Q 48: Quanteninformation: Quantenkommunikation I

Zeit: Donnerstag 14:00–16:00 Raum: Audi-B

Q 48.1 Do 14:00 Audi-B

Robustness of an optimal d-dimensional teleportation protocol — •Bruno Gouvêa Taketani[1], Fernando de Melo[2], Andreas Buchleitner[2], and Ruynet Lima de Matos Filho[1] — [1]Instituto de Física, Universidade Federal do Rio de Janeiro, Caixa Postal 68528, RJ 21941-972, Brazil — [2]Albert-Ludwigs-Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg

Quantum information tasks have as a main resource maximally entangled pure states. However, in real world applications, decoherence and impurities lead to the creation of mixed, non-maximally entangled quantum states. Protocols have been created to allow for the optimal usage of the non-local structure of such mixed states, but require complete knowledge of the noisy channel.

We consider here the robustness of the optimal teleportation protocol based on Bell measurements [1], for a $d \otimes d$ bipartite system. In this protocol, Alice performs Bell measurements on her set of particles. Bob, who knows the quantum channel state and the result of Alice's measurement, can decide which unitary operations to apply to his system, in order to maximize the protocol's fidelity. We analyze the robustness of this protocol when the channel is not completely known.

[1] S. Albeverio, S. M. Fei, and W. L. Yang, Phys. Rev. A **66**, 012301 (2002).

Q 48.2 Do 14:15 Audi-B

Fiber-based QKD system with Heterodyne Detection of Coherent States — •Christoffer Wittmann[1], Josef Fürst[1], Carlos Wiechers[1,2], Dominique Elser[1], Denis Sych[1], and Gerd Leuchs[1] — [1]Max-Planck-Institut für die Physik des Lichts , Günther-Scharowsky-Str. 1 / Bau 24, 91058 Erlangen, Germany — [2]Instituto de Física de la Universidad de Guanajuato

We present a fibre-based continuous-variable quantum key distribution system. It uses weak optical coherent states at the telecommunication wavelength (1550nm) as a quantum signal. The signal and a local oscillator are sent through an optical fiber using a time and polarization multiplexing technique. The system is automated such that the polarisation drift in the channel is compensated. In the receiver, a heterodyne detector measures conjugate quadratures of the signal [1] without any prior knowledge about the signal phase. We reconstruct the Q-function of the transmitted signal for the channel lengths 3m, 20km and 40km. The estimated excess noise originating from the channel transmission is about 1% percent. The channel attenuation allows for an estimated secret key of about 0.001 bit per pulse for a fibre channel of 20km length.

[1] S. Lorenz, N. Korolkova, and G. Leuchs, Appl. Phys. B: Lasers Opt. 79, 273 (2004).

Q 48.3 Do 14:30 Audi-B

Daylight free space quantum cryptography — •Harald Krauss[1], Martin Fürst[1,3], Sebastian Schreiner[1], Henning Weier[1,3], Markus Rau[1], and Harald Weinfurter[1,2] — [1]Department für Physik der LMU München, Schellingstr. 4/III, 80799 München — [2]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching — [3]quTools GmbH, Königinstr. 11a, 80539 München

The BB84 quantum key distribution (QKD) scheme allows provably secure communication. We report on our free space implementation of the BB84 protocol linking two Siemens buildings downtown Vienna in the framework of a QKD network demonstration (SECOQC). The setup uses polarization encoded attenuated laser pulses in combination with decoy states to ensure secret key generation over a distance of 80 m. For the first time continuous and fast daylight operation could be achieved. Employing an active automatic position tracking system and improved filtering methods, key distribution rendered possible even during bad weather conditions. Our system is fully remotely controllable and integrates into SECOQC's network which provides the interface for secure communication in common network applications. The experiments prove daylight free space QKD to be feasible. High secure keyrates of already 20 kbit/s were achieved on a 24/7 basis, while the setup still stays both robust and simple, allowing for everyday applications.

Q 48.4 Do 14:45 Audi-B

Free space quantum key distribution with coherent polarization states — •Bettina Heim[1], Dominique Elser[1], Tim Bartley[1,2], Christoffer Wittmann[1], Denis Sych[1], and Gerd Leuchs[1] — [1]Max-Planck-Institut für die Physik des Lichts, Institut für Optik, Information und Photonik, Universität Erlangen-Nürnberg, Günther-Scharowsky-Str. 1, Bau 24, 91058 Erlangen, Deutschland — [2]Physics Department, Blackett Laboratory, Imperial College, London SW7 2BZ, United Kingdom

We demonstrate for the first time the feasibility of free space quantum key distribution with continuous variables under real atmospheric conditions [1]. More specifically, we transmit weak coherent polarization states over a 100m free space channel on the roof of our institute's building. In our scheme, signal and local oscillator are combined in a single spatial mode auto-compensating atmospheric fluctuations and resulting in excellent interference. Furthermore, the local oscillator acts as a spatial and a spectral filter thus allowing for unrestrained daylight operation.

[1] D. Elser et al., arXiv:0811.4756 [quant-ph] (2008).

