(Form 5)

Forefront Physics and Mathematics Program to Drive Transformation (FoPM)

Report for the International Research Experience

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Overall, my time as a visiting researcher at the Max Planck Institute of Quantum Optics (MPQ) in Germany was an incredibly rewarding experience. Looking back on these past few months, I can confidently say that I benefited tremendously in both academic and cultural terms. It was a rare chance to step out of my usual routine in Japan, experience a completely different research environment, and make many new friends from all over the world.

On the academic side, the environment at MPQ was highly stimulating. I had the privilege of engaging in deep discussions with a variety of researchers, including Prof. Ignacio Cirac, as well as many postdocs and PhD students in his group. I was particularly encouraged when Prof. Cirac showed genuine appreciation for my previous research achievements, as well as the new ideas I am currently developing. During my stay, I was also invited to give a talk in their group seminar. The presentation was quite successful and sparked an intensive Q&A session. I found this to be a fantastic opportunity to advertise our recent results to a top-tier audience, and the straightforward feedback I received gave me fresh perspectives on my own work.

One of the most exciting outcomes of this visit is a brand new collaboration I started with Dr. Alexander Hahn here at MPQ. We quickly realized that we share very similar interests regarding the rigorous mathematical aspects of Schrödinger operators. We decided to launch a new project focusing on the spectral properties of the Schrödinger operator within the Coulombic gas. We spent several months intensely concentrating on this specific topic, often spending hours at the whiteboard arguing about mathematical bounds and physical implications. I am happy to say that we have already obtained some highly satisfactory theoretical results. Right now, we are in the middle of writing a paper to carefully summarize these findings. Of course, research is an ongoing process, and there are still many other interesting mathematical aspects of this system left to explore. We have already agreed that we will surely collaborate again to tackle these remaining questions once our current manuscript is finished.

A significant portion of my daily work in Germany actually revolved around revising a paper I had previously submitted. One of the major milestones in my research career happened during this period: my previous work (arXiv:2411.10759, concerning the clustering theorem for Bose-Hubbard class Gibbs states) was officially accepted by the prestigious journal Communications in Mathematical Physics (CMP). To reach this point, I had to work extensively on preparing the revision and writing highly detailed response letters to address the reviewers' concerns. Since this was my first time writing a rigorous mathematical physics paper, dealing with the three reviewers was an extremely tough and demanding process. They required an exceptionally high standard of mathematical rigor for absolutely every step of our proofs. Consequently, it took a massive amount of my time. I had been grinding on these revisions almost constantly since I first arrived in Germany earlier this year, so finally getting the official acceptance notification was a massive relief.

Beyond my own projects, I actively tried to absorb as much knowledge as possible. Prof. Cirac’s group is incredibly strong in quantum information, and many of the researchers working there are true experts in the field. I made it a habit to regularly attend their group seminars, which allowed me to learn about the state-of-the-art progress in tensor network theory. I also spent a lot of time networking. I made friends

with researchers from various countries, as well as many Chinese international students studying in Munich. We had frequent and intensive discussions, both about physics and our daily lives in Europe.

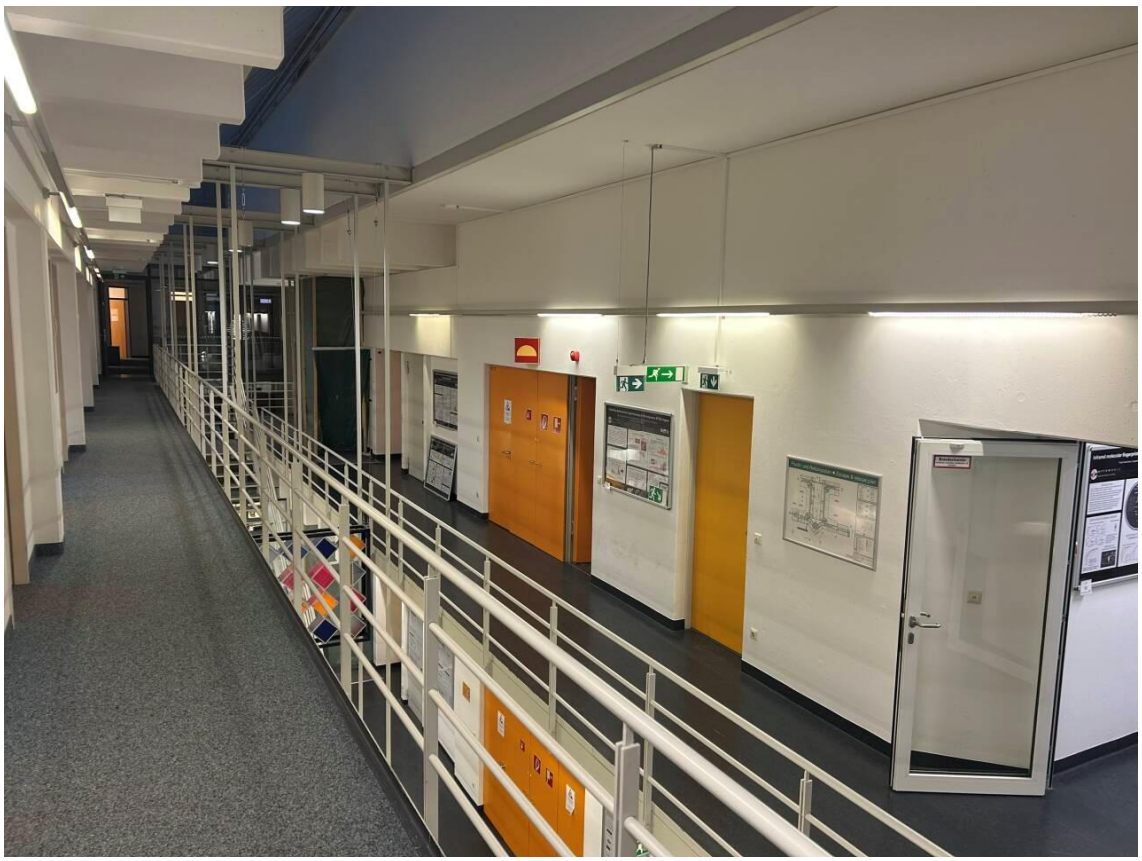
In terms of social and cultural experiences, I made sure to enjoy my time outside the office. I attended a local carnival party, which was a fun way to experience German traditions firsthand. I also planned a dedicated short trip to the Bavarian National Museum. This museum is famous for housing a massive collection of medieval knight armors and weaponry. For me, this trip was an absolute highlight. I have been deeply fascinated by medieval knights since I was young, and I have always loved related movies, games, stories, and books. Getting to see so many authentic armors, steel plates, and medieval weapons right in front of my eyes was wonderful; it felt like the history I usually experience through digital screens had come to life. It felt great to make this cultural trip happen alongside my academic progress during this Germany journey.

Finally, this experience made me reflect on what my supervisor, Prof. Naomichi Hatano, always tells us. He consistently encourages his students to actively go abroad to attend conferences, give seminars, and participate in research exchanges so we can know more about the outside world. After this visit, I completely understand why he says this, and I think he is absolutely right. Being here allowed me to see exactly what other leading researchers are doing, how they think, and how they approach complex problems. It has broadened my horizons in ways that will undoubtedly benefit my future academic career.





Bavarian National Museum



Evening of Max Planck Institute of Quantum Optics