Q 29: Poster Quanteneffekte

Zeit: Dienstag 16:30–19:00 Raum: Poster C2

Q 29.1 Di 16:30 Poster C2

A single photon source with a Ca^+ cavity-QED system — •Andreas Stute[1,2], Carlos Russo[1,2], Helena G. Barros[1,2], François Dubin[1], Piet O. Schmidt[1], and Rainer Blatt[1,2] — [1]Institut für Experimentalphysik, Universität Innsbruck, Technikerstr. 25, A-6020 Innsbruck — [2]Institut für Quantenoptik und Quanteninformation, Österreichische Akademie der Wissenschaften, Otto-Hittmair-Platz 1, A-6020 Innsbruck

Linear optics quantum computation as well as quantum cryptography require a source of single, indistinguishable photons. We realize a deterministic source of single photons in a setup consisting of a single trapped $^{40}Ca^+$ ion coupled to a single mode of a high finesse optical resonator. A single trapped ion can be stored for days and can be precisely positioned in the cavity mode.

Photons are generated in a vacuum-stimulated Raman process driven by a pulsed pump laser and the cavity vacuum field. During the pump pulse a photon is emitted into the cavity mode, subsequently leaves the cavity and is detected with a Hanbury Brown & Twiss setup. The system is initialized again by repumping the ion back to the ground state and the sequence is repeated.

The resulting intensity correlation $g^{(2)}(\tau)$ reveals the signature of a single photon source. The experimental results are in excellent agreement with numerical simulations of the process.

Q 29.2 Di 16:30 Poster C2

Towards controlled Cavity-QED experiments with toroidal microresonators — •Rico Henze[1], Markus Gregor[1], Tim Schröder[1], Helmar Kostial[2], Edith Wiebicke[2], and Oliver Benson[1] — [1]AG Nano-Optik, Institut für Physik, Humboldt-Universität zu Berlin, Hausvogteiplatz 5-7, 10117 Berlin — [2]Paul-Drude-Institut für Festkörperelektronik, Hausvogteiplatz 5-7, 10117 Berlin

Optical microresonators are interesting systems to study the light-matter interaction on the nanometer scale. The so-called Whispering Gallery Modes (WGM) in spherical resonators offer high spatial and temporal light confinement, a prerequisite for Cavity-QED experiments. We report the production and optical characterization of chip-based SiO_2 toroidal microresonators which we produce by standard clean room techniques. A tapered optical fiber is implemented as an efficient light coupler. Combined with scanning probes (SNOM and AFM) a versatile setup is created that allows to study the optical mode structure of the WGMs in a toroidal cavity or to position nanoscopic emitters on the resonator surface at will.

Q 29.3 Di 16:30 Poster C2

Double-Slit Light Diffraction in Strong Electromagnetic Fields — •Ben King, Antonino Di Piazza, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

In [1] the vacuum-polarisation effects of change in ellipticity and polarisation of a laser probe beam passing through an ultra-intense standing wave, were calculated. We further develop these results to increase the measurable polarisation and ellipticity, by calculating diffraction effects from the double-slit-like setup of two parallel and off-centre, gaussianly-focused, strong field waves propagating against each other. We move towards a measurable set-up through calculations of the off-axis effects on a focused probe beam, allowing alternative detection of these vacuum effects.

[1] A. Di Piazza, K. Z. Hatsagortsyan, and C. H. Keitel, Phys. Rev. Lett. 97, 083603 (2006)

Q 29.4 Di 16:30 Poster C2

Thermodynamics and quantum effects — •Stefanie Hilt[1] and Eric Lutz[2] — [1]Institut für Quantenphysik, Universität Ulm, Deutschland — [2]Institut für Physik, Universität Augsburg, Deutschland

We consider a system coupled to a heat reservoir modelled by a harmonic chain and discuss the influence of quantum effects on the equilibrium properties of the system. Special emphasis is put on the low temperature regime where quantum fluctuations play an important role. In particular, we use the negativity to quantify the entanglement created between the system and the reservoir.

Q 29.5 Di 16:30 Poster C2

Dekohärenz molekularer Konfigurationszustände — •Johannes Trost und Klaus Hornberger — Arnold Sommerfeld Center for Theoretical Physics, Ludwig-Maximilians-Universität, München

Superpositionszustände von Enantiomeren, d.h. von isomeren Molekülen mit unterschiedlicher Konfiguration, werden bei komplexeren Molekülen nicht beobachtet. Bei einfachen chiralen Molekülen wie Dihydrogendisulfid, HSSH, (oder der deuterierten Form DSSD) ist zu erwarten, dass die Kohärenz solcher quantenmechanischer Superpositionen durch Streuprozesse mit Molekülen des Umgebungsgases beschränkt wird. Wir entwickelten ein Modell, das dispersive Wechselwirkungen des chiralen Moleküls mit einfachen Hintergrundgasen realistisch und konsistent beschreibt. Anhand dieser chiralitätsabhängigen Wechselwirkungen lässt sich die Dekohärenzrate durch Stöße streutheoretisch berechnen und eine Abhängigkeit spektroskopischer Übergangslinien von der Stoßrate demonstrieren.

