Probing classical and quantum environment with a Nitrogen-vacancy center spin.

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Quantum sensors are one of the most promising quantum technologies nowadays. They can sense physical quantities that are usually very dim to be detected by classical means. In this context, Nitrogen-vacancy (NV) centers in diamond have emerged as quantum sensors to detect magnetic fields, using as a qubit its integer spin ground state [1, 2]. However, the coherence of these spin projection states is reduced by the presence of impurities in the diamond, i.e. nuclear spins. A good understanding of these noise sources would allow us to protect our system from detrimental noise and to improve its sensitivity [4]. Moreover, the controlled and coherent coupling of the NV sensor with its environment have been proposed as a potential resource also for sensing [3].

In this work we present the characterization of the effect that the environment has on one NV center in a diamond with natural abundance of ^{13}C. We use a method proposed in [5] based on the measurement of the coherence of the NV ground state under multi-pulse dynamical-decoupling (DD) sequences. This allows us to distinguish the collective semi-classical effect due to the spin bath, from the pure quantum contribution given by the coherent coupling between the NV electron spin and a single nearby ^{13}C nuclear spin. We obtained the noise-spectral-density associated with the semi-classical interaction, and we measured the coupling strength between our NV spin and two different nucleai.

With the measured noise spectrum and the characterized quantum environment of the NV center, we simulated the time evolution of the NV spin states under different DD sequences and we obtained a very good agreement between experimental data and theory.

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