Towards a solid-state quantum repeater using highly efficient single photon sources

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Abstract

We report on our advances to use quantum dots in micropillar cavities to demonstrate a single quantum repeater node based on the proposal from Luong *et al.* [1].

Modern classical cryptography relies on mathematical complexity and is likely to become insecure with future developments in quantum computing. The security in communication can be recovered using quantum communication, whose security is solely based on the laws of physics. Photons, which are used for encoding, change their quantum state upon measurement and thus a possible eavesdropper can be easily detected. Unfortunately, this feature also disables the use of amplifiers in the classical sense, where the signal that lost strength in the channel is measured and re-amplified to cover bigger distances. To circumvent the problem of amplification while enabling the possibility to cover large distances the concept of a quantum repeater [2] was introduced.

Recently, several groups demonstrated in a proof of principle experiment that two distant quantum dot (QD) ground state spins can be entangled [3, 4], which is a prerequisite to use QDs as quantum repeater nodes. For a scaleable network there are several challenges: The quantum dot transitions have to be indistinguishable to swap the entanglement from the photons to the spin degree of freedom. Furthermore, the photon extraction rates have to be increased to increase success probability. This will become crucial when networks get bigger, with longer paths and more nodes. While looking for quantum dots that are the same by chance is reasonable for small systems (up to maybe 3), it becomes unfeasible for bigger networks. We show some first results of quantum dots embedded in micropillar cavities on a piezo substrate to simultaneously tackle the efficiency [5] and the tuning problem [6].

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