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1. Corresponding author

Name: Yuhei Sekiguchi
Affiliation: Yokohama National University
Address: 79-5 Tokiwadai, Hodogayaku, Yokohama 240-8501, Japan
e-mail address: sekiguchi-yuhei-jc@ynu.jp

2. Title, authors, and affiliations

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2) Authors' list: Yuhei Sekiguchi, Naeko Niikura, Ryota Kuroiwa, Hiroki Kano and Hideo Kosaka

3) Authors' affiliations: Yokohama National University

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☐ Quantum functional devices

Optical holonomic quantum gates over an NV spin in diamond

Yuhei Sekiguchi, Naeko Niikura, Ryota Kuroiwa, Hiroki Kano and Hideo Kosaka

Yokohama National University, Yokohama 240-8501, Japan

kosaka-hideo-yp@ynu.ac.jp

Realization of fast fault-tolerant quantum gates on a single spin is the core requirement for solid-state quantum-information processing. As polarized light shows geometric interference, spin coherence is also geometrically controlled with light via the spin-orbit interaction. Here, we show that a holonomic spin qubit in a degenerate subspace of a spin-1 electronic system under a zero field in a nitrogen vacancy (NV) center in diamond allows implementation of optical non-adiabatic holonomic quantum gates [1]. The holonomic spin qubit under quasi-resonant light exposure undergoes a cyclic evolution in the spin-orbit space, and acquires a geometric phase or holonomy that results in rotations about an arbitrary axis by any angle defined by the light polarization and detuning (Fig. 1). This enables universal holonomic quantum gates with a single operation. We demonstrate a complete set of Pauli quantum gates using the geometric spin preparation and readout techniques. The new scheme opens a path to holonomic quantum computers and repeaters. We also talk about our recent work toward holonomic manipulation of entanglement between an electron spin, nuclear spin and a photon [2-4].

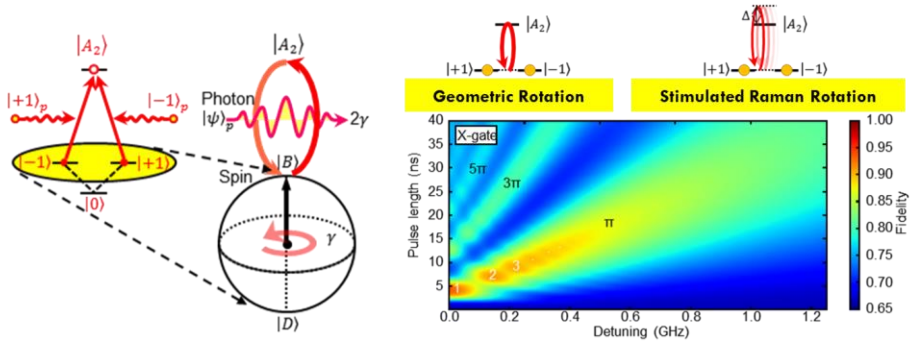

Fig.1 Optical holonomic quantum gates. (left) Degenerate three-level Λ system and conceptual explanation for the geometric spin rotation. (right) Dependence of X-gate fidelity on detuning and pulse length. White numbers indicate the number of turns used to perform the X gates. Black numbers indicate spin rotation angles.

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