A 7: Flying/Stationary Qubit Conversion and Entanglement Generation SYQR 1 (with Q)

Time: Monday 10:30–12:15 Location: UDL HS2002

A 7.1 Mon 10:30 UDL HS2002

Long distance entanglement of single trapped atoms — •Kai Redeker[1], Daniel Burchardt[1], Norbert Ortegel[1], Markus Rau[1], Julian Hofmann[1], Michael Krug[1], Markus Weber[1], Wenjamin Rosenfeld[1,2], and Harald Weinfurter[1,2] — [1]Fakultät für Physik, Ludwig-Maximilians- Universität München, D-80799 München, Germany — [2]Max-Planck Institut für Quantenoptik, D-85748 Garching, Germany

Entanglement is an essential feature of quantum mechanics. Entanglement of stationary particles like atoms forms the basis of a quantum repeater for efficient long distance quantum communication.

We present an experiment on the generation of entanglement between two separately trapped ^{87}Rb-atoms. In our scheme we use spontaneous emission that provides us with entanglement of the spin of the trapped atoms and polarization of the emitted photon together with entanglement swapping to generate entanglement between the atoms. So far we could demonstrate this scheme over a distance of 20m.[1] Additionally we could show quantum teleportation from a weak laser pulse onto the Zeeman-state of a single ^{87}Rb-atom.

Our current work is on increasing the distance of 400 m and implementing a new fast atomic state measurement with ability to randomly chose the measurement basis on a very fast timescale. Such a System can enable device independent quantum key distribution and as such forms the elementary link of a quantum repeater.

[1]J.Hofmann et al. Science 337, 72 (2012)

A 7.2 Mon 10:45 UDL HS2002

High-fidelity heralded photon-to-atom quantum state transfer — •Christoph Kurz, Michael Schug, Pascal Eich, Jan Huwer, Philipp Müller, and Jürgen Eschner — Experimentalphysik, Universität des Saarlandes, Saarbrücken, Germany

A promising platform for implementing a quantum network are atom-based quantum memories and processors, interconnected by photonic quantum channels. A crucial building block in this scenario is the conversion of quantum states between single photons and single atoms through controlled absorption [1, 2] and emission [3].

We present an interface for heralded photon-to-atom quantum state conversion [4], whereby the polarization state of a single photon is mapped onto the spin state of a single absorbing ^{40}Ca^{+} ion with >95% average fidelity. A successful state-mapping event is heralded by a single emitted photon. We record >80 s^{-1} events out of 18,000 s^{-1} repetitions.

[1] N. Piro et al., Nat. Phys. **7**, 17 (2011)
[2] J. Huwer et al., New J. Phys. **15**, 025033 (2013)
[3] C. Kurz et al., New J. Phys. **15**, 055005 (2013)
[4] N. Sangouard et al., New J. Phys. **15**, 085004 (2013)

A 7.3 Mon 11:00 UDL HS2002

Interfacing Superconducting Qubits and Optical Photons via a Rare-Earth Doped Crystal — •Nikolai Lauk[1], Christopher O'Brien[1], Susanne Blum[2], Giovanna Morigi[2], and Michael Fleischhauer[1] — [1]Fachbereich Physik und Forschungszentrum OPTIMAS, Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany — [2]Universität des Saarlandes, Saarbrücken, Germany

Superconducting qubits (SCQ) are promising candidates for scalable quantum computation. However, they are essentially stationary, which makes the transport of quantum information difficult. Telecom-wavelength photons on the other hand, are the best candidates for transporting quantum information, due to the availability of low loss optical fibers.

By interfacing telecom photons with SCQ's one can combine the advantages of both systems to build a quantum network. To this end, we propose and theoretically analyze a scheme for coupling optical photons to a SCQ, mediated by a rare earth doped crystal (REDC). In the first step an optical photon is absorbed in a controlled way into a REDC. This optical excitation is then moved into the spin state using a series of π-pulses and is subsequently transferred to a SCQ through a microwave cavity. Due to intrinsic and engineered inhomogeneous broadening of the optical and spin transitions employed in REDC for the storage of optical photons, we require a special transfer protocol using staggered π-pulses to first move the population into the microwave cavity and then from the cavity to the qubit.

