Quantum control of single spins and single photons in diamond

Diamond has emerged as a unique platform for quantum science and engineering [1]. Single Nitrogen-Vacancy (NV) color centers in diamond form hybrid electron-nuclear quantum registers which can be coupled via the light they emit. Long-distance quantum teleportation and large-scale quantum information processing are exciting possible applications. Primary challenges are to maximize the NV center’s coherent photon emission rate and to protect the hybrid spin states against decoherence, even during quantum gate operations.

In this talk I will present results obtained during my PhD on quantum control of the spin states and optical transition of single NV centers with the goal of creating a large-scale quantum network. We have developed a nanopositioning technique to couple single NV centers in diamond nanocrystals to photonic crystal cavities and reshape the optical spectrum [2,3,4]. Using quantum control of the spin bath surrounding an NV center, we have extended the NV center’s dephasing time and probed the bath dynamics [5]. The main result I will present is the development of decoherence-protected gates for hybrid qubit registers by integrating dynamical decoupling into the gate operation. These gates have enabled, for the first time, the execution of a quantum algorithm with single spins on a chip [6] and allow every NV center to be used as a fully controllable multi-qubit register [7].