R&D Theme

Atom networking technology

Progress until FY2022

1. Outline of the project

In this research and development (R&D) theme, we will develop a quantum interface for networking atom-based quantum computers consisting of neutral atoms as qubits processing quantum information and the necessary photon detection technology. The goal of this R&D theme will establish the elemental technology of quantum networking for scaling up various quantum computers, including atom-based quantum computers, and the realization of a fault-tolerant universal quantum computer, which is the final target of Moonshot Goal 6.

To achieve this goal, we are working on creating quantum entanglement among atoms and photons on a large scale as a challenging theme. Beyond the realization of one-to-one qubit connections demonstrated already, we are working on an attempt at multiplexing technologies for atoms, optical circuits, and photon detectors. These developed elemental technologies useful in other R&D themes and projects will be actively provided and contribute to the final target of Moonshot Goal 6.

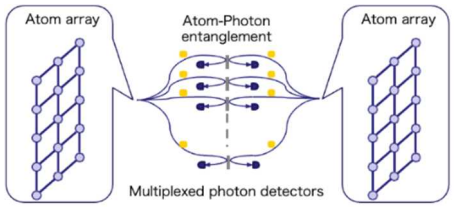

Fig. 1: Concept of a networked atom quantum computer

2. Outcomes so far

(1) Demonstration of Rb atom array and construction of photon detection system and Proposal of Bell state distillation between logical qubits.

(2) Proposal and demonstration of “Optical frequency tweezers” for multiplexed network connections and Proposal of a photonic quantum computer with time-frequency modes.

(3) Superconducting nanowire photon detector (SNSPD) device development for 710 nm, 780 nm, and 850 nm wavelength bands, achieving a detection efficiency of more than 70% and a dark count rate of less than one count per second in each wavelength band. Six patent applications have been made.

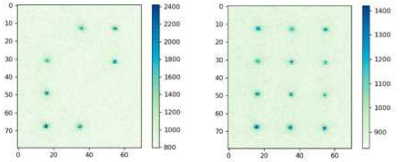

Fig. 2: CCD image of demonstrated atomic array.
Left: Single shot
Right: Integrated

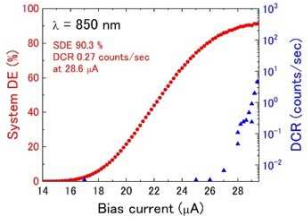

Fig. 3: Detection efficiency and dark count characteristics of SNSPD in 850 nm band.

(4) Refrigerator system development with 12 channels of SNSPD for cooling below 2.3 K. 32 channel SNSPD refrigerator system has been successfully demonstrated.

Fig. 4: 32-ch SNSPD refrigerator system exhibited at G7.
We have developed an SNSPD refrigeration system with 32 SNSPD packages that can be cooled to a temperature of 2.12 K. It has optical signal input, drive circuits, and signal readout ports.

3. Future plans

Our research achievements so far include elemental technologies for quantum processors of atom arrays and a proposal of quantum protocols, demonstration of the working principle of routing photons from multiplexed photon sources, expansion of the wavelength of SNSPD and performance enhancement, and demonstration of a refrigerator system capable of multiplexing SNSPDs to the scale of 32 channels (world competitive scale). In the future, we aim to demonstrate quantum networking using these technologies.