

## Q 34: Poster Quanteninformation

Zeit: Dienstag 16:30–18:30

Raum: Poster C

Q 34.1 Di 16:30 Poster C

**True Quantum Dephasing of 2 Qubits** — •JULIUS HELM and WALTER STRUNZ — Theoretical Quantum Dynamics, Institute of Physics, University of Freiburg, Hermann-Herder-Strasse 3, 79104 Freiburg, Germany

A thorough understanding of dephasing processes is of fundamental importance in quantum information. It is known that for a single qubit general dephasing may always be described by random unitary dynamics (so-called random external field (REF)-channels), yet this ceases to be true for two or more qubits [1]. Our aim is to investigate differences between REF-dephasing channels and dephasing originating from entanglement with an environment. As a toy model we consider a system of two qubits that are independently coupled to an "environment" consisting of another qubit.

[1] L. J. Landau and R. F. Streater, *Lin. Alg. Appl.* 193: 107-127 (1993)

Q 34.2 Di 16:30 Poster C

**Setup of an Improved Single-Photon Source** — •JÖRG BOCHMANN<sup>1</sup>, GUNNAR LANGFAHL<sup>1</sup>, CHRISTOPH ERBEL<sup>1</sup>, AXEL KUHN<sup>2</sup>, and GERHARD REMPE<sup>1</sup> — <sup>1</sup>MPI für Quantenoptik, Hans-Kopfermann-Str. 1, D-85748 Garching, Germany — <sup>2</sup>Clarendon Laboratory, Parks Road, Oxford OX1 3PU, United Kingdom

Single atoms coupled to cavities provide unique systems to study the interaction of light and matter in the quantum regime. Deterministic generation of single photons has been demonstrated [1], but the interaction time of atom and cavity is short ( $35\mu\text{s}$ ). However, recently discovered cavity-cooling schemes enable deterministic coupling of atom and cavity for more than 10 s [2,3]. Using these techniques in an improved single photon source will tremendously increase duty-cycles for single photon generation and enable experiments on atom-photon and atom-atom entanglement.

In our new setup, we have trapped  $^{87}\text{Rb}$  atoms in a MOT and transported to a high finesse cavity in a dipole trap. The cavity parameters put the system at the boundary of the strong coupling regime and coupling of atoms to the cavity has already been observed. Improvements regarding single atom detection and stabilization of the cavity to a non-atomic resonance using an optical frequency comb are under way, latest results will be presented.

[1] T. Wilk, et al., arXiv:quant-ph/0610227 (2006)

[2] S. Nußmann et al, *Nature Physics* 1, 122 (2005)

[3] K. Murr, et al., *Phys. Rev. A* 73, 063415 (2006)

Q 34.3 Di 16:30 Poster C

**Quantum optical measurements with nonclassical ruler states** — •SABINE WÖLK, MICHAEL BUSSHARDT, and MATTHIAS FREYBERGER — Institut für Quantenphysik, Universität Ulm, D-89069 Ulm, Germany

We propose a generalized scheme to measure a quantum state via quantum comparison of the unknown state with certain classes of ruler states. This comparison is realized via joint measurements of commuting observables on both states. Such measurements can be done in the optical domain. The arising probability distribution contains the complete information on the unknown quantum state. With the help of suitable ruler states, for example the Wigner function can be reconstructed. In the case of other ruler states a simple algorithm can be applied to reconstruct the Fock coefficients of the unknown state. This approach can be particularly suitable to estimate few-photon states.

Q 34.4 Di 16:30 Poster C

**Entanglement purification for all graph states** — •CAROLINE KRUSZYNSKA<sup>1,2</sup>, AKIMASA MIYAKE<sup>1,2</sup>, HANS BRIEGEL<sup>1,2</sup>, and WOLFGANG DÜR<sup>1,2</sup> — <sup>1</sup>Institut für theoretische Physik, Universität Innsbruck, Austria — <sup>2</sup>Institut für Quantenoptik und Quanteninformation der ÖAW, Innsbruck, Austria

We present multiparty entanglement purification protocols that are capable of purifying arbitrary graph states directly. We have developed recurrence and breeding protocols and compared our methods with strategies based on bipartite entanglement purification in static and communication scenarios. In a static scenario, the parties get several copies of given noisy multiparty entangled states, while in communication scenarios, they are allowed to generate (arbitrary) multiparty

states locally before distributing them through noisy quantum channels. We found that direct multiparty purification is of advantage with respect to achievable yields and minimal required fidelity in static scenarios, and with respect to obtainable fidelity in the case of noisy operations in both scenarios. The work is published in *Phys. Rev. A* 74, 052316 (2006).

