

Diamond based quantum repeater device

-Geometric bang-bang echo for quantum state preservation-

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A Nitrogen-Vacancy (NV) center in diamond is attractive candidate for quantum information device such as quantum memory. An electron spin of NV center can be easily initialized and read out by light and driven by microwave, and has very long coherence time reaching millisecond order even at room temperature [1].

The electron spin of NV center has spin-1 angular momentum and ground state provides V-type three level system with degenerate $|\pm 1\rangle$ state and largely splitting $|0\rangle$ state. Now we present the “geometric degenerate qubit” [2] (Fig.1) consisting of completely degenerate $|\pm 1\rangle$ state instead of conventional qubit which has some energy gap. Our qubit is protected against bit flip error by longitudinal zero field splitting (ZFS) and against phase flip error by transverse ZFS. Degenerate state can be access by geometric phase control with help of ancillary $|0\rangle$ state, which is robust against control error.

As mentioned above, all of our hardware, qubit, and control scheme have intrinsic robustness against various errors and noises. Moreover, residual effect of noise also can be canceled by geometric spin echo technique. We demonstrate not only simple Hahn echo but also CPMG scheme with bang-bang applied pulse train (Fig.2) and achieve competitive coherence time comparing with other conventional reports.

Combining the intrinsic nature of qubit itself with strong decoupling technique, we can realize the highly robust quantum memory which is sufficient for practical use.

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

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

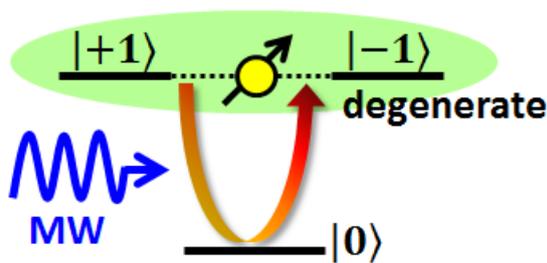


Fig.1
Energy diagram of our degenerate qubit and geometric control with help of ancilla.

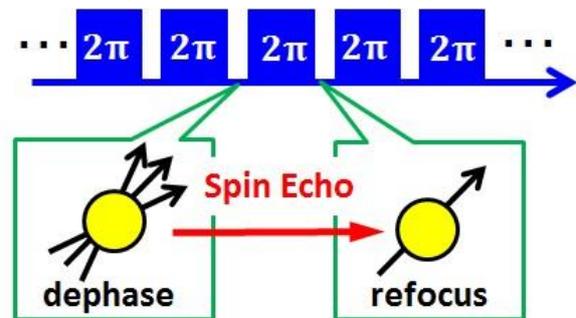


Fig.2
Dephasing is immediately canceled by bang-bang applied phase reversal pulses.