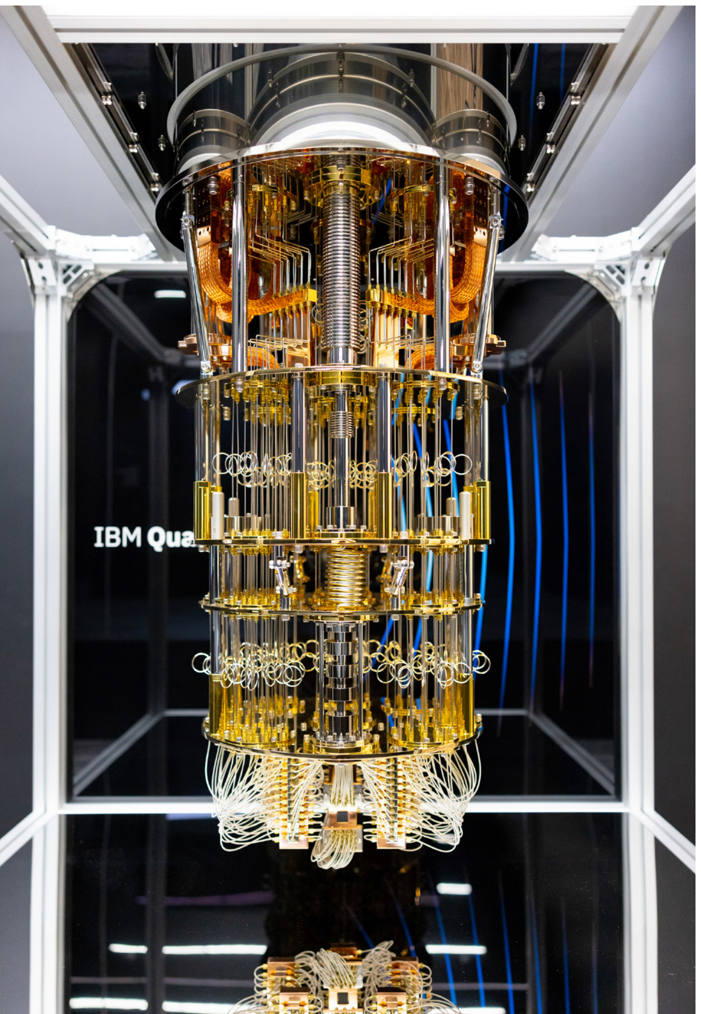
PURSUING THE 100,000-QUBIT

QUANTUM COMPUTER

THROUGH JAPAN-U.S. COLLABORATION

Hoping to accelerate research into quantum technology, which has potential applications in fields as diverse as drug discovery and cryptography and is also crucial for economic security, the governments of Japan and the United States have agreed to strengthen cooperation in education. Industry and academia in both countries are collaborating to pioneer quantum-centric supercomputing.

Quantum technology, which utilizes the quantum nature of substances and energy at the subatomic level, is attracting worldwide attention. As countries race to develop quantum supercomputers with enormous processing power and applications in various fields such as quantum cryptography to ensure more secure communications, Japan and the United States are strengthening their cooperation to develop quantum technology.

