Quantum networks based on spin-photon interface in quantum dots

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Entanglement plays a central role in fundamental tests of quantum mechanics as well as in the burgeoning field of quantum information processing. Particularly in the context of quantum networks and communication, some of the major challenges are the efficient generation of entanglement between distant stationary (spin) qubits, and the transfer of information from flying (photon) to stationary qubits. In this talk, I will present such experimental implementations achieved in our team with semiconductor self-assembled quantum dots (QDs).
I will present the realization of heralded entanglement between two semiconductor QD hole spins separated by 5 m. The protocol relies on single photon interference of Raman scattered light from both dots [1]. A photon detection projects the system into a maximally entangled state. The efficient spin-photon interface provided by QDs [2,3] allows us to reach a rate of 2300 entangled spin pairs per second [4], three orders of magnitude higher than prior experiments with other physical systems [5].
I will also report on other recent experimental results such as the demonstration of heralded absorption of single photon qubits –generated from a neutral quantum dot– by a single-electron charged quantum dot 5m away. When the electron spin is initially prepared in a superposition state, our scheme realizes photon-to-spin quantum state transfer, as evidenced by the strong spin-photon correlations we measured [6].
These results extend or supplement previous demonstrations in single trapped ions or neutral atoms, in atom ensembles and nitrogen-vacancy centres to the domain of artificial atoms in semiconductor nanostructures that allow for on-chip integration of electronic and photonic elements, which has the major advantage of fast spontaneous emission and efficient photon extraction, leading to much higher success rates. This work lays the groundwork for the realization of quantum repeaters and quantum networks on a chip.

References

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