Q 40 Quanteninformation III

Zeit: Mittwoch 11:10–12:55 Raum: HI

Q 40.1 Mi 11:10 HI

Cleaning noisy photons via cross phase modulation — •Michael Nock — Universitätstrasse 10, 78457 Konstanz

\begin{abstract} We propose a scheme for a heralded generation of a pure single-photon state by post-processing the outputs of imperfect single-photon sources. The latter are modelled by mixtures of the single-photon Fock state $|1\rangle$ with the vacuum $|0\rangle$, i.e., $\rho=p|1\rangle\langle 1|+ (1-p)|0\rangle\langle 0|$ with p being the probability that the source has produced one photon. Our scheme is based on phase shifts induced by cross phase modulation (XPM) via the nonlinear optical Kerr effect. Recent progress in this area have led to the feasibility of huge phase shifts on the order of π even for light pulses of tiny energies corresponding to that of single photons. Given two imperfect inputs we achieve a success probability of $P_{\mbox{\tiny success}}=p^2 \sin^2(\phi /2)$ with ϕ being the phase shift due to XPM. The success probability can be enhanced to $P_{\mbox{\tiny success}}=p(1-\exp[-|\alpha|^2])$ if one of the inputs is replaced by a strong coherent laser pulse, i.e., a coherent state $|\alpha\rangle$ with $| \alpha|\gg 1$. Combination of several apparatuses of this kind and allowing more inputs increases the success probability arbitrarily close to 1. \end{abstract}

Q 40.2 Mi 11:25 HI

Experimental Atom-Photon Entanglement — •Markus Weber[1], Jürgen Volz[1], Wenjamin Rosenfeld[1], Stefan Berner[1], Peter Krebs[1], Christian Kurtsiefer[2], and Harald Weinfurter[1,3] — [1]Department für Physik, Ludwig-Maximilians-Universität München — [2]Department of Physics, National University of Singapore — [3]Max-Planck Institut für Quantenoptik, Garching

Entanglement between light and matter is a key resource for new applications in quantum communication and information forming the interface between atomic quantum memories and photonic quantum communication channels [1,2]. Especially for applications like quantum networks or the quantum repeater, atom-photon entanglement enables one to generate entanglement between atoms at remote locations [2,3].

Here we report the observation of high-fidelity entanglement between a single optically trapped ^{87}Rb atom and a single spontaneously emitted photon at a wavelength of 780 nm. To verify the entanglement we introduce a single atom state analysis. This technique is used for full state tomography of the atom-photon qubit-pair. The efficiency of the atomic state detection and the observed entanglement fidelity are high enough to allow in a next step the generation of entangled atoms at large distances, ready for a final loophole-free test of Bell's inequality.

[1] B. Blinov et al., Nature **428**, 153 (2004).
[2] J. Volz & M. Weber et al., arXiv:quant-ph/0511183, accepted for publication in Phys. Rev. Lett.
[3] C. Simon et al., Phys. Rev. Lett. **91**, 110405 (2003).

Q 40.3 Mi 11:40 HI

Entropy and Quantum Kolmogorov Complexity: a Quantum Brudno's Theorem — •Markus Müller[1], Fabio Benatti[2], Tyll Krüger[1], Rainer Siegmund-Schultze[1], and Arleta Szkola[1] — [1]Technische Universität Berlin, Fakultät II - Mathematik und Naturwissenschaften, Institut für Mathematik MA 7-2, Straße des 17. Juni 136, 10623 Berlin — [2]University of Trieste, Department of Theoretical Physics, Strada Costiera, 11, 34014 Trieste, Italy

In classical information theory, entropy rate and Kolmogorov complexity per symbol are related by a theorem of Brudno. We prove a quantum version of this theorem, connecting the von Neumann entropy rate and two notions of quantum algorithmic complexity, both based on the shortest qubit descriptions of qubit strings that, run by a universal quantum Turing machine, reproduce them as outputs.

