HQOC

Harvard Quantum Optics Center

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Jefferson 356

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"Quantum Networks Based on Diamond Spins: From Quantum Teleportation to a Loophole-Free Bell Test"

The realization of a highly connected network of qubit registers is a central challenge for quantum information processing and long-distance quantum communication [1]. Diamond spins associated with NV centers are promising building blocks for such a network as they combine a coherent optical interface with a local register of robust and well-controlled nuclear spin qubits.

Here we present our latest progress towards scalable quantum networks. We have realized unconditional teleportation between long-lived qubits residing in independent setups [2]. The teleportation exploits entanglement between distant NV electronic spins that is generated through spin-photon entanglement and subsequent photon detection [3]. By encoding the source state in a separate qubit (a single nuclear spin) we realize a Bell state measurement that distinguishes between all four outcomes in a single shot.

Analysis of the teleportation experiment shows that the obtained fidelities are in principle high enough for a loophole-free violation of Bell's inequalities. Such a loophole-free Bell test is eagerly pursued around the world with several teams closing in on the final experiment. This Bell test is important both for its fundamental implications and because it will serve as a first demonstration of device-independent quantum key distribution. Latest results towards this goal will be presented.

[1] H. J. Kimble, Nature, 453, 1023 (2008)

[2] W. Pfaff et al., Science 345, 532 (2014)

[3] H. Bernien et al., Nature 497, 86 (2013)