INVITED

High-fidelity Spin-Photon Entanglement Generation using Self-Assembled InAs Quantum Dots

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Self-assembled InAs quantum dots can trap a single electron, and this electron's spin states can be used to encode a quantum bit (qubit). The qubit can be optically initialized, controlled and measured. Measurements of the coherence time of such a qubit have shown that the time required to perform an arbitrary single operation (~50 ps) on the qubit is roughly five orders of magnitude smaller than the T_2 time (~3 μs) [1]. This partially makes electron spins in quantum dots appealing candidates as quantum memories.

Long-distance quantum cryptography will likely require the development of quantum repeaters. Charged quantum dots are an excellent candidate technology for building quantum repeaters, because they provide both a good stationary qubit (to be used as a memory), and a fast optical interface. One of the very first steps towards building a quantum repeater using quantum dots is to show that one can generate a photonic qubit that is entangled with a spin (memory) qubit.

In this talk, I will describe our recent demonstration of such entanglement. In particular, we generated and verified entanglement between the polarization state of a photon emitted by a single quantum dot, and the spin state of the electron in that quantum dot [2]. Atac Imamoglu's group at ETHZ concurrently demonstrated, in the same system, entanglement between the frequency of an emitted photon and the quantum dot electron's spin [3]. We have subsequently performed full-state tomography on our spin-photon qubit pair, and have measured a state fidelity in excess of 90% [4]. This measured fidelity rivals that of nearly all previous spin-photon entanglement results, including those from atomic physics groups, whose fidelities are often considered unachievable in solid-state systems.

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[2] K. De Greve, L. Yu*, P.L. McMahon*, J. Pelc*, *et al*., Nature **491**, 421 (2012).
[3] W. Gao, *et al*., Nature **491**, 426 (2012).
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