Quantum Control of Ensemble Nitrogen-Vacancy Spins in Diamond with Spin Bath Driving

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A fully controllable many-body quantum system can be a powerful tool for high precision quantum sensing and quantum information processing. An ensemble of negatively charged Nitrogen-Vacancy (NV) spins in diamond is an excellent candidate for such quantum technological applications. In particular, their rather long coherence times even at ambient conditions makes them very good magnetic, electric and thermal sensors. Yet, intrinsic noise sources in the diamond itself, specifically impurity spins, can lead to strong decoherence and heavily impact the sensor performance. Decoupling these noisy bath spins, for example through dynamical decoupling protocols, from the NV ensemble system can considerably increase the NV coherence time [1, 2]. Here we are investigating the decoupling of surrounding bath spins from the NV spins by driving the bath with chirped pulses. This method has two advantages: First, by only performing dynamical decoupling on the bath spins, we can maintain the system degrees of freedom for control. Second, the use of chirped pulses allows us to resonantly drive a whole conglomerate of different bath spins simultaneously. We use a home-built confocal microscope combined with microwave (system control) and radio frequency (bath control) signals to study the evolution of coherence times of NV centres in nano-diamonds.

[1] Bauch, Erik, et al. "Ultralong dephasing times in solid-state spin ensembles via quantum control." *Physical Review X* 8.3 (2018): 031025.

[2] Barry, John F., et al. "Sensitivity optimization for NV-diamond magnetometry." *Reviews of Modern Physics* 92.1 (2020): 015004.