Q 29.6 Di 16:30 Poster C2

Creating and Ascertaining Entanglement of Atoms by Photon Scattering — •Torsten Scholak and Cord A. Müller — Physikalisches Institut, Universität Bayreuth, 95440 Bayreuth, Germany

We study the light-scattering dynamics of two tightly trapped atoms with internal spin degrees of freedom. The aim is to manipulate populations and coherences by a selective tuning of photon field parameters like polarization. We are particularly interested in the preparation of entanglement and its subsequent witnessing [1] by interaction with the driving laser field.

[1] arXiv:0710.0825

Q 29.7 Di 16:30 Poster C2

Coherent beam splitting with a single spontaneously emitted photon — •Jiri Tomkovic[1], Michael Schreiber[1], Inka Benthin[1], Arne Schietinger[1], Jörg Schmiedmayer[2], and Markus Oberthaler[1] — [1]Kirchhoff Institut für Physik,Universität Heidelberg, 69120 Heidelberg — [2]Atominstitut der Österreichischen Universitäten, TU-Wien, Stadionallee 2, A-1020 Vienna, Austria

Spontaneous emission of a photon leads to a momentum transfer to the emitting atom. In free space this leads to a incoherent momentum distribution of the atom which is typically used in laser cooling schemes. In case the atom is close to a mirror, the situation can drastically change since directly emitted and reflected light can principally not be distinguished in certain directions. Thus at distances of few micrometers the spontaneous emission of a single photon leads to a coherent superposition of two momentum states of the atom. We will present our experimental results revealing the expected coherence.

Q 29.8 Di 16:30 Poster C2

Electromagnetically induced transparency and retrieval of light pulses in a Pr^{3+}:Y_2SiO_5 crystal — •Georg Heinze, Fabian Beil, Jens Klein, and Thomas Halfmann — Institut für Angewandte Physik, TU Darmstadt, Hochschulstraße 6, 64289 Darmstadt

Recent research on coherent interactions between light and matter already led to a large variety of applications. In particular electromagnetically induced transparency (EIT) and the closely related concepts of slow light and light storage play an important role in quantum information processing and optical data storage. A very promising approach is the implementation of these techniques in solids, e.g. in particular rare earth doped solids. These media offer the advantages of solids, i.e. high density and scalability, while still exhibiting sharp optical transitions - like free atoms in the gas phase. We apply EIT and related techniques in a Pr^{3+}:Y_2SiO_5 crystal, cooled to cryogenic temperatures. The dopant ions are prepared by optical pumping and spectral hole-burning. This permits the generation of spectrally isolated Λ-type or V-type systems within the inhomogeneous bandwidth of the $^3H_4 \leftrightarrow {}^1D_2$ transition of the Pr^{3+} ions. We observe and compare cancellation of absorption due to EIT in the Λ-type coupling scheme as well as in the V-type coupling scheme. By EIT, we also excite persistent nuclear spin coherences between the hyperfine levels of the ground state (Λ-System) or the excited state (V-system). These coherences are probed by time delayed retrieval of light pulses. Hereby we determine the dephasing times of the nuclear spin coherences of the Pr^{3+} ions, either in the ground state or in the optically excited state.

Q 29.9 Di 16:30 Poster C2

Negative refraction in atomic two-component media — •Bastian Jungnitsch and Jörg Evers — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

We discuss the feasibility of obtaining negative refraction with low losses or even gain in an atomic gas consisting of two different species of atoms [1]. The two components yield electrical and magnetical responses, respectively, which are individually tailored via external fields to give the desired negative index of refraction. Using different atoms for magnetic and electric response allows to relax the stringent requirements to achieve negative refraction in single species systems [2]. For this, several few-level systems with different combinations of coherent and incoherent driving fields are compared with an emphasis on the problem of obtaining a sufficiently large magnetic response. Based on these results, we discuss potential candidate systems in real atoms.

[1] B. Jungnitsch and J. Evers, in preparation
[2] P. P. Orth, J. Evers, and C. H. Keitel, arXiv:0711.0303

Q 29.10 Di 16:30 Poster C2

Pulse propagation in a medium with time-dependent refractive index — •Martin Kiffner[1] and Tarak N. Dey[1,2] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany — [2]Indian Institute of Technology Guwahati, Guwahati- 781 039, Assam, India

The phenomenon of electromagnetically induced transparency (EIT) gives rise to counterintuitive effects like the slowing and stopping of light and is of great importance, e.g., for the fields of quantum information theory and nonlinear optics [1]. Here we consider a standard EIT medium comprised of three-level Λ-type atoms and investigate the influence of a polychromatic control field on the propagation of the probe pulse. Our results are analyzed in terms of a time-dependent refractive index.

