Geometric spin echo under zero field

Yuhei Sekiguchi, Yusuke Komura, Shota Mishima, Touta Tanaka, Naeko Niikura and Hideo Kosaka*

Yokohama National University, 79-5 Tokiwadai, Hodogaya, Yokohama 240-8501, Japan

* Corresponding author: kosaka@ynu.ac.jp

Spin echo is a fundamental tool for quantum registers and biomedical imaging. It is believed that a strong magnetic field is needed for the spin echo to provide long memory and high resolution since a degenerate spin cannot be controlled or addressed with frequency selectivity under a zero magnetic field, although week or zero magnetic field scheme suits interface between single photon polarization and single electron spin [1,2]. While a degenerate spin is never subject to dynamic control, it is still subject to geometric control. We here show the spin echo of a degenerate spin subsystem, which is geometrically controlled via a mediating state split by the crystal field, in a nitrogen vacancy center in diamond. The demonstration reveals that the degenerate spin is protected by inherent symmetry breaking called zero-field splitting and the bath spins are frozen by the electron hyperfine field under zero magnetic field. The geometric spin echo under zero field provides an ideal way to maintain the coherence without any dynamics, thus opening the way to pseudo-static quantum RAM and non-invasive biosensors.

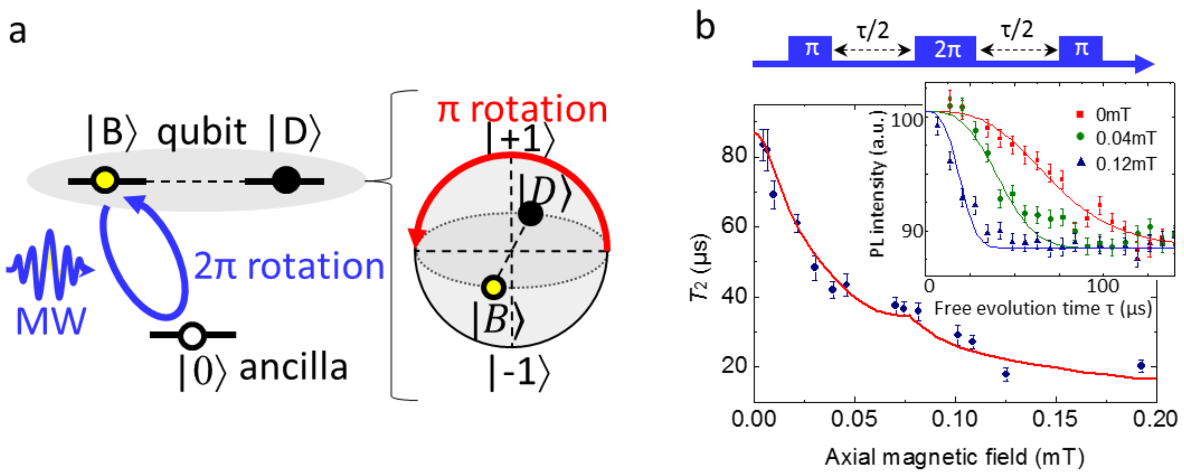

Fig. (a) The energy level diagram of a ground state electron spin system in an NV center in diamond. Inset illustrates the geometric spin bit-flip operation in degenerate space as a result of -1 geometric phase sift on bright state |B⟩ induced by 2π rotation from the bright state |B⟩ through the ancilla state |0⟩. (b) Echo coherence decay time T_2 as a function of the magnetic field. Inset shows echo decays under magnetic fields of 0 mT (red squares), 0.04 mT (green circles) and 0.12 mT (blue triangles).

[1] E. Togan et al., Quantum entanglement between an optical photon and a solid-state spin qubit. *Nature* **446**, 730-734 (2010).

[2] H. Kosaka and N. Niikura, Entangled absorption of a single photon with a single spin in diamond. *Phys. Rev. Lett.* **114**, 053603 (2015).