（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	西村　直樹
所属部局	理学系研究科　　物理学専攻
受入先	中国科学院大学カブリ理論科学研究所
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I stayed the Kavli Institute for Theoretical Sciences (KITS) at the University of Chinese Academy of Sciences (UCAS) for 2 weeks. Together with my supervisor, I visited Prof. Matsuo at KITS to conduct collaborative discussions on chiral phonons. We had already been conducting joint research with Professor Matsuo, but the direct, in-person discussions significantly improved our efficiency. This visit was an excellent opportunity to accelerate our project.

Chirality, representing the breaking of left-right symmetry, is a fundamental concept across a wide range of fields, including physics and chemistry. Recently, chirality-induced spin transport phenomena have been reported, raising expectations for their application in spintronics. Conventional spintronic devices typically require heavy elements with strong spin-orbit coupling. However, by utilizing chirality-induced spin-dependent phenomena, it becomes possible to fabricate devices using only light elements, which places a significantly lower burden on the environment. In particular, the conversion of chiral phonons to electron spin is being considered. Therefore, elucidating the mechanisms behind the emergence of phonon chirality is essential.

Long-wavelength phonons are typically described using elasticity theory. However, conventional Cauchy linear elasticity cannot break spatial inversion symmetry, making it unsuitable for describing chiral phonons. Describing these phonons requires a more advanced framework known as Micropolar Elasticity. Unlike conventional theories, this approach introduces microrotation (local rotation) as an independent degree of freedom in addition to lattice displacement. A major goal of this joint research was to gain a deeper understanding of this theory and explore its potential applications in spintronics.

In this collaboration, my role was to perform phonon calculations for carbon nanotubes. I investigated the effects of applying torsional stress to induce structural chirality. Through calculations based on Cauchy elasticity theory, I showed that hybridization occurs between the phonon twisting modes and breathing modes. Crucially, I was able to correspond the twisting mode in this system to microrotation, thereby providing a simple example of the origin of microrotation. This result is expected to advance the understanding of micropolar elasticity.

Intensive Collaboration & Progress



The stay felt like an intensive research retreat. On weekdays, Prof. Matsuo, my supervisor, and I held daily discussions on Micropolar Elasticity, while I dedicated the rest of my time to my own research. I was astonished by the speed at which our project progressed. Prof. Matsuo would summarize the ideas from our discussions into notes that very same day, allowing us to hit the ground running the next morning using his notes as a base. Meanwhile, my supervisor consistently focused on interpreting the physical significance of our findings. This synergy drove our discussions forward daily and led to significant progress. While actively participating in these discussions, I also focused on my own calculations during the remaining time and managed to complete them. I tried my best to keep up with the fast pace of the two professors to produce results within the two weeks, and I am relieved that we succeeded. Needless to say, thorough preparation was crucial. I had studied the necessary background material in Japan beforehand. Similarly, the professors were able to maintain

such speed because they had cleared their schedules of other work prior to the trip. It was an incredibly enjoyable and valuable experience to participate in such a focused project built upon solid preparation.

Beijing's Rich Food Culture



Good meals are essential for productive research, and in this respect, Beijing offered an ideal environment. China's vast territory has given rise to a rich and diverse food culture. I particularly enjoyed the local specialty, Peking Duck, which was outstanding. While Chinese cuisine is often associated with sharing large dishes among a group, there are also plenty of excellent options for solo dining, such as Beef Noodle Soup (Niu Rou Mian) and Rice Bowls (Gaifan). These meals are not only affordable but also come in generous portions. I also savored the unique spicy flavors of authentic dishes like Malatang and Mala Xiang Guo. In addition, I was delighted to find high-quality Chinese tea easily available. Enjoying a cup during my breaks was the perfect way to refresh my mind. Thanks to this wonderful culinary environment, I was able to fully dedicate myself to my research.

Transportation and Commuting

Apart from food, another major difference was the transportation. Unlike Tokyo, where people rely heavily on subways and roads are often narrow, Beijing is a city built for cars. The avenues are wide, with separate lanes designed for electric scooters and bicycles. I found the bike-sharing systems—available everywhere—to be incredibly convenient. Thanks to the dedicated lanes, riding in Beijing was far more comfortable than in Tokyo. For just 1.5 yuan per ride, these bikes helped me speed up my morning routine, although I stuck to walking at night as the bikes didn't have lights. Even on foot, my commute was only about 20 minutes. For someone used to a 90-minute commute each way in Japan, this was a life-changing difference. Having that extra time really allowed me to make the most of every day.

Conclusion

This stay was incredibly fulfilling, both in terms of my research and daily life. It was a transformative experience that I believe will have a lasting impact on my future path. I would like to express my sincere gratitude to everyone at KITS and all those who supported this visit.