

R&D Item

5. Testbed and Integrated Implementation for Integrating and Demonstrating Technologies

Progress until FY2024

1. Outline of the project

This constructing testbed is a core system in this project and planned to be a public facility in the future for universities, national laboratories, and companies to test or validate hardware and software for quantum computer network. The testbed has two main functionalities to be established:

1. Scalability by integrating quantum optics and optical technologies
2. Actual distributed quantum computation by connecting multiple quantum computers

We design the testbed can connect arbitrary type of quantum computers, but first promising candidate is ion-trap quantum computer which can be connected by light directly.

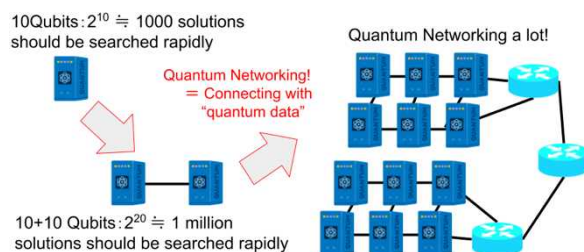


Fig 1. Scalable distributed quantum computer

2. Outcome so far

We launched from 2022, and grew up, then we have already integrated the basic optical technologies into our prototype system and we validate remote quantum entanglement between different quantum nodes principally by physical experiments.



Fig 2. Testbed overview in our laboratory.

We have justified the prototype system work well and, establish remote entanglement between selected two of three node. It means the system have functionality of switching or routing the nodes to be connected.

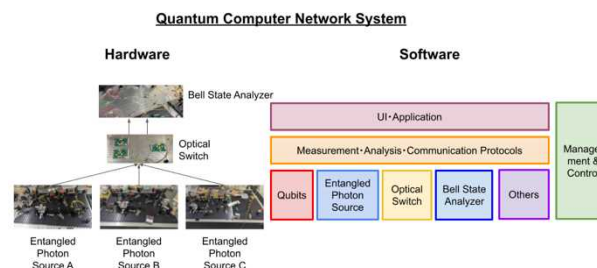


Fig 3. System architecture (left) three end nodes and 1 switch node hardware (right) software stack for control and operation

We are developing a photonically interconnectable trapped-ion quantum node. We recently succeeded in trapping and laser cooling of strontium atomic ions in a vacuum, as shown in Fig. 4.

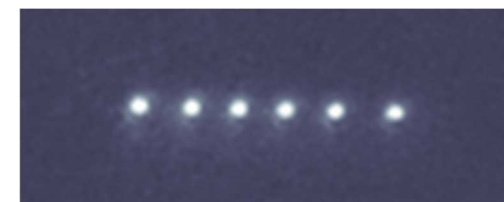


Fig 4. Fluorescence image of trapped strontium atoms

3. Future plans

We are planning to connect actual quantum computers, and realize fault-tolerant distributed quantum computation. To achieve this purpose, we develop high scalable network control and management system and communication protocol.

Furthermore, we will expand our concept of quantum network system to work in arbitrary type of quantum computers.