Q 75 Poster Quanteninformation

Zeit: Donnerstag 16:30–18:30 Raum: Labsaal

Q 75.1 Do 16:30 Labsaal

Adaptive quantum estimation of phase shifts — •Daniela Denot and Matthias Freyberger — Abteilung Quantenphysik, Universität Ulm, 89069 Ulm

We discuss an adaptive interferometric approach to quantum estimation of phase shifts. In a first step we find optimized two-mode input states for a generalized Mach-Zehnder interferometer. These two states show a small phase variance at the so-called Heisenberg limit. It turns out that they can be generated by entangling a coherent state and a squeezed vacuum at a beam splitter. Moreover, the interferometric setup allows us to describe an adaptive estimation scheme for arbitrary phase shifts if we assume a fixed mean photon number as a quantum resource. We minimize the error of this adaptive scheme for realistic squeezing parameters.

Q 75.2 Do 16:30 Labsaal

Coherent coupling between two single electron spins in diamond — •Torsten Gaebel, Michael Domhan, Philipp Neumann, Augusta Ene, Fedor Jelezko, Philippe Tamarat, and Jörg Wrachtrup — 3. Physikalisches Institut, Universität Stuttgart

Coherent control of single spins has attracted attention during last decade because of application in quantum information technology. We present recent progress on single spin magnetic resonance using single spins associated with defects in diamond. Optical readout of spin state allows achieving the ultimate sensitivity down to single electron spin level. Using novel implantation technique, single spin pairs consisting of nitrogen-vacancy and nitrogen defects have been created. Surprisingly, dipolar coupling, which is often considered as source of decoherence, do not shorten long phase memory time for two single coupled spins. Polarization transfer from optically pumped nitrogen-vacancy spn to nitrogen spin via cross-relaxation mechanism will be presented.

Q 75.3 Do 16:30 Labsaal

Completely positive covariant maps for qubits and the U-NOT — •Jaroslav Novotny[1], Gernot Alber[2], and Igor Jex[1] — [1]FJFI CVUT v Praze, CZ-115 19 Praha 1, Czech Republic — [2]Institut für Angewandte Physik, TU Darmstadt, D-64289, Darmstadt

We investigate characteristic properties of completely positive covariant quantum processes involving one and two qubits. In particular, we analyze how the complete positivity and linearity of quantum processes constrains various operations of special interest for quantum information processing. As particular examples we consider the U-NOT operation acting on arbitrary pure single qubit states and on entangled pure two-qubit states of a given degree of entanglement. The influence of the degree of entanglement on the optimally achievable fidelities is worked out.

Q 75.4 Do 16:30 Labsaal

Control of cold collisions between single neutral atoms — •Leonid Förster, Wolfgang Alt, Igor Dotsenko, Michał Karski, Mkrtych Khudaverdyan, Dieter Meschede, Yevhen Miroshnychenko, Arno Rauschenbeutel, and Sebastian Reick — Institut für Angewandte Physik, Wegelerstraße 8, 53115 Bonn

We use two orthogonally oriented standing wave dipole traps as independent optical “conveyer belts” to transfer single neutral Caesium atoms along the trap axes [1]. By this method and due to sub-micrometer precision of the axial transport an atom can be deterministically deposited into a potential well which already contains another atom. We use light induced inelastic collisions for the reliable detection of the success of this manipulation.

Coherent control of collisions between two individual neutral atoms can be realized by the technique of spin dependent transport [2]. Thereby, the transport direction is determined by the internal state of the atom. We want to study the coherence properties of this controlled atom-atom interaction depending on different transport parameters and atom temperature. We present the current status of the experiment.

