

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 visited Professor Erdős at Institute for Science and Technology Austria (ISTA) from February 5th to March 3rd to discuss the possibility of an analytical approach to the eigenstate thermalization hypothesis (ETH) under physical constraints with him and his group members. He is a mathematician working on the random matrix theory and proved the typicality of the ETH for Wigner matrices. I was a little nervous because it was my first time abroad alone, and I was not good at catching English by ear. I arrived at Vienna International Airport on Sunday, February 4th, and took a taxi to ISTA that Professor Erdős and his secretary kindly arranged for me. It took about half an hour to ISTA, which is located on the outskirts of Klosterneuburg.

The discussion started on Monday. After doing some administrative work, I talked with Professor Erdős for about half an hour and had lunch with him, his group members, and other researchers on the same floor. As I had worried before, I could not catch daily conversations in English well, but they always kindly answered me when I asked them to repeat. After lunch, I explained my research topic to Prof. Erdős and the group members. Although we all are interested in the ETH, our formulation differed between the physics and mathematics sides, requiring some detailed discussion to reach a consensus. We eventually agreed to investigate the effects of the interplay between the symmetry of the system and physical constraints on observables on the ETH.

During my stay at ISTA, we had discussions almost on a daily basis. My routine at ISTA was to work on the problem by myself in the morning, have lunch with Prof. Erdős and researchers on the same floor, and have discussions for several hours in the afternoon. Professor Erdős is a calm and active person known for his hard work. He kindly explained in detail whenever some mathematics came in, such as results from number theory, that I was unfamiliar with. As the discussion progressed, we ran into a subproblem whose solution I had been sure of from numerical calculations but could not give proof of. However, group members of Prof. Erdős's group solved the problem just in one night, using a result from number theory. The method presented in this stage turned out to be applicable to the calculation of other quantities of interest in our research, suggesting an unexpected connection between thermalization of isolated quantum many-body systems and the number theory. Eventually, we could make a joint result by combining their rigorous techniques and proof methods from the mathematics side and my intuition and numerical finding from the physics side. We are continuing the discussion via e-mail and preparing the manuscript about our joint result to submit it to a journal even after I went back to Japan.

In parallel with working on the main problem, I asked each member of Prof. Erdős's group about their research topics. They study the ETH for a so-called deformed Eigner matrix, the statistics of the eigenvalues at various scales such as extreme, mesoscopic, and macroscopic, and the stability against perturbation of eigenvalues of non-Hermitian matrices. Some of them are conducting analytical research using graphical representations. I was inspired by their method and could apply a similar approach to our main problem.

In ISTA, there are usually two seminars in a week. One of which is a somewhat formal seminar about mathematical physics organized by Professors, and the other is an informal seminar organized by students and about various topics ranging from mathematics to biology. We had cakes and coffee before or after each seminar, and we casually talked to each other about the topics of the seminar. During my stay, two Ph.D. candidates came from France and Italy, respectively, to seek their postdoc position at ISTA. The formal seminar served as a part of the interview for them, and after the seminar, we went to dinner with the speaker. To my surprise, the dinner was also a part of the interview for the postdoc candidates.

In the last week of my stay, I also gave a presentation about my research in Japan about the ETH (but not as a postdoc candidate). Although the target of the study (i.e., the ETH) is common among us, my research in Japan is mainly based on numerical methods and thus a bit apart from mathematical physics. But participants showed their interest in the topic and asked me many questions about it. Discussions continued even after the seminar was closed, and I could have valuable insights from it.

On the last day of my stay in Austria, I went sightseeing in Vienna with the members of the Erdős group (Professor Erdős could not come because he was busy.) Overall, the experience in Austria was precious and a lot of fun for me. I want to express my deep gratitude to the FoPM program for supporting and encouraging me to go abroad.