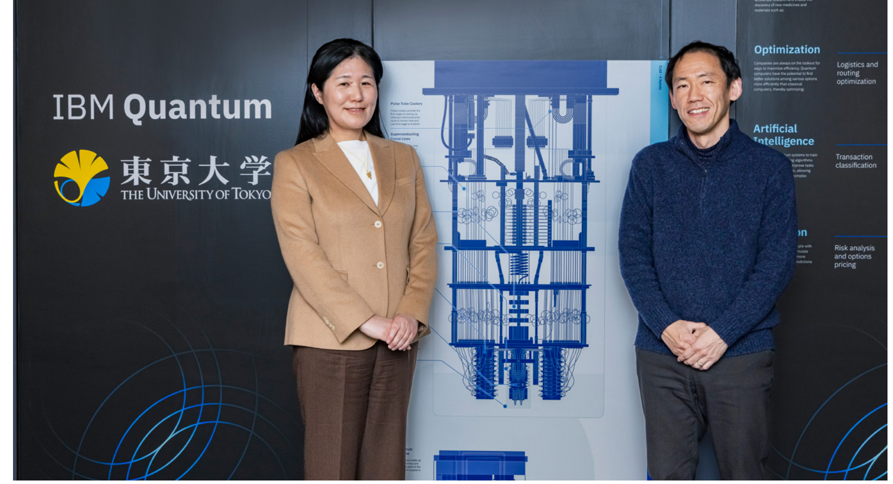


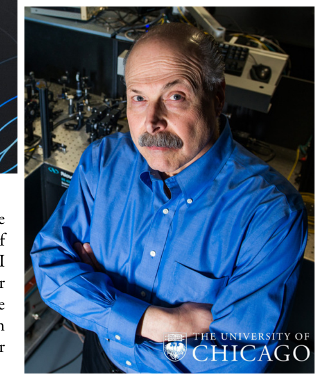
In May 2023, on the occasion of the G7 Hiroshima Summit, IBM, the University of Tokyo, and the University of Chicago agreed to enter a partnership to build a cooperative relationship in quantum research. IBM will provide 100 million dollars over the next decade to advance technological innovation toward the development of a 100,000-qubit quantum-centric supercomputer.

While classical computers, in common use today, process information as binary digits (bits) in one of two states—0 or 1—quantum computers use quantum bits (qubits), which can be not only in the two "basis states" representing 0 and 1 but also in their superposition that is neither 0 nor 1. It is an entirely new technology that can perform complex calculations by taking advantage of the properties of superposition. The realization of a 100,000-qubit quantum-centric supercomputer could lead to solutions to pressing problems that even the most advanced supercomputers of today may never be able to solve.

The University of Tokyo has already been collaborating with IBM on quantum research for some time. The two parties signed the Japan-IBM Quantum Partnership in 2019 and established the Quantum Innovation Initiative Consortium the following year, involving a wide range of partnerships from industry and academia. This led to the launch in 2021 of Japan's first gate-based commercial quantum computer, IBM Quantum System One. Then, in the fall of 2023, the quantum computer, equipped with the 127-qubit Eagle processor, began operation. Owning the exclusive rights to use the processor, the University of Tokyo has been leading the field of quantum research in Japan by promoting research on its use collaboratively with participating companies and research institutions.

The University of Tokyo partnered with IBM in 2019, leading to the launch two years later of the gate-based commercial quantum computer known as IBM Quantum System One. IBM





Top: Professor MURAO Mio (left) of the University of Tokyo's Graduate School of Science, and Associate Professor TERASHI Koji of the International Center for Elementary Particle Physics from the same university. Right: Professor David Awschalom of the Pritzker School of Molecular Engineering, University of Chicago.

"Now that quantum computers are here and can actually be used, researchers and students have become more inclined to develop ever more useful applications for them. In that sense, I believe that our partnership has had a significant impact on quantum research in Japan," says MURAO Mio, a professor specializing in quantum information theory at the University of Tokyo.

According to Professor Murao, the strength of the university's quantum research lies in its breadth of fields and wide-ranging perspectives. "We have an advantage in this kind of unique research. For example, Professor NAKAMURA Yasunobu created the basic element of superconducting quantum computers, and Professor FURUSAWA Akira achieved impressive results in the development of the optical quantum computer."

Meanwhile, the University of Chicago is home to the Pritzker School of Molecular Engineering, the first educational institution in the United States to offer a doctoral program in quantum engineering. It has been involved in research in a variety of fields, from quantum algorithms to quantum cryptography communications. Talking about the partnership, David Awschalom, Liew Family Professor of Molecular Engineering at the University of Chicago, makes these comments: "Collaboration—across borders, fields, and sectors—is critical to fully realizing the transformative potential of quantum computers. I believe that some of the most seismic impacts of at-scale quantum computing are yet to be discovered." He adds, "We've already held joint workshops, identified powerful new areas for collaboration, and are launching graduate student exchange programs between Tokyo and Chicago."

Also, TERASHI Koji, associate professor at the University of Tokyo, states, "We aim to openly innovate while complementing each other's technologies. We hope that this experience of personnel exchange with the University of Chicago will lead to the development of the next generation of researchers."

However, creating a supercomputer with 100,000 qubits is by no means an easy task. There are many difficulties to overcome, such as maintaining quantum superposition and correcting errors caused by noise. "I think it's important at this stage to research algorithms that will prove useful and beneficial for the future, for when we will have realized quantum computers that are able to maintain proper operation in the event of errors," explains Terashi.

Quantum computers, which until recently were only a theoretical concept, are now becoming a reality. That is why universities and companies across Japan and the U.S. are complementing each other and competing to usher in a new paradigm of quantum computing.