Sensing buckyball spin qubits using color centers in diamond

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Molecular spin qubits show great promise for quantum technologies. An interesting case is that of the endofullerene N@C_{60}, which consists of a single nitrogen atom encapsulated in a C_{60} cage. N@C_{60} has some fascinating properties as an atomic spin qubit– the high-symmetry of the buckyball cage results in a long coherence time, it is thermally stable at room temperature, and the inherent scalability of fullerene networks allows for construction of complex nanoscale devices [1]. However, there is a problem – until now, the spin state readout of *single* endofullerene qubits has proven to be very difficult.

Our approach to single endofullerene qubit readout mechanism utilizes single nitrogen-vacancy (NV) color centers in diamond [2]. We use the magnetic dipolar coupling between single NV centers and N@C_{60} spins in a low-temperature (4.2 K) and ultra-high vacuum (10^{-10} mbar) experimental setup capable of performing confocal microscopy, $g^{(2)}$ autocorrelation and pulsed EPR measurements.

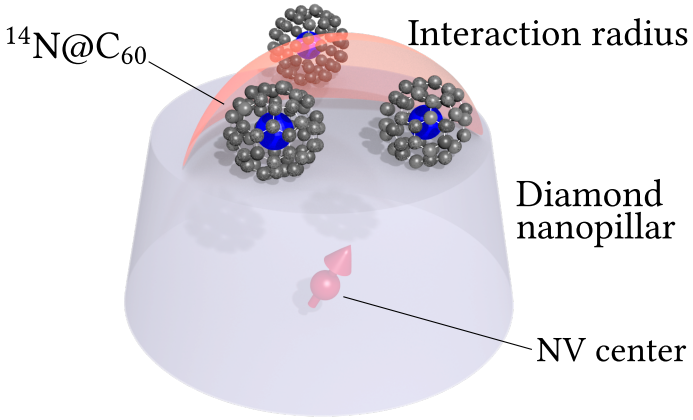

Fig. 1: Schematic of a diamond nanopillar ($r \sim 100$ nm) containing a single nitrogen-vacancy color center which is coupled to few N@C_{60} spin qubits on the surface (image not to scale).

Utilzing this readout mechanism we performed double electron resonance spectroscopy (DEER) between the NV center and the N@C_{60} spins. This allowed us to observe the hyperfine interaction of encapsulated nitrogen. Additionally, we also implemented simple quantum gate operations by driving spin state transitions of ^{14}N. These results are possibly the first steps towards realizing endofullerene based quantum registers [3], and even alternative quantum processors such as the quantum cellular automaton [4].

References

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