Q 48.5 Do 15:00 Audi-B

Towards long-distance atom-photon and atom-atom entanglement — •Michael Krug[1], Florian Henkel[1], Norbert Ortegel[1], Julian Hofmann[1], Wenjamin Rosenfeld[1], Markus Weber[1], and Harald Weinfurter[1,2] — [1]Department für Physik der LMU, Schellingstraße 4/III, 80799 München — [2]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Straße 1, 85748 Garching

Entanglement between single neutral atoms separated by several hundred meters is an essential step towards future applications in long-distance quantum communication like the quantum repeater and a first loophole-free test of Bell's inequality [1]. Atom-photon entanglement is the key element to realize both goals. By swapping the entanglement from two non-interacting entangled atom-photon pairs via a photonic Bell-state measurement onto the two atoms a pair of entangled atoms at large distances can be prepared.

Here we present progress towards long-distance atom-atom entanglement. We have established a robust photonic fiber-communication channel of 300 m length, which allowed us to reliably distribute atom-photon entanglement [2]. Towards two entangled ^{87}Rb atoms we present recent progress in the setup of our second mobile single-atom trap. First atom-photon correlation measurements are discussed.

[1] W. Rosenfeld et al., *Towards a loophole-free test of Bells inequality with entangled pairs of neutral atoms*, accepted for publication in *Advanced Science Letters* (2009)

[2] W. Rosenfeld et al., *Long-Distance Atom-Photon Entanglement*, arXiv:0808.3538v1

Q 48.6 Do 15:15 Audi-B

Towards two photon interference using NV color centers in diamond — •Florian Kaiser, Vincent Jacques, Helmut Rathgen, Fedor Jelezko, and Jörg Wrachtrup — 3. Physikalisches Institut in Stuttgart

The NV color center in diamond is of special interest for quantum information science because it exhibits a paramagnetic ground state, that spin can be optically polarized and read out with long coherence times [1,2]. To perform quantum operations by using such solid state spin qubits, multipartite entanglement among single spins is required. One strategy to entangle two distant qubits requires the emission of Fourier-transform limited single photons from each NV center. By performing a two photon interference experiment, it would then be possible to create conditional entanglement between the spin qubits without any direct interactions between them [3]. However counting rates are yet not sufficient to use such a protocol. To increase the photon collection efficiency, different Solid Immersion Lens techniques are investigated. We demonstrate a five times enhancement of the setup collection efficiency, which might be sufficient to perform two photon interference between two independent NV centers.

[1] F. Jelezko et al., Phys. Rev. Lett. 92, 076401 (2004).

[2] T. Gaebel et al., Nat. Phys. 2, 408 (2006).

[3] D. L. Moehring et al., Nature 449, 68 (2007).

Q 48.7 Do 15:30 Audi-B

Quantum Memory with Optically Trapped Atoms —

•Thorsten Strassel[1], Valentin Hagel[1], Chih-Sung Chuu[1], Bo Zhao[1], Yu-Ao Chen[1], Markus Koch[1], Shuai Chen[1], Zhen-Sheng Yuan[1,2], Jörg Schmiedmayer[3], and Jian-Wei Pan[1,2] — [1]Physikalisches Institut, Heidelberg, Germany — [2]Hefei National Laboratory for Physical Sciences at Microscale, Department of Modern Physics, Department of Modern Physics, University of Science and Technology of China, Hefei, China — [3]Atominstitut der Österreichischen Universitäten, TU-Wien, Vienna, Austria

A quantum memory is a key element for long distance quantum communication and in the conversion of probabilistic single photon sources into deterministic ones. We report the experimental demonstration of a quantum memory of an increased lifetime for DLCZ-type protocols with ultra-cold atoms for single photon states in a far red-detuned optical dipole trap (FORT). The generation of the collective atomic state is heralded by the detection of a Raman scattered photon and accompanied by storage in the ensemble of atoms. The optical dipole trap provides confinement for the atoms during the quantum storage while retaining the atomic coherence. By addressing first-order magnetic field insensitive atomic states the dephasing of the atomic coherence caused by stray fields is suppressed. We probe the quantum storage by cross-correlation of the photon pair arising from the Raman scattering and the retrieval of the atomic state stored in the memory. Non-classical correlations are observed for storage times up to 60 microseconds. In addition we provide an outlook on future experiments.

Q 48.8 Do 15:45 Audi-B

Optical Implementations of Discrete- and Continuous-Variable Quantum Error Correcting Codes — •Ricardo Wickert and Peter van Loock — OQI Group, Max-Planck Research Group, Institute of Optics, Information and Photonics, University of Erlangen-Nuernberg

Reliability is of paramountal importance in both Quantum Computation, ensuring the accuracy of calculations, and in Quantum Communication, protecting the transmitted state from losses along the channel. As in the classical case, Quantum Error Correction (QEC) relies on redundancy[1]. However, Quantum Mechanics imposes fundamental limits which affect information processing directly; one example is the so-called 'No-Cloning' theorem[2], which forbids the creation of perfect copies of a given state. In this context, we propose theoretical implementations for different quantum error correcting codes (QECC). Particular cases considering the encoding of discrete variables[3] (ie, $\alpha|0> +\beta|1>$) as well as continuous variables[4] (utilizing the quadratures of the electric field) are discussed, based on a linear optics toolbox with beam splitters, phase shifters and conditional photon or homodyne detection.

References:
[1] P. W. Shor, Phys. Rev. A 52, R2493 (1995)
[2] W. K. Wootters and W. H. Zurek, Nature 299, 802 (1982)
[3] P. Kok et al, Rev. Mod. Phys 79, 135 (2007)
[4] S. L. Braunstein and P. van Loock, Rev. Mod. Phys. 77, 513 (2005)