[1] S. Kuhr et al., Science 293, 278 (2001)
[2] O. Mandel et al., Nature 425, 937 (2003)

Q 75.5 Do 16:30 Labsaal

Dynamical entanglement between two trapped atoms and decoherence — •Michael Busshardt and Matthias Freyberger — Abteilung Quantenphysik, Universität Ulm, D-89069, Germany

We investigate the dynamical creation of entanglement between two cold atoms in a trapping potential. Both atoms interact via s-wave-scattering, modelled by a δ-potential, which only depends on the relative coordinate. By introducing an environment we model the effects of dissipation and decoherence. This is done by constructing a master equation for the relative wave packet and simulating the dynamics using the Monte Carlo Wave Function Method. The entanglement can be quantified by calculating the maximal violation of a Bell inequality, which is constructed using so-called pseudospin operators. The entanglement shows an oscillatory behaviour and is very sensitive to the damping constant.

Q 75.6 Do 16:30 Labsaal

Entanglement measurement with discrete multiple coin quantum walks — •Jochen Endrejat and Helmut Buettner — Theoretische Physik I, Universitaet Bayreuth

Within a special multi-coin quantum walk scheme we analyze the effect of the entanglement of the initial coin state. For states with a special entanglement structure it is shown that this entanglement can be meausured with the mean value of the walk, which depends on the i-concurrence of the initial coin state.

Q 75.7 Do 16:30 Labsaal

Entanglement witnesses and the loophole-problem — •P. Skwara, H. Kampermann, and D. Bruss — Heinrich-Heine-Universität Düsseldorf, Institut für theoretische Physik III

In analogy to loopholes in Bell-experiments we consider possible loopholes in experiments to measure entanglement witnesses, with special emphasis on the detector-efficiency-loophole[1]. We derive bounds for the detector-efficiency, which guarantees that a negative expectation value of the witness is due to entanglement, rather than to erroneous detectors. The decomposition of two-qubit witnesses into local measurements[2] is optimized with respect to the detector-efficiency. A generalization of this method to the case of two qudits is presented.

[1] J.-Å. Larsson, Phys. Rev. A **57**, 3304, 1998
[2] O. Gühne, P. Hyllus, D. Bruß, M. Lewenstein, C. Macchiavello, A. Sanpera, Phys. Rev. A **66**, 62305, 2002

Q 75.8 Do 16:30 Labsaal

Experimental Demonstration of a Six Photon Entangled GHZ State — •Alexander Goebel[1], Qiang Zhang[1,2], Claudia Wagenknecht[1], Yu-Ao Chen[1], Alois Mair[1], and Jian-Wei Pan[1,2] — [1]Physikalisches Institut, Universität Heidelberg, Philosophenweg 12, D-69120 Heidelberg, Germany — [2]Department of Modern Physics, University of Science and Technology of China, Hefei, Anhui, 230027, PR China

Preparation and manipulation of multi-particle entanglement has been a major breakthrough in modern physics. Up to five-particle entanglement has been used to experimentally demonstrate the stunning contradiction between quantum mechanics and local realism. However, many further experiments, such as teleportation of a complex system and quantum error correcetion, require the entanglement of at least six particles, which up to recently has remained an experimental challenge. Here, we report the first experimental demonstration of a six photon entangled Greenberger-Horne-Zeilinger (GHZ) state. In the experiment, we used a pulsed IR laser source to produce short (˜200 fsec) UV light pulses via second harmonic generation. Each pulse was directed onto beta barium borate (BBO) crystals to generate three entangled photon pairs via type-II parametric downconversion. All pairs were in a |Ψ-> Bell state. Photons 2(4) and 3(5) of the first(second) and second(third) pair were then combined on a polarising beam splitter in order to entangle all three pairs and to generate a six photon GHZ state. We used the process of quantum witness to prove that our system was in fact in a maximally entangled GHZ state.

