1. Corresponding author

Name: Hideo Kosaka

Affiliation: Yokohama National University

Address: 79-5 Tokiwadai, Hodogaya, Yokohama 240-8501, Japan

e-mail address: kosaka-hideo-yp@ynu.ac.jp

2. Title, authors, and affiliations

1) Title of the presentation: Teleportation-based quantum media conversion from a photon to a nucleon in diamond

2) Authors' list: Hiroki Kano[1], Ryota Kuroiwa[1], Yuhei Sekiguchi[1], Hideo Kosaka[1]

3) Authors' affiliations: [1]Yokohama National University

3. Presentation type (please, check where it applies)

☐ invited

☐ contributed (oral presentation preferred)

☑ contributed (poster presentation preferred)

4. Category (choose the most appropriate one)

☐ Coherent phenomena in solids

☐ Quantum information processing

☐ Charge and spin physics in nanostructures

☐ Spintronic materials and devices

☐ Optical properties of nanostructures

☐ Photonic nanostructures

☑ NV centers in diamonds

☐ Phononic nanosturctures

☐ MEMS/NEMS and novel mechanical effects

☐ Novel materials for hybrid quantum systems

☐ Nanocarbon and 2D materials

☐ Topological insulators and superconductors

☐ Quantum metrology

☐ Quantum functional devices

Teleportation-based quantum media conversion from a photon to a nucleon in diamond

Hiroki Kano[1], Ryota Kuroiwa[1], Yuhei Sekiguchi[1], Hideo Kosaka[1]*

[1]*Yokohama National University, 79-5 Tokiwadai, Hodogaya, Yokohama 240-8501, Japan*

*Corresponding author: kosaka-hideo-yp@ynu.ac.jp

Quantum information is carried on various kinds of quantum media such as photons, electrons and nucleus in the basis of polarization or spin states. A photon transmits a quantum state over a long distance through an optical fiber, while a nuclear spin stores a quantum state for a long time because of its long coherence time [1]. Quantum media conversion from a photon to a nuclear spin is thus required to utilize their characteristics.

We report demonstration of quantum state transfer of a photon polarization state to a nuclear spin in a nitrogen vacancy (NV) center in diamond based on quantum teleportation scheme, which is achieved by generating electron-nuclear quantum entanglement, manipulating electron-nuclear quantum entanglement with light, and measuring photon-electron quantum entanglement (Fig. 1). Our demonstration has three features. First, we reduce a magnetic field as low as possible to degenerate $m_s=\pm 1$ states of the electron spin serving as a logical quantum bit [2]. Second, we receive a heralding signal upon the success of the state transfer via the single-shot measurement of the electron to be $m_s=0$ [3]. Third, we control the unitary operator applying the nuclear spin upon the success of the state transfer [4].

We experimentally performed quantum state tomography of the ^{14}N nuclear spin after the transfer (Fig. 2). The achieved fidelities are over 80% for all, which enough exceeds the classical limit of 66%. This results ensures that the state transfer we demonstrated is truly “quantum” state transfer.

We thank Yuichiro Matsuzaki, Kae Nemoto, William Munro, Norikazu Mizuochi, Fedor Jelezko, and Joerg Wrachtrup for their discussions and experimental help. This work was supported by National Institute of Information and Communications Technology (NICT) Quantum Repeater Project, and by Japan Society for the Promotion of Science (JSPS) Grant-in-Aid for Scientific Research (24244044, 16H06326, 16H01052) and Ministry of Education, Culture, Sports, Science and Technology (MEXT) as “Exploratory Challenge on Post-K computer” (Frontiers of Basic Science: Challenging the Limits).

References

[1] Sen Yang, Hideo Kosaka, Joerg Wrachtrup, et.al., “High fidelity transfer and storage of photon states in a single nuclear spin”, ***Nature Photonics***, 10, 507-511(2016).

[2] Yuhei Sekiguchi, Yusuke Komura, Shota Mishima, Touta Tanaka, Naeko Niikura and Hideo Kosaka, “Geometric spin echo under zero field”, ***Nature Communications***, **7**, 11668 (2016).

[3] Hideo Kosaka, Naeko Niikura, “Entangled Absorption of a Single Photon with a Single Spin in Diamond”, ***Physical Review Letters***, **114**, 053603 (2015).

[4] Yuhei Sekiguchi, Naeko Niikura, Ryota Kuroiwa, Hiroki Kano and Hideo Kosaka, “Optical holonomic single quantum gates with a geometric spin under a zero field”, ***Nature Photonics***, **11** ,**309** (2017).

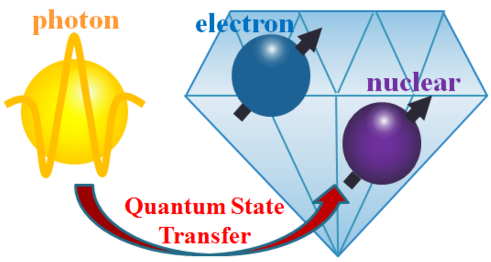

Fig. 1. Teleportation-based quantum state transfer

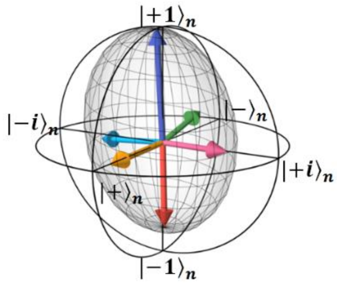

Fig. 2. Results of quantum state tomography of nuclear spin after the transfer