

MERIT Overseas Research Visit Report

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Affiliated research group during the stay: Jens Eisert Group, Department of Physics, Freie Universität Berlin, Germany

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Research and Background

During this overseas research stay, I visited the theoretical physics group led by Professor Jens Eisert at Freie Universität Berlin. This group is internationally renowned in the field of quantum information theory and comprises nearly 50 PhD students and postdocs, attracting researchers from around the world. My research interests lie in understanding quantum chaos in many-body systems from the perspective of quantum information theory. I chose to spend this period in Professor Eisert's group to advance my own research through exposure to cutting-edge knowledge and interdisciplinary collaboration. This visit was made possible thanks to Mr. Ryotaro Suzuki, a PhD student in the group, who has previously collaborated with me and kindly provided support for both academic and everyday matters during my stay.

While I explored several topics during the visit, including the emergence of quantum randomness and chaos, I obtained promising results on one specific theme: how many genuinely “quantum” gates are necessary for the generation of quantum randomness. In this research, we investigated how much doping with quantum gates is needed when arbitrary classical operations—those that generate no coherence or entanglement—are freely available. We aimed to determine how many quantum operations are sufficient to elevate such a classical circuit into one capable of producing quantum randomness. Our approach extended an analytical technique previously developed for a different setting. During my stay, I had the opportunity to engage in detailed discussions with Dr. Lorenzo Leone and Assistant Professor Jonas Haferkamp, two of the original authors of the prior works. Their feedback was instrumental in validating and refining the method, and in exploring its potential generalizations.

Through these research activities, as well as the participation in group seminars and informal conversations, I was able not only to deepen my knowledge but also to significantly improve my ability to communicate and debate in English. The experience of interacting with researchers from diverse backgrounds has been invaluable for building a network for future international

collaborations.

Life in Berlin

Freie Universität Berlin is located in a suburban area approximately 40 minutes by train from the Berlin Central Station. The neighborhood around the university was safe and quiet, with access to cultural and natural resources such as a large botanical garden and the former residence of Albert Einstein (Figure 1), which provided a peaceful environment conducive to focused research.



Fig. 1: Former residence of Albert Einstein

One particularly notable aspect of daily life was the convenience of public transportation. The Berlin city area is well connected with subways, buses, and trams, allowing for smooth travel. Of special note is the “Deutschland-Ticket,” a nationwide transportation pass (excluding high-speed trains) that allows unlimited use of local trains, subways, and buses throughout Germany for €58 per month. This ticket provided exceptional freedom of movement during my stay. Another difference from Japan was the absence of ticket gates in public transit systems. Ticket checks were rare, offering a glimpse into a society built on mutual trust.

Regarding meals, I typically had lunch at the university cafeteria and prepared simple dinners using groceries purchased at nearby supermarkets. The cafeteria offered a wide variety of vegetarian options, and it was notable that one or two days each week were designated as “Vegetarian Days,” when only vegetarian meals were served.

Overall, I was able to enjoy the differences in culture and lifestyle without experiencing any major issues concerning health or safety. The time I spent in Berlin was productive and enriching, both academically and personally.

Acknowledgments

I would like to express my deep gratitude to Professor Jens Eisert for accepting me into his group, and to Mr. Ryotaro Suzuki for serving as my mentor during the stay. I also thank Ms. Claudia Thomas for her assistance with administrative matters. I had the pleasure of engaging in fruitful discussions with Assistant Professor Jonas Haferkamp, Dr. Pavel Kos, Dr. Lorenzo Leone, Mr. Antonio Anna Mele, Mr. Roberto Losada, and many other researchers and students.

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