Q 75.9 Do 16:30 Labsaal

Experimental squeezing distillation — •Ruifang Dong[1], Joel Heersink[1], Christoph Marquardt[1], Maria Chekhova[2], Radim Filip[1], Stefan Lorenz[1], Gerd Leuchs[1], and Ulrik Andersen[1] — [1]Institute for Optics, Information and Photonics,Max-Planck Research-group, University Erlangen-Nuernberg, Guenther-Scharowsky-Str. 1, 91058, Erlangen,Germany — [2]Department of Physics, M.V. Lomonosov Moscow State University, 119992, Moscow, Russia

We report on the first experimental distillation of non-classical, continuous variable mixed states. These states are based on Gaussian intense polarization squeezed states [1], our quantum resource, which are subject to a non-Gaussian noise source. Such noise may arise from phase kicks caused by either a noisy channel or by intrinsic phase jitter in the squeezing source. Experimentally this is implemented by an appropriate phase shift to the beam before or after feeding it into the polarization squeezer. In the distillation protocol a small portion of the corrupted resource is tapped off and a measurement is performed along the quadrature exhibiting maximal modulation. Conditioned on the resulting measurement outcome the remaining state is either accepted or discarded, hereby accomplishing a probabilistic distillation of the noisy signal, and a recovery of the original quantum resource, the squeezing, is obtained. [1] J. Heersink et al, Opt. Lett., Vol.30, 1192 (2005).

Q 75.10 Do 16:30 Labsaal

Integration of microoptics on atom chips — •Kai Wicker, Marco Wilzbach, Dennis Heine, Björn Hessmo, and Jörg Schmiedmayer — Physikalisches Institut der Universität Heidelberg, Philosophenweg 12, 69120 Heidelberg, Germany

To develop the atom chip towards a universal tool for quantum information processing, we explore the possibility of integrating micro-optical components for the preparation, manipulation, and detection of atomic qubit states. As a first step we are working on the implementation of an integrated single atom detector based on an optical fibre cavity. First fibre cavities have been realized and tested in our labs. At the moment we are exploring several new cavity designs allowing for higher detection efficiency. We will describe our setup, show first measurements with these designs and give first experimental results.

Q 75.11 Do 16:30 Labsaal

MAPLE procedures for the simulation of N-qubit quantum registers — •Thomas Radtke and Stephan Fritzsche — Universität Kassel, Institut für Physik, D–34109 Kassel, Germany

In the last decade, the field of quantum computation and quantum information has attracted an increasing amount of interest. By exploiting the long-known phenomenon of quantum entanglement, several interesting applications could be demonstrated successfully, such as efficient quantum computing or secure communication. However, apart from the promising perspectives of this new field of research, there are still a lot of open problems which remain to be solved, both in theory and experiment.

In order to facilitate the simulation of n-qubit quantum systems (quantum registers) we recently started to develop the Feynman program [1] which is a flexible and easily extendible hierarchy of procedures within the framework of the computer algebra system Maple. Currently, the Feynman program supports the definition and manipulation of n-qubit quantum registers as well as the application of unitary (and some user-defined non-unitary) quantum operations. Moreover, useful tools for the qualitative and quantitative analysis of the entanglement and separability properties in quantum registers are also provided.

[1] T. Radtke, S. Fritzsche, Comp. Phys. Comm. 173 (2005) 91.

Q 75.12 Do 16:30 Labsaal

Manipulating individual neutral atoms deterministically loaded into a standing wave optical dipole trap using a feedback loop — •Sebastian Reick, Wolfgang Alt, Igor Dotsenko, Leonid Förster, Mkrtych Khudaverdyan, Dieter Meschede, Yevhen Miroshnychenko, Dominik Schrader, and Arno Rauschenbeutel — Institut für angewandte Physik, Wegelerstr. 8, 53115 Bonn

Neutral atoms trapped in light induced potentials are a promising candidate for quantum information processing. We have demonstrated that a string of single caesium atoms trapped in an optical dipole trap (DT) can serve as a quantum register. To realize two-qubit operations we aim to use atom-atom interactions enhanced by the exchange of a photon inside a high-finesse optical resonator. In order to place two atoms into the fundamental mode of our cavity it is essential to accurately control the absolute position and the distance between atoms.

We move the atoms by means of our "conveyor belt" technique. Using optical tweezers we extract atoms out of a string and reinsert them at a predetermined position, thereby precisely controlling the interatomic distances. Using this method we prepare regular strings of up to seven atoms.