[1] M. Fleischhauer, A. Imamoglu, and J. P. Marangos, Rev. Mod. Phys. **77**, 633 (2005).

Q 29.11 Di 16:30 Poster C2

Stationary light in cold gases — •Gor Nikoghosyan and Michael Fleischhauer — Fachbereich Physik, TU Kaiserslautern

One of the challenging problems of practical quantum information processing with photons is to achieve a strong nonlinear coupling between two single-photon pulses. A promising approach for its realizations is based on so-called stationary light in resonant Λ-type media with electromagnetically induced transparency. Here a weak probe pulse is trapped in the medium by a stationary coupling field. Previous theoretical studies considered room-temperature ensemble where atomic motion leads to a rapid dephasing of high-frequency components of the ground-state coherence allowing for a secular approximation. In the present work we study the dynamics of the probe pulse in cold media where this approximation no longer holds. We show that in the case of one-photon resonance forward and backward components of the probe field are decoupled and no stationary light pattern is formed.

Q 29.12 Di 16:30 Poster C2

Stationary light and Klein tunneling — •Razmik Unanyan and Michael Fleischhauer — Fachbereich Physik, TU Kaiserslautern

We discuss the generation and coherent manipulation of stationary pulses of light in atomic ensemble with electromagnetically induced transparency with two counterpropagating control fields. In particular we discuss the limits on the spatial confinement of these pulses when the latter becomes comparable to the absorption length of the medium. In this case the stationary field in the dilute gas can be described by a two-component spinor which obeys the two-dimensonal Dirac-Weyl equation in an external potential generated by a spatially varying two-photon detuning. We show that a fundamental lower limit to the spatial confinement arises from Klein tunneling. We determine the linewidth of the resonances in the effective potential and discuss conditions for optimizing spatial confinement and tunneling losses.

Q 29.13 Di 16:30 Poster C2

Efficient coherent population transfer to highly excited vibrational states in NO molecules by Stark-chirped rapid adiabatic passage — •Holger Münch, Martin Oberst, and Thomas Halfmann — Institute for Applied Physics, TU Darmstadt, Schlossgartenstr. 7, 64289 Darmstadt, Germany

The interaction of strong, coherent radiation fields with quantum states permit the efficient and selective manipulation of population distributions. Adiabatic processes, e.g. rapid adiabatic passage (RAP), allow to prepare complete population inversion between two quantum states. An extension of RAP is Stark-chirped rapid adiabatic passage (SCRAP). This process uses dynamic stark-shifts to drive the transition frequency through resonance with an initially detuned laser field and thereby realize a RAP process. The implementation of SCRAP in a L-type three state system rather than application of other coherent techniques, e.g. STIRAP, offers e.g. advantages in inhomogeneous broadened media. We demonstrate the experimental realization of SCRAP among three states in nitric oxide (NO) molecules. SCRAP permits complete population inversion between a vibrational ground state and a highly excited vibrational state. Both states are coupled through strong, pulsed laser fields (pump and Stokes laser) to an electronically excited intermediate state. An intense Stark laser pulse induces dynamic stark-shifts of the transition frequencies. Appropriate choice of laser detunings and time delays between the laser pulses permits complete and robust population inversion in the NO molecules and efficient storage of large amounts of internal energy.

Q 29.14 Di 16:30 Poster C2

Stimulated Raman Adiabatic Passage (STIRAP) in a Pr^{3+}:Y_2SiO_5 crystal — •Fabian Beil, Jens Klein und Thomas Halfmann — Institute for Applied Physics, TU Darmstadt, Schlossgartenstr. 7, 64289 Darmstadt, Germany

STIRAP is a well-established, efficient and robust technique to manipulate population distributions in atoms and molecules. Among others, STIRAP found applications in optical data storage and quantum information processing. Experimental studies of STIRAP have been mainly constricted to media in the gas phase. However, it is solid media which are (due to their high density and scalability) of special interest for applications. Usually, ultra-fast decoherence processes in solids prevent the implementation of coherent excitations. This obstacle is overcome in rare earth ion doped inorganic crystals, which combine the advantages of solids and the coherent properties of atoms. We implemented STIRAP in a Pr^{3+}:Y_2SiO_5 crystal (Pr:YSO). The experiment yielded striking data on complete adiabatic population transfer in a solid. Population is transferred between two hyperfine levels of the $^3H_4$ ground state of a selected ensemble of Pr^{3+} ions. Efficient transfer is observed for negative pulse delay (STIRAP) as well as for positive delay. The latter is due to an alternative adiabatic passage process, i.e.b-STIRAP, which is closely related to conventional STIRAP. We record the population dynamics for both adiabatic processes by time-resolved absorption measurements. In addition to the experimental investigations, we performed numerical simulations. The results are in good qualitative agreement with the experimental observations.

