（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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Through FoPM's long-term overseas partner-institution program, I worked for three months at Quantinuum in London, UK. Quantinuum is one of the world's largest integrated quantum computing companies, advancing both high-performance quantum hardware and cutting-edge quantum software solutions. The company was created by combining Honeywell Quantum Solutions and Cambridge Quantum, bringing together industry-leading trapped-ion hardware expertise and a rich software ecosystem in areas such as compilers, toolchains, and quantum applications.

Quantinuum's London office is located in Victoria, in the center of the city. Besides the London office, Quantinuum also possesses offices in Oxford and Cambridge. The workspace was lively and welcoming. I mostly commuted by bus, but there was an abundance of public transportation, which gave me the same feeling as Tokyo, except that it often didn't run on time.

Over a three-month internship at Quantinuum's London office, I worked on developing quantum algorithms that bridge artificial intelligence and quantum computing. Because this work is part of ongoing, unpublished research, I can only describe my internship at a high level. The details of the algorithms, datasets, and full results are intentionally omitted.

I led a project to design and prototype a new quantum algorithm for state preparation. State preparation is the task of constructing a desired quantum state using a sequence of quantum gates. It is foundational because nearly every quantum algorithm begins with preparing a specific state such as encoding an instance of a problem, loading data, or initializing a resource state (e.g., for simulation or optimization). The quality and cost of this step (fidelity, circuit depth, and robustness to noise) often dominate overall performance, especially on near-term devices. Efficient, low-depth preparation directly improves accuracy, reduces error accumulation, and enables larger-scale experiments.

In the early phase of the project, I surveyed the key literature and, together with my supervisor, Enrico Rinaldi, explored a research direction. I initially struggled to find a concrete path, but through Enrico's introductions we brought into the team colleagues across the company whose expertise aligned with the project. As the team formed, the missing pieces (both in people and in knowledge)were gathered, and the direction gradually took shape. Once a working plan was established, we held weekly meetings with the project members. In parallel, I built up the mathematical framework while validating assumptions and intermediate claims through numerical computations. Making the results visible in this way helped us iterate quickly and decide which directions to pursue. Throughout this period, I benefited from wide-ranging feedback from the team, not only on technical and mathematical details but also on motivation and on which numerical experiments were truly necessary. Their guidance shaped the refinement of the approach. On the final day of my internship, I presented the project to team members and other colleagues. The talk generated a lively Q&A and constructive feedback. I am continuing to collaborate with the London office project members toward a paper, and we are working to share the results publicly in the near future.

Beyond my independent project, I also contributed to several projects aimed at exploring synergies between AI and quantum computing. In these collaborations, my role mirrored what my colleagues did for my own project: surveying relevant literature and brainstorming algorithmic ideas. One of these collaborations has already resulted in a publication.

I also used paid leave to travel within the UK and to other European countries. Snowdonia in Wales left the strongest impression. Hiking is a hobby of mine, and I've climbed high, rugged peaks in the Alps. Until recently, I was mostly interested in tall, technically demanding mountains. However, Snowdonia's peaks are only around 1,000 meters, yet they have steep sections and spectacular landscapes, which reminded me of the dramatic mountains surrounding Hogwarts in the Harry Potter films. This experience changed how I think about mountains and what makes them inspiring. The Scottish Highlands were equally striking. Their distinctive terrain was first created by the ancient Caledonian orogeny (continental collisions roughly 400 million years ago) and later sculpted by repeated Ice Age glaciations, which carved some of the region's most iconic places.

Although I had visited Europe and the UK before, living and working in an unfamiliar country was a major step in my personal growth. Starting at a new company while adapting to an unfamiliar environment was hard. I also faced day-to-day challenges, including periods of poor health, minor injuries, and general safety concerns. Despite these challenges, I'm proud that I kept the research on track and built good relationships with colleagues while fully enjoying the UK's culture, landscapes, and history.

