Detection of Entangled NV Electron Spin Pairs in Diamond

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Diamond nitrogen-vacancy (NV) electron spin qubits offer a promising platform for solid-state quantum computing and quantum sensing devices based on entangled states. However, the maturity of NV center technology for quantum computing remains relatively low, primarily due to a central challenge in the field: engineering dipole-dipole coupled NV spin qubits and addressing them individually—an intrinsically complex and non-trivial task, particularly at room temperature.

In this presentation, we report the realization of strongly coupled NV spin qubit pairs with coupling frequencies exceeding 100 kHz, characterized under ambient conditions. Both Optical Detection of Magnetic Resonance (ODMR) and Photo-electrical Detection of Magnetic Resonance (PDMR) spin state readout techniques were employed [1]. Using Double Electron-Electron Resonance (DEER), we verified NV-NV pair formation and extracted key coupling parameters. Quantum State Tomography based on Rabi oscillations and two-qubit states enabled us to evaluate the state fidelity.

Our results could open pathways toward a scalable approach for room-temperature entanglement generation and readout, supported by spatially resolved electrical detection. In particular, electrical spin state readout offers the potential for spatial resolution at the level of spin-spin coupling distances, which is critical for scaling up such systems.

We conclude by outlining technological pathways toward system miniaturization and integration.

References

[1] P Siyushev, M Nesladek, E Bourgeois, *et al.*, Science **363**, 728 (2019); DOI:10.1126/science.aav2789