Quantum networking with silicon-vacancy centers in diamond

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Silicon-vacancy centers in diamond (SiVs) are a promising platform for quantum information applications[1]. In particular, SiVs containing the ^{29}Si-isotope are well suited for use in quantum networks: they serve as an integrated two-qubit register with universal one- and two-qubit gates, a long-lived nuclear spin memory, and high-fidelity single-shot readout[2]. We achieve an efficient spin-photon interface by integrating SiVs into overcoupled nanophotonic cavities[3] and efficiently extracting photons with a tapered optical fiber. Here, we will discuss the operation of individual ^{29}SiV quantum memories, demonstrating heralded spin-photon gates to generate electron-photon and nuclear-photon Bell states with integrated error detection. We will then show that the platform is extensible to multi-node operation: we realize a quantum link and demonstrate entanglement between two independent nodes each containing a single SiV that are spatially separated by 20 meters. These results demonstrate the potential for large-scale quantum networking and quantum repeaters based on SiVs in diamond.

References

[1] M. Bhaskar et al., Nature, 580 (2020), 60-64
[2] P.J. Stas et al., Science, 378 (2022), 557-560
[3] E. Knall et al., Phys. Rev. Lett. 129 (2022), 053603

Figures

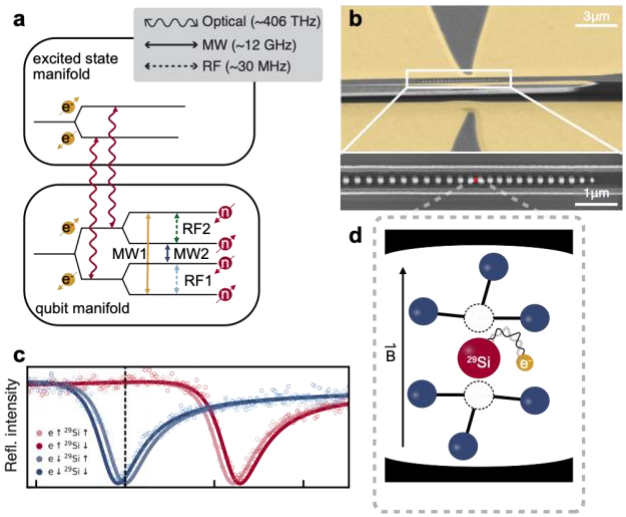

Figure 1: a) Silicon-vacancy center (SiV) energy spectrum. b) SEM micrograph of nanophotonic diamond cavity. c) Reflection spectrum of SiV-cavity system. d) Crystallographic structure of the SiV.

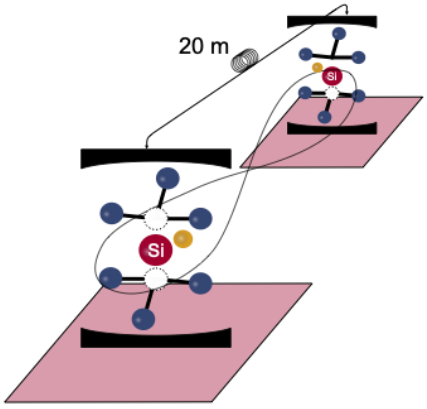

Figure 2: Schematic illustrating two-node quantum networking with silicon-vacancy centers in diamond.