For our experiments it is desirable to work with a predetermined number of atoms. Therefore we developed a loading feedback to circumvent the Poission-statistical limit of the MOT loading process. The efficiency of this feedback is enhanced by collisional re-distribution of atoms during loading the DT which allows us to load up to 20 atoms into the DT.

Q 75.13 Do 16:30 Labsaal

Quantum Memory and Two-Mode-Squeezing in Atomic Ensembles — •Christine Muschik, Klemens Hammerer, and J. Ignacio Cirac — Max Planck Institut für Quantenoptik, Hans Kopfermannstr.1, 85748 Garching

We propose two protocols based on a scheme for an atomic ensemble in a magnetic field interacting wih light. The first protocol provides a passive interaction that enables the exchange of states of light and atoms. It can therefore be used as a quantum memory. An unknown state of light can be written onto the collective spin state of the atoms and subsequently be retrieved. Remarkably the fidelity of the state transfer approaches unity exponentially in the coupling strength. The second protocol creates an EPR state between atoms and light. The interspecies correlations produced in the scheme can be used to perform quantum teleportation and unconditional spin squeezing of the collective spin of the atomic sample. Squeezing which grows exponentally in the coupling can be achieved. Both protocols are shown to be robust against the dominant sources of noise.

Q 75.14 Do 16:30 Labsaal

Real-valued representations in quantum mechanics and decoherence — •Volker Schauer, Alexander Wolf, and Matthias Freyberger — Abteilung Quantenphysik, Universität Ulm, 89069 Ulm, Germany

The problem of representing a quantum state is discussed since the early days of quantum mechanics. We give a representation of a quantum state as the real part of an entire function on a closed path in complex plane. The quantum state is therefore completely encoded in a real-valued function of just one variable. This representation is closely linked to entangled position and momentum measurements on a coupled system, which uses a Schroedinger cat-like state as a reference state. Therefore, these measurements can be used to reconstruct nonclassical states. Moreover the corresponding algorithm turns out to be stable with respect to decoherence since we can correct the measurement data by a rescaling procedure.

Q 75.15 Do 16:30 Labsaal

Spin entanglement produced from elastic scattering of unpolarized electrons — •Rustam Berezov, Sebastian Böttger, and Joachim Jacoby — Inst. f. Ang. Phys., Max von Laue-Str. 1, JWG-Univ. Frankfurt/Main

A Moeller scattering experiment is set up where a beam of unpolarized electrons is scattered quasi elastically from a target. In this case entanglement appears if the two particles are indistinguishable. For identical fermions the scattering cross-section to 90° in the center of mass system is forbidden, whereas for identical bosons the scattering cross-section at that angle is twice as big as the one for distinguishable particles. Therefore scattering of electrons to 90° is only permitted for distinguishable electrons, where the spin orientation for both scattered electrons is anticorrelated. A new design of a spin detector is proposed to detect the spin of the electrons.

Q 75.16 Do 16:30 Labsaal

Towards deterministic coupling of two atoms to a mode of a high-finesse optical resonator — •Mkrtych Khudaverdyan, Wolfgang Alt, Igor Dotsenko, Dieter Meschede, Yevhen Miroshnychenko, Sebastian Reick, and Arno Rauschenbeutel — Institut für Angewandte Physik, Universität Bonn, Wegelerstrasse 8, D-53115 Bonn

The realization of controlled coherent interaction between neutral atoms is a fundamental requirement for the realization of quantum information processing with neutral atoms. One approach relies on deterministic coupling of two or more atoms to a mode of a high-finesse optical resonator in the so called strong coupling regime. We discuss the latest results about resonator properties as well as on deterministic placement of individual atoms into the mode of the optical resonator by means of our optical "conveyor belt" technique. More specifically, we present the integration of our resonator with our MOT and dipole trap, transporting, holding, and subsequent detection of single atoms inside the resonator mode.