Single-photon - single-atom quantum interfaces

Jürgen Eschner

Experimentalphysik, Universität des Saarlandes, Saarbrücken, Germany
E-mail: juergen.eschner@physik.uni-saarland.de

We are developing a comprehensive set of experimental tools, based on single photons and trapped single ions, that enable controlled generation, storage, transmission, and conversion of photonic qubits in quantum networks. Specifically, we implemented a programmable atom-photon interface, employing controlled quantum interaction between a single trapped $^{40}Ca^{+}$ ion and single photons [1,2]. Depending on its mode of operation, the interface serves as a bi-directional atom-photon quantum state converter (receiver and sender mode), as a source of entangled atom-photon states (entangler mode), or as a quantum frequency converter of single photons [3,4] (converter mode). It lends itself particularly to integrating ions with single photons or entangled photon pairs from spontaneous parametric down-conversion (SPDC) sources [5,6]. As an experimental application of the receiver mode, we demonstrate the transfer of entanglement from an SPDC photon pair to atom-photon pairs with high fidelity [7]. It is realized by heralded absorption and storage of a single photonic qubit in a single ion. We also extend our quantum network toolbox into the telecom regime by entanglement-conserving quantum frequency conversion [8] of photons that are generated by the interface in entangler mode [9].

References

[1] M. Schug et al., Phys. Rev. A **90**, 023829 (2014).
[2] P. Müller, J. Eschner, Appl. Phys. B **114**, 303 (2014).
[3] C. Kurz et al.,Nat. Commun. **5**, 5527 (2014);
[4] C. Kurz et al.,Phys. Rev. A **93**, 062348 (2016).
[5] A. Lenhard et al., Phys. Rev. A **92**, 063827 (2015).
[6] J. Brito et al., Appl. Phys. B. (2016), 122:36.
[7] S. Kucera et al., in preparation.
[8] A. Lenhard et al., Opt. Express **25**, 11187 (2017).
[9] M. Bock et al., arXiv:1710.04866.