Single-shot measurement of a nuclear spin in an NV center in diamond

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Quantum repeaters, which enables long-distance quantum communications, require complete Bell measurement with extremely high fidelity for the entanglement swapping or the quantum teleportation [1,2]. However, it is impossible to measure a quantum state to any arbitrary accuracy by itself. We thus need to develop the technique called quantum-non-demolition measurement to perform a single-shot measurement, which allows single preparation and repeated measurement.

We demonstrate the single-shot measurement of the quantum state of a nuclear spin in a nitrogen vacancy (NV) center in diamond under a zero field [3,4]. We were able to measure the nuclear spin state of a target ^{14}N impurity atom by repeatedly measuring the spin state of an entangled ancillary electron (Fig.1). After preparing the nuclear spin into the m_I=0 state, we observed 3.7 photons on average over 44-time repeated optical readouts of the electron spin in the m_S=0 state. It indicates that we can perform the single-shot measurement of the nuclear spin with the fidelity of 95% (Fig.2 b).

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

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Fig.1

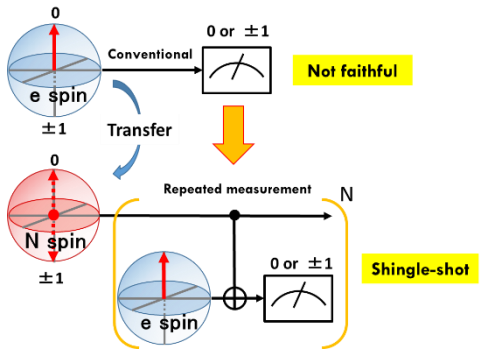

Fig.2 (a)

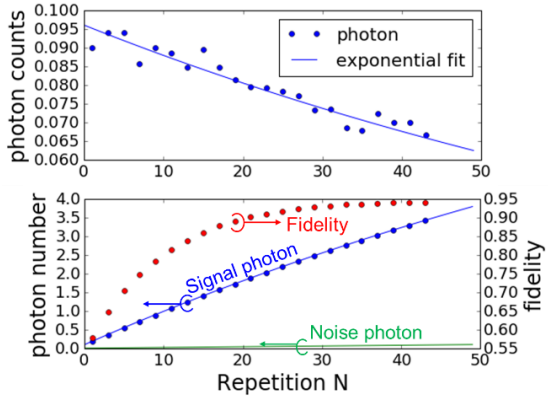

Fig.1 Quantum circuit for the conventional (upper) and single-shot (lower) measurements. Fig.2 (a) Averaged photon counts of Nth measurement decaying by the relaxation of the nitrogen nuclear spin. (b) Accumulated counts of the signal and noise photons and the corresponding measurement fidelity.