

# Geometrical stabilization of degenerate logical spin in diamond

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A nitrogen-vacancy (NV) center in diamond is an attractive candidate for quantum information devices such as quantum memories and sensors. An electron spin of NV center can be easily initialized and read out by light and driven by microwave, and has long coherence time reaching some milliseconds at room temperature [1].

The electron spin of NV center has spin-1 angular momentum and provides V-type three level system consists of two degenerate  $|\pm 1\rangle$  states and a largely-split  $|0\rangle$  state (Fig.1). The degenerate states provide a logical stationary spin [2] in contrast to the conventional dynamic spin with an energy gap. The logical spin is protected by inherent symmetry breaking called zero-field splitting and the decohered state is recovered by the geometric spin echo technique [3]. Here we demonstrate geometrical stabilization of the logical spin with periodically applied decoupling pulses to achieve further long coherence time. Figure 2 shows the pulse-number dependence of the coherence time  $T_2$ , which reached 1.9 ms with 128 decoupling pulses and approaching the relaxation time of the  $|\pm 1\rangle$  states to the  $|0\rangle$  state  $T_1$  amounting 2.6 ms even at natural isotopic abundance at room temperature.

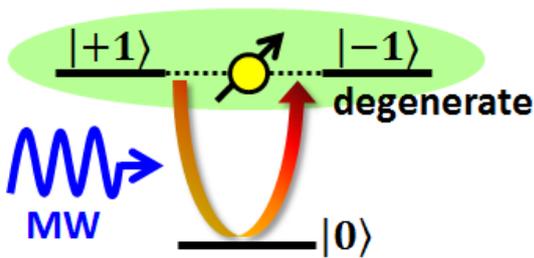
The geometrically-stabilized logical spin utilizes the intrinsic symmetry breaking of an electron spin system without requiring an external field or isotope engineering, thus promising for largely-integrated quantum memories and highly-sensitive quantum sensors.

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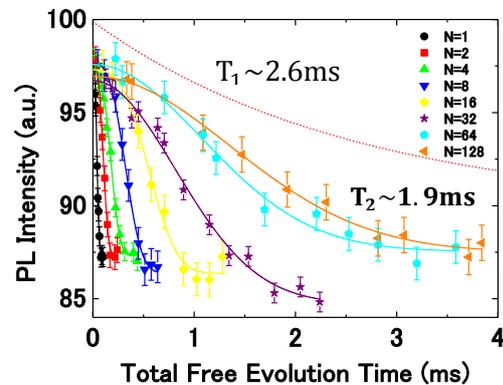
[1] Balasubramanian, G. *et al. Nature materials* 8, 383-387 (2009)

[2] H. Kosaka & N. Niikura, *Phys. Rev. Lett.* 114, 053603 (2015)

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**Fig. 1:** Energy level diagram of the electron system in an NV center in diamond consisting of a degenerate logical spin based on  $|\pm 1\rangle$  states and an ancillary  $|0\rangle$  state.



**Fig. 2:** The recovered coherence time of the degenerate logical spin approaching  $T_1$  limit with 128 decoupling pulses.