（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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In the host laboratory, experiments for realising quantum information processing using light are conducted as well as in the Furusawa laboratory to which I belong. Particularly, researchers there are working on the generation and measurement of optical quantum states in integrated optical waveguide chips. I was sent to the laboratory for the purpose of gaining experience in the research there and to provide techniques for experiments in free-space optics, with the mutual aim of further developing quantum optics research.

I was involved in two experiments on the generation of quantum states using non-linear optical effects inside optical waveguides. One was an experiment in which continuous variables of light are supposed to be the quantum information, which was in the system of free-space optics, so I utilised the experimental techniques obtained in Furusawa laboratory. Specifically, I built an optical resonator as a frequency filter to cut the light scattered and reflected in the optical chip. The host researchers do not usually work with free-space optical systems, so when I finished building the optical resonator in several hours and succeeded in controlling the length of the resonator using electric circuits, they were very impressed as it was the first time they had actually seen this physical phenomenon. The other was an experiment in which discrete variables of light are supposed to be the quantum information, which is different from one being carried out in our scheme. In this experiment, I aligned an optical chip so that an external laser beam could couple to it and generated single-photon states by non-linear optical effects inside the optical chip, which were confirmed by a photon detector made of a superconducting circuit.

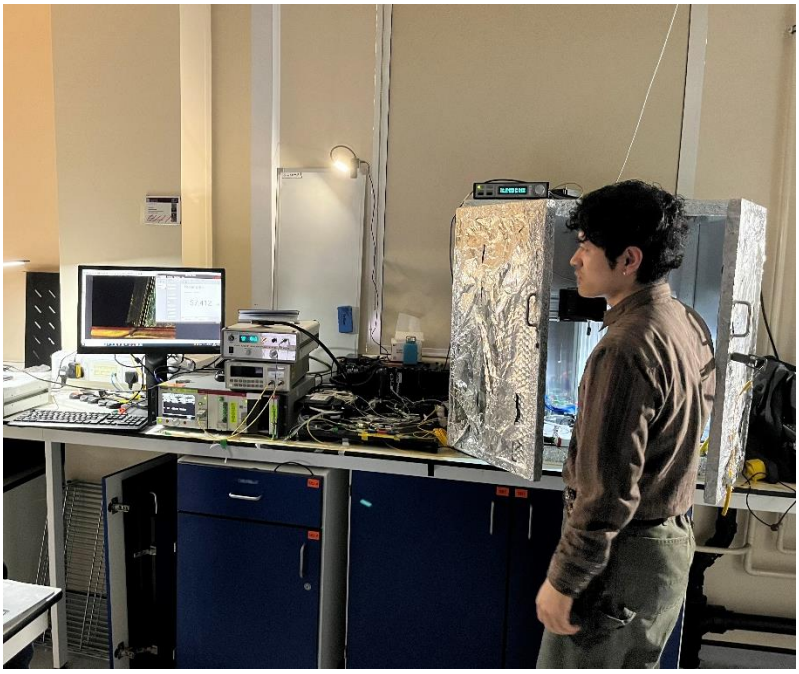
The advantage of using optical chips is that quantum optical systems can be implemented in a scalable way, including non-linear optics for generating quantum state and photodetectors for its measurements. In addition, while it is essential to control an optical path length which fluctuates due to physical vibrations of optical elements in free-space optical systems, the path length can be precisely defined in an optical chip using advanced optical lithography technology, which has the experimental advantage of simplifying the experimental system. On the other hand, optical loss due to light scattering or reflection, which is a phenomenon peculiar to waveguides, is a problem, but our research has demonstrated quantum operation tolerant to such optical loss by applying optical communication technology. This means that experiments can also be conducted using the advantages of optical chips. From this perspective, we realised that the ability to precisely define the optical path length and to construct a high-speed photodetector inside an optical chip is extremely useful for our quantum optics experiments, and we were able to obtain ideas for new experiments. In addition, we also acquired the technical know-how for experiments with such optical chips.

At the university of Bristol, there is an organisation called QET:Labs across the boundaries between laboratories, whose members are working on quantum mechanical experiments. I gave a 40-minute talk about my research to the members. The talk was rather difficult because few people

understood our research in the first place, but after the talk some people talked to me saying it was interesting.

During the last week of my stay, I attended a workshop (Bristol Quantum Information Technologies Workshop) held at a hotel in Bristol. As I got registered just before several days, I did not give a presentation, but I was able to see oral and poster presentations on quantum information processing experiments from all over the world.

Although not related to the research, it was very stimulating to live amongst foreign researchers. It was a great experience to gradually learn to speak English in an environment where it is essential to communicate in English. It was also fantastic to experience the lifestyle of the local people. I was impressed by the fact that they seemed to be enjoying research as a part of their lives rather than focusing solely on research.



Me aligning an optical chip while watching the image of the chip on the PC screen