

Geometric quantum entanglement manipulation with a polarized microwave in an NV center in diamond

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We have recently demonstrated teleportation-based quantum media conversion from a photon to a nuclear spin [1], geometric spin echo [2] and optical single electron quantum gates [3] in a nitrogen vacancy center in diamond. Although these demonstrations use a degenerate subspace of a spin-1 system of the electron and nuclear spins as qubits under a zero field, arbitrary manipulation of the degenerate qubits cannot be performed by using linearly polarized microwaves or radiowaves, which are generated by the conventional single wire or a strip line.

We succeeded to generate any arbitrary entangled state between an electron and a nuclear spin and manipulate them geometrically with a polarized microwave and radiowave across a crossed wire (Fig. 1). The achieved fidelity of one of the Bell states Φ^+ was 98% (Fig. 2a). We also successfully transformed the entangled state from the Φ^+ state to another Bell state Ψ^- by the bit-phase flip (rotation around +Y axis) with a polarized microwave with the fidelity of 84% (Fig. 2b). The demonstration indicates that we are able to generate and manipulate any arbitrary quantum state over the degenerate electron and nuclear spin qubits.

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References

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Fig. 1

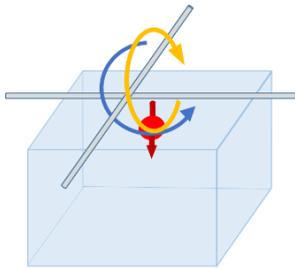
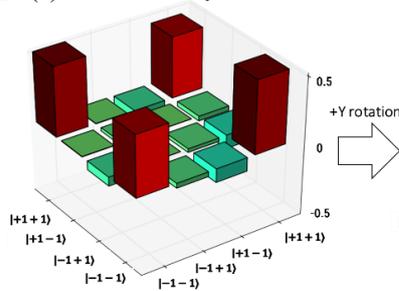


Fig. 1 Configuration of a crossed wire on a diamond and the generated two polarized microwaves or radiowaves applying to an NV center.

Fig. 2 (a) $|\Phi^+\rangle$ fidelity 98%



(b) $|\Psi^-\rangle$ fidelity 84%

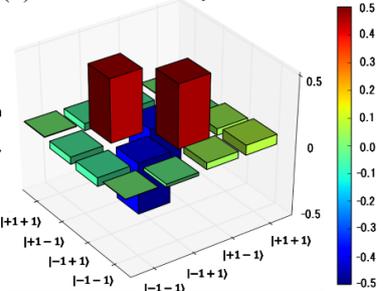


Fig. 2 The reconstructed density matrices of the generated entangled states (a) Φ^+ and (b) Ψ^- , which is transformed by applying a polarized microwave allowing Y rotation.