

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	塚本 萌太
所属部局	理学系 研究科 物理学 専攻
受入先	スイス連邦工科大学チューリッヒ校 物理学科 スピン物理グループ
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I visited Eidgenössische Technische Hochschule Zürich (ETH Zürich) in Switzerland as an invited researcher for a month. In particular, I belonged to the Spin Physics group under the supervision of Prof. Dr. Christian Degen, one of the pioneers of the subject I am studying in my Ph.D. The spin-off company of the group, QZabre LLC, provided the experimental equipment for me. In this report, I first focus on my research and later on the interaction with people and other experiences.

In my research, I use single spins in the diamond, which are quantum sensors, to measure the distribution of magnetic fields from materials precisely. There are two main types of quantum sensors: the first, which I constructed at the University of Tokyo, uses omnipresent spins on the surface of a millimeter-size diamond crystal. This method can measure large areas quickly but has a low spatial resolution, making it challenging to observe fine magnetic structures. Another method, developed and improved by Prof. Dr. Christian Degen, uses diamonds containing a single spin attached to the tip of a thin needle, which is traced over the material. This method has a high spatial resolution, providing a high possibility of observing fine magnetic structures, but it requires a lot of time. In this project, I use the optimal measurement conditions identified in the high-speed measurements at The University of Tokyo for the high-resolution measurements at ETH Zürich. In other words, this project is efficient by using both instruments at the University of Tokyo and ETH Zürich.

I measured a magnetic material. When a magnetic field is applied to the material by close to a magnet, the internal structure of the material changes, which depends on the strength and angle of the magnetic field. At first, I observed the responses roughly under hundreds of different magnetic field conditions at The University of Tokyo. These included the power and angle of the magnetic field and the order of these conditions. After that, I took the magnetic material to ETH Zürich for measurement under some interesting conditions.

The equipment I used at QZabre is a commercially available one. However, this stay is necessary for achieving high-quality measurements because it relates to many high-quality technologies. At QZabre, I accessed a wealth of related equipment and jig. Its employees helped me by using their professional knowledge. Only QZabre had all of these. Even without that, the visit was very worthwhile because QZabre is the provider of the diamond tip with the highest sensitivity in all that of any company or research institute in the world.



I interacted mainly with the people of ETH Zürich and QZabre.

At ETH Zürich, I discussed a lot with students and faculty members of the Spin Physics group. At a weekly meeting for my section, I reported the week's results and discussed the results and plans for the following week as others did. At another weekly meeting for all members, I listened to lectures by people studying other fields and Ph.D. interviews. Ph.D. interview is one of the examinations to enroll in the doctoral program in the group. All members of the group listen to the presentation from the master's student who wants to belong and discuss the talk after that.

I was surprised because that events really showed the intensity of the competition. In a daily conversation with a cup of coffee, we talked about careers after a Ph.D. and the opportunity to collaborate with a researcher in other countries.

I also had physics discussions with Prof. Dr. Pietro Gambardella, Prof. Dr. Klaus Ensslin, and members of their group. During the month, I stayed at the house of Prof. Dr. Ghazoul Jaboury, a plant ecologist at ETH Zürich, so I talked about his and my research and heard about his career in academia.

QZabre is a small company with about ten employees, so I also talked with the CEO and CTO. I heard about not only the work of improvement in both hardware and software but also advertising, such as at the APS March meeting, which was new for me. Since the employees have a Ph.D. or the experience of a postdoc, I also heard meaningful stories about career development and entrepreneurship.

I attended a meeting of the Japanese staying in Zurich and met post-doctoral fellows and Ph.D. students at ETH Zürich. Since my stay was only one month, I could not acquire much information about the research environment in overseas on my own. However, I heard many episodes from them staying for a long. Those are very helpful in considering international competition. I also had the opportunity to hear many helpful stories about career development as well. On March 11, I also participated in the event to thank Switzerland for assisting Japan after the Great East Japan Earthquake.

Moreover, I have had many valuable experiences. There are people from many cultural backgrounds at ETH Zürich. Much of the knowledge I got by living with them may be necessary when living in another area of the world with them or welcoming them to Japan. I also found some of their sense of values about doctoral programs and careers different from those in Japan. Some of these ideas are still challenging in Japan, but this knowledge will be necessary in this internationalized and turbulent world.

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