【Grant-in-Aid for Scientific Research (S)】

Science and Engineering (Mathematical and Physical Sciences)

Title of Project : Realization and Application of Large-scale Quantum Entangled States Using Photonic Quantum Circuits

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Research Project Number : 26220712 Researcher Number : 80321959
Research Area : Quantum optics, Quantum information science
Keyword : Quantum computer, Nanophotonics, Optical waveguide, Photon

【Purpose and Background of the Research】

In quantum information technology, the fundamental features of quantum mechanics is applied for communication, computation, and more. Photons are especially promising media for quantum information since they can be transmitted over long distances. In this project, we aim to realize photonic quantum circuits, which generates multi-photon quantum entangled states containing up to 10 photons. We also try to apply these photonic quantum circuits to "boson sampling", which is large-scale multi-photon quantum interference, and ultra-sensitive quantum measurements.

【Research Methods】

In this project, first we try to realize a table-top single-photon source with suppressed excess photon components by using bulk optics. Furthermore, we investigate on-chip single-photon sources by using optical waveguides and optical nanofibers. This program is under the collaboration of three groups (Kyoto Univ., Kyusyu Univ., and Hiroshima Univ.). The details of the research topics are as follows.

(1) Desk-top photonic quantum circuits

We try to suppress the excess photons in the output of the heralded single-photon source by using a parametric down-conversion process. Then, we use the generated single-photon pulses for the multi-photon interference and investigate boson sampling and quantum metrologies by using the generated quantum entangled states.

(2) On-chip photonic quantum circuits

For the realization of compact and highly integrated photonic quantum circuits, we try to realize on-chip single photon source by using SiN-organic material hybrid waveguides.

(3) Optical nanofiber single-photon source

Optical nanofiber is a single-mode optical fiber, a part of which is stretched until the diameter of the fiber is on the order of a few hundred nanometers.

(4) Theory and analysis

We try to deepen our understanding of multi-photon entangled states and apply these states for quantum metrology theoretically.

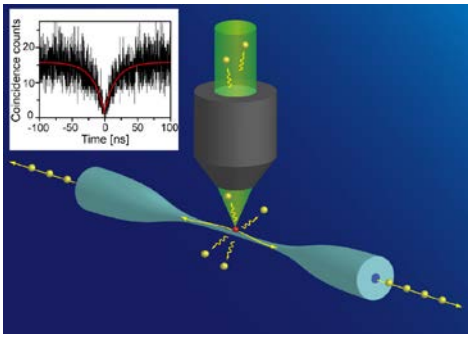

Figure 1 Nanofiber single-photon source

【Expected Research Achievements and Scientific Significance】

This project is one of the exploration of the boundary region between the quantum and classical worlds. The realization of boson sampling with up to 10 photons will have a great impact on both quantum physics and computer science. The application of on-chip quantum entangled photons to quantum measurements will also greatly contribute to related areas such as life science and material science.

【Publications Relevant to the Project】

- T. Ono, R. Okamoto and S. Takeuchi, **Nature Communications**, Vol. 4, 3426 (2013).
- M. Fujiwara, K. Toubaru, T. Noda, H. Q. Zhao and S. Takeuchi, **Nano Letters**, Vol. 11, 4362-4365 (2011).
- R. Okamoto, J. L. O'Brien, H. F. Hofmann, T. Nagata, K. Sasaki and S. Takeuchi, **Science**, Vol. 323, 483-485 (2009).

【Term of Project】 FY2014-2018

【Budget Allocation】 146,300 Thousand Yen

【Homepage Address and Other Contact Information】

http://plasma1.kuee.kyoto-u.ac.jp/