Development of Large-scale Fault-tolerant Universal Optical Quantum Computers

Project manager

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R&D institutions

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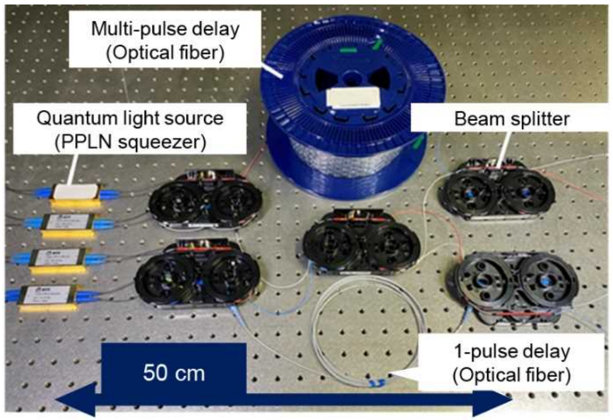
Summary of the project

We develop our own quantum lookup table method to realize large-scale fault-tolerant quantum operations. By 2050, we aim to realize a large-scale optical quantum computer that can operate at room temperature. Generating experimentally fault-tolerant logical qubits, we will attain all quantum gates (quantum operations) necessary for general-purpose quantum computation fault-tolerant. For this purpose, we develop the techniques of squeezed light above a level sufficient to exceed the error threshold in a sufficient bandwidth to perform time-domain multiplexing, and optical quantum computer modules for stable optical quantum computation, and furthermore develop a superconducting photon number discriminator for an arbitrary quantum state generator that generates logical qubits.

Using the recently developed optical fiber-connected low-loss quantum light source modules (optical parametric amplification module) as shown in the Photograph, the basic configuration for large-scale photon entanglement experiments (four quantum light sources, optical fiber delay lines of two different lengths, five beam splitters), is established in principle, for quantum calculations of any scale.



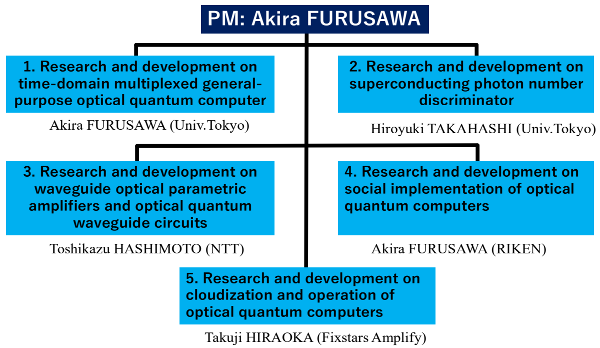
Milestone by year 2030

We will carry out research and development to realize a fault-tolerant large-scale general-purpose optical quantum computer partially with an electrical signal processing system. In order to realize this, we will apply the continuous quantum teleportation, which is now the world standard, and use the method of time-domain multiplexed general-purpose optical quantum computing. We use cluster states as quantum entanglement for quantum computation. The cluster state is generated using squeezed light. Since we want to make the fault-tolerance threshold of the squeezing level of quantum light as low as possible, we aim to reduce the requirements for qubits resulting in further lower threshold values, and quantum error correction experiments will be performed successfully. We will then, be ready to start toward the aim of realization of a fault-tolerant all-optical quantum computer that uses only optical signal processing without the electrical signal processing system.

Milestone by year 2025

Using time-domain multiplexed general-purpose optical quantum computing technique, we develop a waveguide optical parametric amplifier without cavity structures to generate broadband squeezed light. The squeezing level is aimed at a higher level that is currently realized in a narrow band using a resonator. We aim to generate squeezed light of 8 to 10 dB in the terahertz band for the waveguide optical parametric amplifier we are developing. In this way, we will realize quantum entangled light that exceeds the quantum error correction threshold toward the realization of a fault-tolerant all-optical quantum computer.

R&D theme structure of the project



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