A 7.4 Mon 11:15 UDL HS2002

Remote entanglement generation with parabolic mirrors — •Nils Griebe, József Zsolt Bernád, and Gernot Alber — Institut für Angewandte Physik, Technische Universität Darmstadt, 64289 Darmstadt, Germany

We develop an entanglement generation scheme which uses parabolic mirrors in a multimode and single photon scenario in order to create an entangled state between two remote material qubits. The qubits are implemented as internal states of trapped ions located in the foci of the two parabolic mirrors [1] which face each other. This configuration which might be used in free space communication causes an interesting dynamics of the two ions and the radiation field. We analyze the dynamics by using semiclassical methods and a photonic path representation of the time evolution operator. In this proposal we use the spontaneous decay as a tool for distant entanglement generation and not as an effect to evade.

[1]Alber,G., Bernád,J.Z., Stobinska,M., Sánchez-Soto,L.L., Leuchs,G.: QED with a parabolic mirror, Phys. Rev. A 88, 023825 (2013).

A 7.5 Mon 11:30 UDL HS2002

Double-heralded single-photon absorption by a single atom — •José Brito, Stephan Kucera, Pascal Eich, Michael Schug, Christoph Kurz, Philipp Müller, Jan Huwer, and Jürgen Eschner — Experimentalphysik, Universität des Saarlandes, Saarbrücken, Germany

We present a single-photon single-atom interface experiment, where a heralded single photon generated by Spontaneous Parametric Down Conversion (SPDC) is absorbed by a single atom, generating a single blue (393 nm) photon in an anti-Stokes Raman process [1].

The SPDC photon-pair source [2] is stabilized and tuned to match resonantly the D$_{5/2}$–P$_{3/2}$ atomic transition of ^{40}Ca^{+} at 854 nm [3, 4].

A single ^{40}Ca^{+} ion is trapped in a linear Paul trap and prepared for the absorption of these photons by coherent excitation from the S$_{1/2}$ ground state to the metastable D$_{5/2}$ state. We correlate the detection of the partner photon that heralds the 854 nm SPDC photon with the blue Raman photon that heralds the absorption event. Furthermore, we explore the subsequent frequency conversion of the SPDC herald to the telecom band.

[1] C. Kurz et al., New J. Phys. **15**, 055005 (2013)
[2] N. Piro et al., J. Phys. B **42**, 114002 (2009)
[3] N. Piro et al., Nat. Phys. **7**, 17 (2011)
[4] J. Huwer et al., New J. Phys. **15**, 025033 (2013)

A 7.6 Mon 11:45 UDL HS2002

Fiber-Cavity Coupled Atomic Ensembles for Photon Storage — •Miguel Martinez-Dorantes, Wolfgang Alt, Jose Gallego, Sutapa Ghosh, Lucie Paulet, Lothar Ratschbacher, Yannik Völzke, and Dieter Meschede — Universität Bonn, Institut für Angewandte Physik, Wegelerstraße 8, 53115 Bonn

Quantum networks have the potential to revolutionize the area of information technology, where the unconditionally secure transmission of information represents a prominent application. The most advanced architectures for realizing long distance quantum links rely on stationary quantum network nodes that are communicating with each other via optical photons. Here, we are experimentally implementing such network node based on small ensembles of neutral atoms coupled to high-finesse optical resonators. The fiber coupled optical cavities are formed by microscopic mirrors that we fabricate at the end facet of optical fibers [1]. Collective interaction of multiple Rubidium atoms in such a small resonator mode can allow atom-photon interface operations with increased bandwidth and fidelities. In order to effective prepare small dense atomic ensembles we start by loading tens of Rubidium atoms from a small magneto optical trap into an optical dipole "conveyor belt". Raman-cooling and adiabatic compression techniques [2] are currently investigated to further compress the atom clouds before they will be transported into a 3D optical lattice created inside an optical resonator [3]. [1] D Hunger et al New J. Phys. 12 065038 (2010) [2] Marshall T. DePue, et al, PRL 82, 11 (1999). [3] Schrader, et al, App. Phys, B 73, 8 (2001)

A 7.7 Mon 12:00 UDL HS2002

Individual addressing of multiple neutral atoms in an optical cavity — •Andreas Neuzner, Matthias Körber, Carolin Hahn, Stephan Ritter und Gerhard Rempe — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Straße 1, 85748 Garching

Single neutral atoms trapped in a Fabry-Perot-type optical cavity were shown to be a powerful system for the implementation of various quantum-information-processing protocols. This includes the highly efficient creation of single photons and the implementation of an optical quantum memory based on a single ^{87}Rb atom. We present recent progress on the addressing of several atoms trapped in a two-dimensional optical lattice within the resonator by means of a high-numerical-aperture objective. The addressing capability is used to quasi-deterministically load predetermined patterns of atoms and to control the interaction of individual atoms with the resonator mode. Progress towards the realization of a multi-qubit memory for a quantum repeater node will be presented.