Q 29.15 Di 16:30 Poster C2

Adaptive quantum estimation of continuous systems — •Sabine Wölk and Matthias Freyberger — Institut für Quantenphysik, Universität Ulm, D-89069 Ulm, Germany

We propose an adaptive scheme to reconstruct unknown quantum states of light via quantum comparison with certain classes of reference or ruler states. This comparison is realized by joint measurements of EPR variables on both states. The arising probability distribution contains the complete information of the unknown quantum state. Different ruler states allow us to estimate different representations of the unknown state. As an example, we have developed an adaptive algorithm to determine the quadrature representation using Gaussian states as ruler states.

Q 29.16 Di 16:30 Poster C2

Quantum theory of atom lasers — •Tobias Kramer[1], Mirta Rodríguez[2], and Christian Bracher[3] — [1]Institut I: Theoretische Physik, Universität Regensburg, Germany — [2]Institut de Ciències Fotòniques, Barcelona, Spain — [3]California State University, Long Beach, USA

We present a three-dimensional, quantum mechanical and largely analytical theory for the properties of atomic laser beams in the gravitational field. The results describe both the total emission rate and the beam profile. Depending on the trapping frequencies and the strength of interactions, the theory predicts a transverse substructure in the atomic beam. Recent experiments on atom laser beam profiles are in good agreement with the model.

T. Kramer and M. Rodriguez Quantum theory of an atom laser originating from a Bose-Einstein condensate or a Fermi gas in the presence of gravity, Phys. Rev. A, 74, 013611-1-13, (2006)

Q 29.17 Di 16:30 Poster C2

Simultaneous measurements in quantum optics — •Michael Busshardt and Matthias Freyberger — Institut für Quantenphysik, Universität Ulm, 89069 Ulm, Germany

Various possibilities for simultaneous measurements of conjugate variables in the optical domain are investigated. Here, for example, the quadratures of the electromagnetic field do not commute and therefore cannot be precisely measured simultaneously. Possible setups, necessary for measuring such non-commuting observables simultaneously by allowing the system to interact with certain classes of ruler systems, are reviewed and discussed. The question arises, which states of the ruler systems are optimal to gain specific information about the investigated system. This leads to generalized versions of the Heisenberg uncertainty relation.

Q 29.18 Di 16:30 Poster C2

Riemann's Zeta Function in Phase-Space — •Cornelia Feiler, Rüdiger Mack, and Wolfgang P. Schleich — Institut für Qunatenphysik, Universität Ulm

The Riemann hypothesis is at the very heart of number theory. We propse a novel approach where the Riemann Zeta function emerges in a quantum system. For that, we consider states, which provide us with the Riemann Zeta function when we take appropriate scalar products. Moreover, we present the corresponding Wigner and Q-functions and discuss their behaviour in phase space.

Q 29.19 Di 16:30 Poster C2

Nicht-klassische Lichtquellen für die Zweiphotonenabsorption — •Axel Heuer, Benjamin Freyer, Andreas Jechow und Ralf Menzel — Institut für Physik, AG Photonik Universität Potsdam, Am Neuen Palais 10, 14469 Potsdam

Für die Beobachtung der Zweiphotonenabsorption (TPA) von nichtklassischem Licht, wird eine Lichtquelle benötigt, die eine genügend hohe Anzahl an Photonenpaaren mit einem hohen Grad an zeitlicher und räumlicher Korrelation emittiert. Es werden zwei Lichtquellen vorgestellt, die jeweils auf der parametrischen Fluoreszenz (PDC) beruhen.

Die eine Quelle besteht aus einem BBO Kristall, der für die kollineare PDC mit Typ I Phasenanpassung geschnitten ist. Der Kristall wird gepumpt mit der dritten Harmonischen eines modengekoppelten Nd:YVO4-Laser. Bei einer mittleren Pumpleistung von 120 mW konnten Zählraten korrelierter Photonenpaare von über 1010 Photonen/s detektiert werden. Die Photonen erstreckten sich über eine spektrale Bandbreite von über 200 nm. Bei dieser Lichtquelle verteilen sich die korrelierten Photonen jedoch auch über ein Winkelspektrum von mehreren Grad, was eine geeignete Fokussierung für die Zweiphotonenabsorption schwierig macht. Daher wurde eine weitere Lichtquelle realisiert, bei der die beiden korrelierten Photonen sich in einer räumlichen Mode befinden. Dieses lässt sich realisieren, wenn ein periodisch gepolter Kristall mit Wellenleiterstruktur verwendet wird. Es werden Ergebnisse präsentiert, die mit einem 10 mm langen PPLN Kristall erzielt wurden