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Preparation, single-shot readout and long-distance coupling of solid-state quantum registers

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A key challenge in quantum science is to robustly control and to couple long-lived quantum states in solids. In this talk, we report on our latest advances towards realizing long-distance quantum networks with spins in diamond. First, we demonstrate preparation and single-shot measurement of a quantum register containing up to four quantum bits [1]. Projective readout of the electron spin of a single NV center in diamond is achieved by resonant optical excitation. In combination with hyperfine-mediated quantum gates, this readout enables us to prepare and measure the state of multiple nuclear spin qubits with high fidelity. We show compatibility with qubit control by demonstrating initialization, coherent manipulation, and single-shot readout in a single experiment on a two-qubit register, using techniques suitable for extension to larger registers. Second, we observe quantum interference of photons emitted by two spatially separated NV centers [2]. By using electrical tuning of the optical transition frequencies, we are able to observe such interference even for initially dissimilar centers, indicating a viable path for scaling towards a multi-node diamond-based quantum network. We will present these results, along with our most recent data, and discuss the prospects of realizing quantum networks with NV centers in diamond in the near future.

[1] Nature 477, 574 (2011)
[2] arXiv 1110.3329