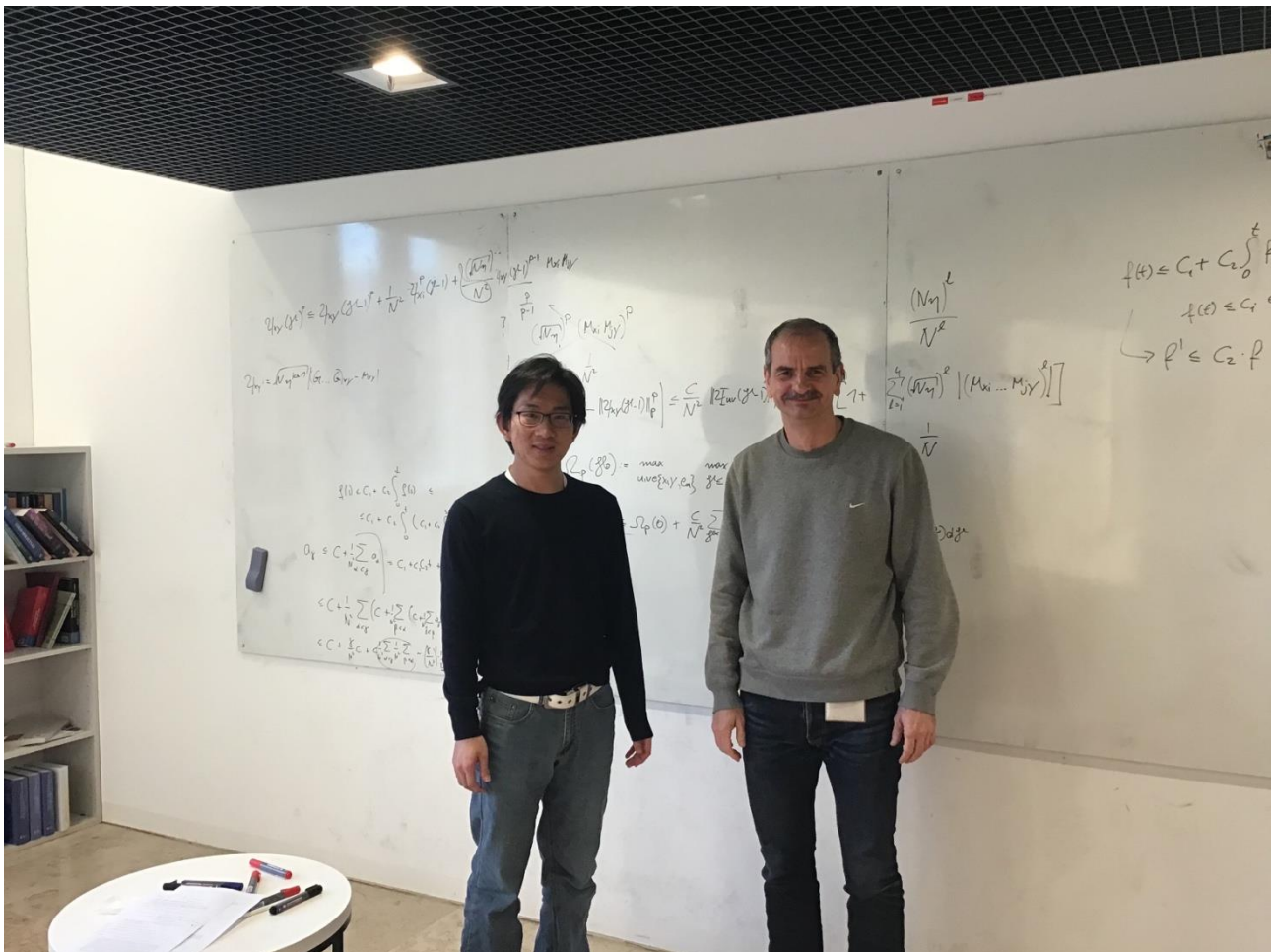


Photo with Professor Erdős