（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

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With the financial support of this program, I visited Prof. Tanmay Vachaspati at Arizona State University and Prof. Tina Kahniashvili at Carnegie Mellon University. They are specialists in cosmology and magneto-hydrodynamics, respectively, which exactly match my current research interest. I really enjoyed this chance of studying abroad, and I will report on the experience of both the research activities and the cultural immersion in the US.

I had a two-fold main purpose to visit those research groups. One side is to start a new research project and obtain new skills in conducting research. The other side is to discuss and advertise my research outcomes and get to know many researchers overseas. Since this chance was my first time in the US, I tried just enjoying the atmosphere as well. With these purposes in mind, I believe I achieved a lot for my future life as a researcher.

The research project with Tanmay was about particle emission from the superconducting cosmic strings. It is widely believed that line-shaped objects are formed at a certain type of cosmological phase transition (Kibble mechanism). These objects are called the cosmic string. The microscopic nature of cosmic strings depends on the model of the theory that describes the nature of the cosmological phase transition. Since we don't know the exact theory that describes the early universe, we often assume a model and investigate the essential nature of the cosmic strings that are formed under the model. The simplest one is the so-called Abelian-Higgs model, whose string solution has been deeply investigated. The string solution in one of the second simplest ones is the bosonic superconducting string, which has an electromagnetic current along the string carried by a charged scalar. Superconducting cosmic strings are interesting because they have not only gravitational interaction but also electromagnetic interaction, although the numerical studies of their dynamics are not sufficient to further discuss their phenomenology. In such a situation, our project started aiming to do the three-dimensional numerical simulation of the dynamics of a superconducting string loop.

It was not an easy task for me to do that simulation because I had never experienced numerical stuff before. At first, I tried to find a static string configuration of the superconducting string. The problem seemed very elementary and easy to solve. However, unexpected numerical instabilities appeared. I came up with many ways to modify the method of solving the equation, consulted literature, and failed to overcome the instability many times. It took me so much time before I finally succeeded in solving the problem that I felt that I was wasting time because of my lacking skill.

However, I learned a lot in struggling to overcome the problem. I got used to the coding language, learned many numerical techniques, and communicated with the people there. The former two points will broaden the possible research fields I can work on in the future. I feel that, for theorists, numerical simulations are a kind of experiment and can complementarily enhance theoretical thoughts. The last point gave me the confidence to conduct future research beyond the difference in language. Therefore, the duration I didn't get any good results, I believe, is not a waste of time at all.

Along with the research activities with Tanmay, I gave a seminar about my research interest both at Arizona State University and at Carnegie Mellon University. Broadly speaking, my interest is the cosmological magnetic field in the early universe, and these two groups have much interest and are strong in that field. I received

many questions and comments about my previous works. Tina at Carnegie Mellon University is a specialist in that field, and she has critical opinions about what I assumed in my previous works. She has her own opinion, and we discussed it. Such communications with experts were fruitful since I believe I got broader perspectives through the discussions.

Life in the US was very comfortable. The language, social norms, and culture are different from those in Japan, but it seems the same in that people are respectful of other people. I participated in a cultural event at Arizona State University, which exhibits the culture of the Middle East and North Africa. Many people from different countries in that region were there, and some of them wore their beautiful national costumes. Although I am not a person from that region, they kindly accept me. It is rare in Japan to be in such a diverse community, so I had not experienced such an atmosphere in which people of different nationalities respect each other. I enjoyed it very much.

In summary, my research activities did not go as fast as I expected but are successful. I learned a lot both technically and from a meta point of view. In addition, the atmosphere in the US made me a more international person than I was before. I believe that this valuable opportunity helps me a lot in my future life as a researcher.