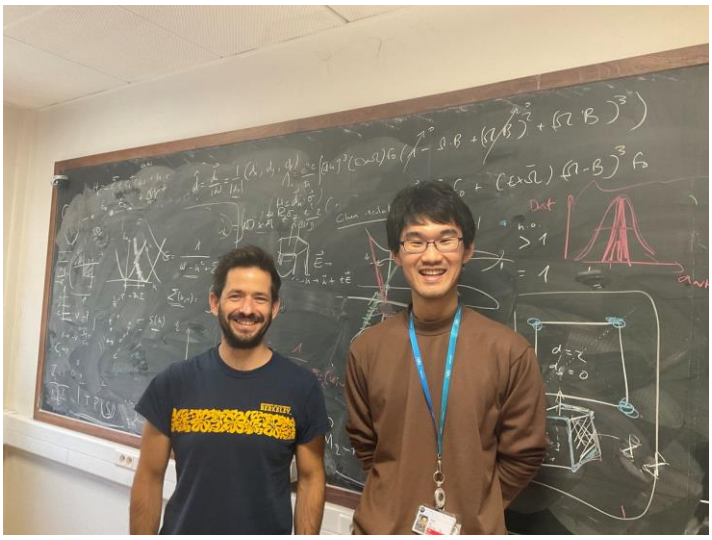
Thanks to this program, I could attend one conference and have two discussions. One reason why I visited France at that time is that there was a conference in Evian. This is a conference about the aperiodic systems supported by Japan and France. At this conference, I gave a talk about the Gap Labelling theorem. After this talk, I had a chance to have a chat with Prof. Anuradha Jagannathan from Université Paris-Saclay. She is one of the top researchers in quasicrystal and noticed that we have many overlaps in the interest. In addition, I attended the talk by the experimentalists on other fields. Especially, boson peak was a new topic for me and I want to try it one day.

After the conference, I discussed with the attendees of this conference. First, I visited SIMAP at Université Grenoble Alpes and discussed with Prof. Marc de Boissieu. He is a famous experimentalist on the structure of the quasicrystal. I learned a lot about the coherence X-ray diffraction from him. After that, I explained my research and received interesting comments.

Before going back to Japan, I moved to Paris one day earlier than the initial plan to visit the Laboratoire de Physique des Solides (LPS) at Université Paris-Saclay. At LPS, I discussed with Prof. Frédéric Piéchon. He has been working on quasicrystals and I've cited many papers of him.
Discussion with him was very fruitful for me and I have deepened the understanding of his papers.

Conclusion

My life in Grenoble was very meaningful. Not only the researchers, I could also interact with local people at bakeries and bouldering gyms. Through this interaction, I could get to know more about French culture. Moreover, when I communicate, I had to use French. This improved my French. After going back to Japan, I will continue the research and study French.



With Prof. Adolfo G. Grushin