Q 59: Quantum Information: Quantum Communication I

Time: Thursday 14:30–16:00 Location: K/HS1

Group Report Q 59.1 Thu 14:30 K/HS1

Scaling up ion-trap quantum computers and new directions in quantum simulations. — •Christian Schmiegelow, Thomas Ruster, Henning Kaufmann, Marco Dillmann, Claudia Warschburger, Ferdinand Schmidt-Kaler, and Ulrich Poschinger — QUANTUM, Institut für Physik, Johannes Gutenberg Universität Mainz, Staudingerweg 7, 55128 Mainz

We present a full set of tools for scalable quantum computing on microstuctured linear Paul traps. We put together cold ion splitting and transport with entangling- and single-qubit gates to achieve addressing by moving the ions in and out of the lasers. With this platform we test the resistance of a magnetic Decoherence-Free-Subspace to ion separations of above 5mm. We'll also present our advances in scaling up to more ions and gates between Decoherence-Free qubits. Finally we'll introduce some new directions into quantum simulations which include 2D spectroscopy and measurement of time correlation functions.

Q 59.2 Thu 15:00 K/HS1

Protocols for a quantum network based on single photons — •Susanne Blum[1], Christopher O'Brien[2], Daniel Reich[3], Nikolai Lauk[4], Christiane Koch[3], Michael Fleischhauer[4], and Giovanna Morigi[1] — [1]Universität des Saarlandes, Saarbrücken, Germany — [2]Texas A & M University, College Station, USA — [3]Universität Kassel, Kassel, Germany — [4]TU Kaiserslautern, Kaiserslautern, Germany

Two protocols for interfacing single optical photons with individual qubits are theoretically discussed. The first is a protocol which allows one to interface a single optical photon with a superconducting qubit. It makes use of a a spin ensemble, where the individual emitters possess both an optical and a magnetic dipole transition. Reversible frequency conversion is realized by combining optical photon storage, for instance by means of EIT, with the controlled switching on and off the coupling of the magnetic dipole transition with a microwave cavity, which in turn couples to a superconducting qubit. We test various strategies and compare their efficiencies in terms of robustness and transfer time. The second protocol aims at achieving perfect absorption of a photon by a single trapped atom, or solid-state emitter, by means of optimal control theory. We make use of the Krotov algorithm for the purpose of identifying pulses driving the atom, that maximize the efficiency and fidelity of absorption in the setup of [Reiser et al., Nature **508**, 237 (2014)]. These protocols contribute to the development of a toolbox for quantum networks using hybrid platforms.

Q 59.3 Thu 15:15 K/HS1

Towards entanglement of two single trapped atoms over a distance of 400 m — Daniel Burchardt[1], Kai Redeker[1], Robert Garthoff[1], Norbert Ortegel[1], •Wenjamin Rosenfeld[1,2], and Harald Weinfurter[1,2] — [1]Ludwig-Maximilians-Universität, München — [2]Max-Planck-Institut für Quantenoptik, Garching

Entanglement between atomic quantum memories separated by large distances will be a key resource for future applications in quantum communication including the quantum repeater.

Here we present our current progress on establishing heralded entanglement between two single Rb-87 atoms over a distance of 400 meter. Based on our previous work over a shorter distance [1] we implemented the steps necessary for extending the separation between the atomic traps by more than one order of magnitude. Moreover we incorporated a scheme for fast and efficient state detection on single atoms. Together, this also forms the basis for a loophole-free test of Bell's inequality and device-independent quantum key distribution.

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

Q 59.4 Thu 15:30 K/HS1

Ion traps as nodes in a fiber-cavity quantum network — •Robert Maiwald[1], Tim Ballance[1,2], Martin Link[1], Hendrik M. Meyer[1], and Michael Köhl[1] — [1]Physics Institute, University of Bonn, Germany — [2]Cavendish Laboratory, University of Cambridge, UK

Linking quantum systems across larger topologies requires strong light-matter interaction as well as excellent control over the quantum systems themselves, enabling applications such as entanglement distribution, quantum simulation, and distributed quantum computing. We approach this research area by combining fiber-based cavities and ion traps, with the goal to capitalize on both the benefits of high-finesse cavities and the established quantum control of trapped atomic ions.

The talk will highlight our recent progress in realizing individual nodes of a quantum network based on trapping Yb-ions in specialized Paul-type ion traps with integrated fiber cavities. We will present ways to incorporate fiber-cavities in more versatile traps and discuss scalability of our system.

Q 59.5 Thu 15:45 K/HS1

Satellite Quantum Communication using Weak Coherent States — •Dominique Elser[1,2], Christian Peuntinger[1,2], Bettina Heim[1,2], Imran Khan[1,2], Christoph Marquardt[1,2], Gerd Leuchs[1,2], Frank Heine[3], Stefan Seel[3], and Herwig Zech[3] — [1]Max Planck Institute for the Science of Light, Erlangen, Germany — [2]Institute of Optics, Information and Photonics, University of Erlangen-Nuremberg, Germany — [3]Tesat-Spacecom GmbH & Co. KG, Backnang, Germany

Continuous-variable quantum communication can be mostly implemented with standard telecommunication components. This opens the possibility to adapt conventional optical communication systems to quantum key distribution (QKD).

We have recently demonstrated, for the first time, continuous-variable quantum communication through a real-world free space link [1, 2]. Our QKD link employs binary and quadrature phase shift keying of weak coherent states and homodyne detection at the receiver. The same methods are also used in the spaceborne Laser Communication Terminals (LCTs) of the European Data Relay System (EDRS). Based on this close similarity, we are investigating possibilities to adapt LCTs to QKD operation.

Here we will present an overview of this project.

[1] B. Heim *et al.*, New J. Phys. **16**, 113018 (2014).
[2] C. Peuntinger *et al.*, Phys. Rev. Lett. **113**, 060502 (2014).