（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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I stayed in San Pedro de Atacama in Chile for about a month to develop one of the cosmic microwave background (CMB) telescopes. The CMB has a variety of information that is useful for understanding the early universe. The Simons Array (SA), an ongoing ground-based CMB experiment, is located in the Atacama plateau in northern Chile, and its second telescope expects the first light soon. For the first light, I worked on installing some key parts of the telescope, testing readout devices, and setting up some switches to control the telescope remotely. The research in Chile was a great experience for me, as I learned much about how the telescope worked and the difficulties of observation. I discuss the activities at the site and developments of these devices below.

SA telescopes are operated at an altitude of about 5200m, which is suitable for the CMB observation because its dry climate suppresses water absorption in the millimeter wavelength. However, the activities at the site in such a harsh environment were much more difficult than that in our daily lives. There was less oxygen, I always needed to carry an oxygen tank. Also, the wind was high, such as 80 km/h, so all site works were weather dependent. To work in such limited time, I planned meticulously what to do outside and what I can do at the office. Also, there were site meetings with people not at the site three times a week in the morning. We checked our plans for the next couple of days and discussed how to work efficiently. In this way, through close communication with collaborators not at the site, we could make to proceed rapidly with the data analysis. For example, I took the data during the day at the site and the data was analyzed by the people in the US in the evening. We discussed the results at the evening meeting and tried to take the extra data the next day.

Regarding the installation of the telescope parts, we installed the stimulator as a significant accomplishment. The stimulator is crucial to observe the CMB signal. It is placed behind the hole in the center of the secondary mirror of the telescope and used to calibrate the telescope. It was developed and tested at a lab and delivered to the site. We adjusted the screw holes and the stimulator itself to fit the telescope. It was needed to work at heights and precision handling, so it was done by collaborating with local researchers. Also, we connected it to the control box placed beside the telescope so that we can test and operate it remotely. We were able to work smoothly while talking remotely with the Thai collaborator who developed the stimulator. Finally, we checked the network and booted it correctly. It leads to the next step of the test and approaches the first light.

Photo taken in front of the telescope

To observe the tiny CMB signals, it is needed to estimate the loadings from the sky. We connected the readout cables that can connect from the cryogenic stage in the telescope's receiver to the ambient temperature boards to check the data. We could take the data from the sky, which is not the CMB signal, and analyze the data. When we interpreted the data, using the data taken by the other telescope was useful. The first telescope of the SA was finished installing and started observations. By pointing the second telescope in the same direction as the first one and taking data at the same time, we could compare the data and could have a deeper understanding of the situation. When we take the data, some devices at the ambient temperature are heated to about 50

C, and it is dangerous if it gets too hot because the devices will break down. For this reason, multiple fans are placed to create airflow for cooling. We found some problems with the fans and tried to solve them. By measuring the airflows of all the fans, we checked the status and found the cause. It is continuous after I came back to Japan, but it was a good test to compare with other experiments and to isolate the cause.

The telescope will be operated remotely after finishing the installation, so setting up switches is important for later operation. At the site, there were many power supplies and network switches. Therefore, the site network is a little bit complicated. Also, it takes a lot of time because work should be done outside of the office. By discussing with a knowledgeable collaborator and being taught to work on the site, I set up the IP addresses of some switches and checked whether it works correctly. In this way, I learned many things that I would not normally experience in the lab and obtained technology essential to the future operation of the telescope.