Q 40.4 Mi 11:55 HI

Experimental Observation of the Four-Photon Entangled State $W_4^{(2)}$ — •Christian Schmid[1,2], Nikolai Kiesel[1,2], Geza Toth[1], Enrique Solano[1,3], and Harald Weinfurter[1,2] — [1]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, D-85748 Garching, Germany — [2]Department für Physik, Ludwig-Maximilians-Universität, D-80797 München, Germany — [3]Sección Física, Dpto. de Ciencias, Pontificia Universidad Católica del Perú, Apartado 1761 Lima, Peru

The entanglement contained in bipartite quantum systems is quite well understood and can easily be quantified. In contrast multipartite quantum systems offer a rich structure of different classes of entanglement. Here it is an entitled question, not only, how strongly but also in particular in which way a quantum system is entangled. It is thus necessary to seek for new multi-qubit quantum states and to investigate their inherent properties in order to get a deeper understanding of multipartite entanglement as well as to find possible applications in quantum communication protocols. We present an experimental examination of a novel four-photon entangled state $W_4^{(2)}$ – a four-qubit Dicke state with two excitations. Besides its high entanglement persistency against photon loss it has the remarkable property of connecting the two inequivalent classes of genuine tripartite entanglement via von Neumann measurements on one photon. The state is observed in a simple experimental scheme which allows the accomplishment of a complete quantum state tomography yielding a high fidelity of 0.844 ± 0.008. We further apply novel entanglement witness operators to verify the entanglement properties and discuss applications of the state for quantum telecloning.

Q 40.5 Mi 12:10 HI

A realistic quantum gate on an atom chip — •Philipp Treutlein[1], Antonio Negretti[2], Tommaso Calarco[2], Theodor W. Hänsch[1], and Jakob Reichel[3] — [1]Max-Planck-Institut für Quantenoptik and LMU München, Germany — [2]ECT* and Universita di Trento, Trento, Italy — [3]Laboratoire Kaster Brossel de l'ENS, Paris, France

We propose a realistic scheme for a quantum gate on an atom chip and discuss the progress of our experiment towards its realization. In contrast to previous proposals [1], the qubit is encoded in two hyperfine states of ^{87}Rb with a very long coherence lifetime. The quantum phase gate is implemented by state-selective collisions of two qubit atoms in a state-selective potential. This scheme allows for gate operation times below one millisecond, more than three orders of magnitude shorter than the experimentally demonstrated coherence lifetime of the qubit [2]. A crucial role is played by microwave fields guided on the atom chip, which generate the state-selective potential for the atoms. We present a simulation of the gate performance in a realistic potential and show that high fidelity gate operations are possible, taking a large number of error sources into account. On the experimental side, we discuss the chip fabrication, show measurements of the propagation characteristics of the microwave guiding structures on the chip, and present the current status of our experiment.

[1] T. Calarco *et al.*, Phys. Rev. A **61**, 022304 (2000).
[2] Ph. Treutlein *et al.*, Phys. Rev. Lett. **92**, 203005 (2004).

Q 40.6 Mi 12:25 HI

Purifying and Reversible Physical Maps — •Matthias Kleinmann, Hermann Kampermann, Tim Meyer, and Dagmar Bruss — Institut für Theoretische Physik III, Heinrich-Heine-Universität Düsseldorf, D-40225 Düsseldorf, Germany

The laws of quantum mechanics only allow constant universal purifying processes, i.e. any process which maps an unknown quantum state to a pure state has to be constant. Furthermore, a universal reversible process cannot increase the purity of any state. But it can be shown, that a restriction of the set of input states makes purifying or reversible processes possible and can even allow physical maps, which combine both properties.

[1] M.Kleinmann, H. Kampermann, T.Meyer, and D. Bruß (2005), quant-ph/0509100.

Q 40.7 Mi 12:40 HI

Experimental Quantum Teleportation of A Complex System — •Q. Zhang[1,2], A. Goebel[1], C. Wagenknecht[1], Y.-A. Chen[1], A. Mair[1], and J.-W. Pan[1,2] — [1]Physikalisches Institut, Universität Heidelberg, Philosophenweg 12, 69120 Heidelberg, Germany — [2]Hefei National Laboratory for Physical Sciences at Microscale and Department of Modern Physics, University of Science and Technology of China, Hefei, Anhui 230026, China

We present the first experimental realization of quantum teleportation of a two-qubit system. In the experiment, we exploit a six-photon interferometer to teleport an arbitrary quantum state of two photons. The average fidelity of the teleported two-photon state is about $(70 \pm 3)\%$, which is well beyond the classical limit of 40% for optimal estimation of an unknown two-qubit state. The technology developed in the experiment is not only an important step to teleportation of complex systems, but also a critical ingredient for quantum communication and quantum computation networks.