【Grant-in-Aid for Specially Promoted Research】

Science and Engineering

Title of Project : Study on time-domain-multiplexed 2D continuous-variable cluster states and its application to large-scale quantum information processing

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Keyword : Cluster states, Quantum entanglement, Quantum Computer

【Purpose and Background of the Research】

By using the technology of continuous-variable (CV) quantum teleportation, we will try to establish a methodology to build a large-scale optical quantum computer. Here, we succeeded in CV quantum teleportation for the very first time in the world and the technology has become a "world standard" in these days. Since we can build a large-scale quantum computer by combining quantum teleportation technology and a large-scale 2D entangled state (cluster state), we will try to create a large-scale 2D CV cluster state by time-domain multiplexing and will establish a methodology how to use it with CV quantum teleportation technology to build a large-scale optical quantum computer. Here, we also developed the technology of time-domain multiplexing.

【Research Methods】

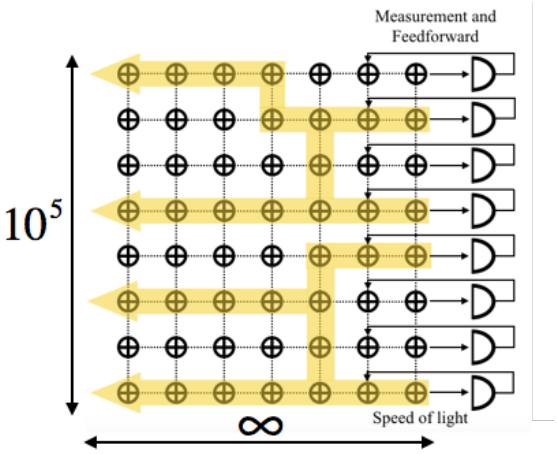

Fig. 1 Large-scale quantum computing with time-domain multiplexing.

By using a large-scale 2D cluster state, we can make a large-scale universal quantum computer as shown in Fig.1. Here a large-scale 2D cluster state corresponds to a superposition of all possible quantum computing patterns. We can select one of them by changing the measurement bases and can make a collapse of the cluster state to the desired state, which is the output of the quantum computer. The randomness of the measurement results can be eliminated by operations depending on the measurement results, which is called "feedforward". The whole process is called "one-way quantum computing", because a measurement process is irreversible.

This type of large-scale 2D cluster states can be created only by using four squeezed vacua, five beam splitters, and two delay lines as shown in Fig. 2. We will realize the large-scale 2D cluster states by using this methodology.

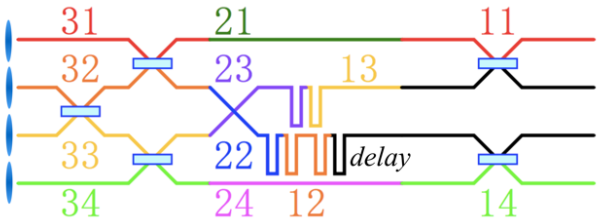

Fig. 2 Schematic of experimental setup for the creation of large-scale 2D cluster states.

【Expected Research Achievements and Scientific Significance】

We will show that our methodology works well for building a large-scale universal quantum computer.

【Publications Relevant to the Project】

- A. Furusawa et al., Science **282**, 706 (1998)
- N. Lee et al., Science **332**, 330 (2011)
- H. Yonezawa et al., Science **337**, 1514 (2012)
- S. Yokoyama et al., Nature Photonics **7**, 982 (2013)
- S. Takeda et al., Nature **500**, 315 (2013)

【Term of Project】 FY2018-2022

【Budget Allocation】 489,200 Thousand Yen

【Homepage Address and Other Contact Information】

http://alice.t.u-tokyo.ac.jp