Q 34.5 Di 16:30 Poster C

**A quasi-permanent single-photon source with online verification.** — •BERNHARD WEBER, MARKUS HIJLKEMA, HOLGER SPECHT, TOBIAS MÜLLER, SIMON WEBSTER, and GERHARD REMPE — MPI für Quantenoptik, Hans-Kopfermann-Str.1, 85748 Garching, Germany

We combine very long trapping times of single atoms in an optical dipole trap inside a high-finesse microcavity with a pulsed scheme for single-photon generation. In our setup, a standing-wave optical dipole trap orthogonally oriented to the cavity mode is loaded with a few cold Rb atoms extracted from a magneto-optical trap. A pump laser illuminating the intersection of the trap lasers and the cavity mode provides, when slightly red-detuned from the cavity, three dimensional cooling forces. They allow for trapping a single atom up to a minute under constant observation via the scattering signal into the cavity. Applying a pulsed sequence of pump pulses and repumping intervals with cooling parameters, we show the antibunching behavior of the photons emitted from the cavity in just one trapping event with a single atom. This enables us to first specify the properties of the emitted light online and second guarantee its subsequent performance as a quasi-permanent single photon source.

Q 34.6 Di 16:30 Poster C

**Theoretical investigation of single-photons storage in media with electromagnetically induced transparency** — •GOR NIKOGHOSYAN<sup>1</sup>, MICHAEL FLEISCHHAUER<sup>1</sup>, MATHEW EISAMAN<sup>2</sup>, and MIKHAIL LUKIN<sup>2</sup> — <sup>1</sup>Technische Universität Kaiserslautern, Germany — <sup>2</sup>Harvard University, Cambridge, MA, USA

Recently the storage of narrow bandwidth single photons in a room-temperature ensemble of Rb atoms using electromagnetically induced transparency has been experimentally investigated (M. D. Eisaman, A. Andre, F. Massou, M. Fleischhauer, A. S. Zibrov and M. D. Lukin, *Nature* 438, 837 (2005)). These experiments verified that the quantum statistics of single photons were preserved under EIT propagation by measuring their second order correlation function. At certain single-photon frequencies, the second order correlation function exhibited an unexpected increase above the classical limit. In the present work we discuss a theoretical model of the single-photon generation and EIT-based propagation that accurately describes such an enhancement in the second-order correlation function, and is in good agreement with experimental observations.

Q 34.7 Di 16:30 Poster C

**Classical correlations, Bell inequalities, and communication complexity** — •JOHANNES WILMS<sup>1</sup>, GERNOT ALBER<sup>1</sup>, and IAN C. PERCIVAL<sup>2</sup> — <sup>1</sup>Institut für Angewandte Physik, Technische Universität Darmstadt, D-64289 Darmstadt — <sup>2</sup>Department of Physics, Queen Mary College, University of London, Mile End Road, London E1 4NS, UK

A computer program is presented which is capable of exploring generalizations of Bell-type inequalities for arbitrary numbers of classical inputs and outputs. Thereby, polytopes can be described which represent classical local realistic theories, classical theories without signaling, or classical theories with explicit signaling. These latter polytopes may also be of interest for exploring basic problems of communication complexity. As a first application the influence of non-perfect detectors is discussed in simple Bell experiments.

Q 34.8 Di 16:30 Poster C

**Adaptives Schätzen eines Qubits durch Symmetriemessungen** — •CHRISTOF HAPP und MATTHIAS FREYBERGER — Institut für Quantenphysik, Universität Ulm, 89069 Ulm

Wir beschreiben Methoden zur adaptiven Bestimmung eines Qubits, die auf reinen Symmetrieargumenten beruhen. Dazu werden Produktzustände  $|\psi\rangle|r_\nu\rangle$  bestehend aus Kopien des zu messenden Zustands  $|\psi\rangle$  und frei wählbaren Referenzzuständen  $|r_\nu\rangle$  verwendet, und de-

ren Symmetrie bezüglich Teilchenaustausch betrachtet. Mit Hilfe von Monte-Carlo-Simulationen wird untersucht, wie auf Grundlage von bereits durchgeführten Symmetriemessungen einerseits der unbekannt Zustand  $|\psi\rangle$  möglichst genau geschätzt und andererseits der Referenzzustand  $|r_{\nu+1}\rangle$  einer weiteren Messung am besten gewählt werden können.

Q 34.9 Di 16:30 Poster C

**Implementation of universal two qubit processes using elementary gates** — JAROSLAV NOVOTNY<sup>1</sup>, GERNOT ALBER<sup>2</sup>, and IGOR JEX<sup>1</sup> — <sup>1</sup>Department of Physics, FJFI CVUT, Brehova 7, 115 19 Praha 1 - Staré Město, Czech Republic — <sup>2</sup>Institut für Angewandte Physik, Technische Universität Darmstadt, D-64289 Darmstadt, Germany

We present a network of quantum gates which is capable of implementing a large variety of universal two qubit processes. The design is based on several interesting properties of universal two-qubit processes which are discussed briefly. In particular, applications are presented for implementing optimal universal NOT processes.

Q 34.10 Di 16:30 Poster C

**Quantum simulations under translational symmetry** — CHRISTINA KRAUS, MICHAEL WOLF, and IGNACIO CIRAC — Max-Planck-Institut für Quantenoptik, Garching

We investigate the power of quantum systems for the simulation of Hamiltonian time evolutions on a cubic lattice under the constraint of translational invariance. Given a set of translationally invariant local Hamiltonians and short range interactions we determine time evolutions which can and those that can not be simulated. Whereas for general spin systems no finite universal set of generating interactions is shown to exist, universality turns out to be generic for quadratic bosonic and fermionic nearest-neighbor interactions when supplemented by all translationally invariant on-site Hamiltonians.

Q 34.11 Di 16:30 Poster C

**Semiclassical approach to laser-matter interaction for quantum information** — CHRISTOPH-MARIAN GOLETZ and FRANK GROSSMANN — Institut für Theoretische Physik, TU Dresden, 01062 Dresden

A pi-laser pulse is near optimal to achieve population inversion in a diatomic OH-molecule, which may serve as a NOT-gate, respectively as a qubit in quantum information [1]. In this poster we show that the time-dependent semiclassical approach by Herman and Kluk [2] is capable to describe this fundamental phenomenon.

[1]T. Cheng and A. Brown, J.Chem. Phys. 124, 034111 (2006)

[2]M.F. Herman and E. Kluk, Chem. Phys. 91, 27 (1984)

Q 34.12 Di 16:30 Poster C

**Entanglement of Collectively Interacting Harmonic Strings** — RAZMIK UNANYAN<sup>1</sup>, MICHAEL FLEISCHHAUER<sup>2</sup>, and DAGMAR BRUSS<sup>1</sup> — <sup>1</sup>Theoretische Physik III, Universität Düsseldorf, Universitätsstraße 1, 40225 Düsseldorf — <sup>2</sup>Fachbereich Physik, Technische Universität

Kaiserslautern, 67663, Kaiserslautern

We study the ground-state entanglement of one-dimensional harmonic strings that are coupled to each other by a collective interaction as realized e.g. in an anisotropic ion crystal. Due to the collective type of coupling, where each string interacts with every other one in the same way, the total hamiltonian has a vanishing energy gap and thus shows critical behavior even though the isolated harmonic strings are gapped and thus non-critical. We derive lower and upper bounds for the entanglement, quantified by the von Neumann entropy, between a compact block of oscillators and its environment. For sufficiently large size of subsystems the bounds coincide and show that the area law for entanglement is violated by a logarithmic correction.

Q 34.13 Di 16:30 Poster C

**The ion trap not as an universal, but as an "universe-quantum-computer"** — HECTOR SCHMITZ, AXEL FRIEDENAUER, STEFFEN KAHRA, LUTZ PETERSEN, and TOBIAS SCHÄTZ — MPI für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching

Paul-style ion traps can be used for quantum simulation purposes in versatile ways. Besides the proposal of universal quantum computing with stroboscopic gates one can benefit from the quantum dynamics of trapped ions directly: additional interaction with laser beams allow for a wide range of Hamiltonians that evolve probe systems in the laboratory in analogy to their often hard to access pendants in nature. By adjusting lasers and electrical potentials with the same ions totally different Hamiltonians can be implemented, like quantum phase transitions in different Ising model families or the quantum random walk.

Another interesting Hamiltonian arises from quantum field theory on curved space times—applied to the evolving universe. The Robertson-Walker-metric leads to a wave equation in which a scale parameter describes the cosmological expansion. Starting with a vacuum state a non-adiabatic time variation of this scale parameter might lead to the generation of particle pairs. This amplification of quantum fluctuations probably seeded the observed distribution of matter in the universe and its background radiation. In strong analogy we predict for the non-adiabatic change of the ion trapping potential the generation of phonon pairs.

Q 34.14 Di 16:30 Poster C

**Towards Simulations of Quantum Systems in Ion Traps** — AXEL FRIEDENAUER, HECTOR SCHMITZ, LUTZ PETERSEN, STEFFEN KAHRA, GÜNTHER LESCHHORN, and TOBIAS SCHÄTZ — MPQ Garching

We report on the progress of building a quantum simulator or analog quantum computer designed to simulate quantum mechanical systems as e.g. quantum spin models, the Hubbard model or quantum random walks. Using hyperfine levels of Magnesium ions aligned in a linear chain in a Paul trap and applying optical dipole forces we are able to tailor interactions between these and control coupling strengths. Thus we can adapt our simple system to many interesting quantum single or many-body systems. We recently demonstrated ground-state cooling and are now heading for simulations with a single ion.