Q 61: Poster Quanteneffekte

Zeit: Donnerstag 16:30–18:30 Raum: Poster C

Q 61.1 Do 16:30 Poster C

Kohärenter Besetzungstransfer zwischen atomaren Niveaus: Erzeugung und Vermessung von Überlagerungszuständen — •Frank Vewinger[1,2], Manfred Heinz[1], Christian Barthel[1,3], Ulrich Schneider[1,4] und Klaas Bergmann[1] — [1]Fachbereich Physik der Universität, Kaiserslautern — [2]Institut für angewandte Physik, Universität Bonn — [3]Department of Physics, Harvard University, USA — [4]Institut für Physik, Johannes Gutenberg-Universität Mainz

In den letzten Jahren wurden laser-basierte Techniken für die Manipulation von atomaren und molekularen Zuständen in grosser Vielfalt entwickelt. Wir präsentieren Arbeiten zur kontrollierten Erzeugung von Überlagerungszuständen entarteter Niveaus durch Erweiterungen der stimulierten Raman-Streuung mit adiabatischer Passage (STIRAP). Metastabile Neonatome werden durchgeeignete Laserfelder vom Anfangszustand $(2s53p)^3P_0$ in eine Superposition der entarteten Zeemanzustände des Niveaus $(2s53p)^3P_2$ transferiert, wobei sowohl die relativen Phasen der Zustände als auch die Amplitudenverteilung kontrolliert wird[1]. Zusätzlich präsentieren wir ein Verfahren zum "schalten" der relativen Phase einer Superposition mittels der Frequenz der beteiligten Laserfelder[2]. Die experimentelle Charakterisierung der erzeugten Überlagerungszustände geschieht mittels phase-to-population mapping, welches die vollständige Tomographie der erzeugten Superpositionszustände erlaubt [3].

[1] F. Vewinger et al., Phys. Rev. Lett., **91**, 213001 (2003)
[2] M. Heinz et al., Opt. Comm. **264**, 247 (2006)
[3] P. Ivanov et al., Opt. Comm. **264**, 368 (2006)

Q 61.2 Do 16:30 Poster C

Adiabatic frequency conversion of quantum optical information in atomic vapor — •Frank Vewinger[1,2], Eden Figueroa[2], Jürgen Appel[2], and Alexander Lvovsky[2] — [1]Institut für angewandte Physik, Universität Bonn — [2]Institute for Quantum Information Science, University of Calgary, Canada

We experimentally demonstrate a quantum communication protocol that enables frequency conversion and routing of quantum optical information in an adiabatic and thus robust way. The protocol, termed "Raman adiabatic trabsfer of optical states (RATOS)" [1] is based on electromagnetically induced transparency in systems with multiple excited levels: transfer and/or distribution of optical states between different signal modes is implemented by adiabatically changing the control fields. The proof-of-principle experiment is performed using the hyperfine levels of the rubidium D1 line [2].

[1] J. Appel et al., Phys. Rev. A **73**, 013804 (2006)
[2] F. Vewinger et al, quant-ph/0611181 (2006)

Q 61.3 Do 16:30 Poster C

Optimal truncation of Gauss sums for integer factorization — •Martin Štefaňák[1,2], Wolfgang Merkel[2], Wolfgang P. Schleich[2], Daniel Haase[3], and Helmut Maier[3] — [1]Department of Physics, FJFI CTU in Prague, Czech Republic — [2]Institut für Quantenphysik, Universität Ulm, Germany — [3]Institut für Zahlentheorie und Wahrscheinlichkeitstheorie, Universität Ulm, Germany

We analyze truncated Gauss sums in the context of integer factorization. The absolute value of the Gauss sum is a useful tool to discriminate factors from non-factors. Recently, an experimental realization in physical systems demonstrated the ability to factorize numbers with Gauss sums. Experimental limitations directly translate into a truncation of the summation range. However, this constraint results in less contrast between factors and non-factors. We derive an upper bound on the truncation parameter which allows to suppress all non-factors below a threshold value. Moreover, we show that if we tolerate a limited number of errors we can reduce the truncation even further.

Q 61.4 Do 16:30 Poster C

Towards Quantum Optics with Surface Plasmons — •Vasily V. Temnov[1], Yuri Fedutik[1], Marco Allione[1], Oliver Schöps[1], Vitaly Anikeyev[1], Mikhail V. Artemyev[1,2], Jose Dintinger[3], Eloise Devaux[3], Thomas W. Ebbesen[3], and Ulrike Woggon[1] — [1]Experimentelle Physik IIb, Universität Dortmund, Otto-Hahn-Str. 4, 44221 Dortmund, Germany — [2]Institute of Physico-Chemical Problems of Belorussian State University, Leningradskaya Str. 14, 220080 Minsk, Belorussia — [3]Laboratoire des Nanostructures, ISIS, Universite Louis Pasteur, 8 allee Monge, BP 70028, 67083 Strasbourg, France

Excitation and propagation of electromagnetic surface waves (surface plasmons) at optical frequencies in different types of metallic nanostructures, i.e. slit-groove nanostuctures in noble metal films manufactured by a focused ion beam or chemically grown silver nanowires, are investigated by optical spectroscopy. Distinct Fabry-Perot-type periodic modulations in transmission spectra of these nanostructures can be attributed to excitation of surface plasmons and form the eigenmodes in plasmonic nanocavities. Using microphotoluminescence spectroscopy we demonstrate the excitation of plasmonic cavity modes via photoluminescence emission of semiconductor nanocrystals positioned $\sim$20 nm above the metal surface. Picosecond time-resolved photoluminescence measurements demonstrate the increase in SP-mediated spontaneous emission rate (Purcell effect). The possibilities to observe further quantum-optical effects with surface plasmons are discussed.

Q 61.5 Do 16:30 Poster C

Casimir Forces and nano-crafted surfaces — Lodewijk Arntzen, Maarten DeKieviet, Felix Laux, and •Ulrich Warring — Physikalisches Institut der Universität, Philosophenweg 12, D-69120 Heidelberg

In the Heidelberger Atomic Beam Spin Echo (ABSE) spectrometer, we have recently succeeded to detect Quantum Reflection (QR) of ^{3}He atoms from plain and well-characterized surfaces. For semi-conductors, we find that QR takes place at the transition from the van der Waals dominated part of the interaction potential to the Casimir-Polder part. In order to investigate the topological aspects of the Casimir-Polder force, we studied QR from different gratings. Depending on the shape and the orientation of these nano-structures, changes in the reflected intensity and the angular-distribution were observed. Quantitatively, the data are explained by vertical and lateral Casimir-Polder forces.

Q 61.6 Do 16:30 Poster C

Photon correlations in broadband down-converted light — •Benjamin Freyer, Axel Heuer, and Ral Menzel — Institute of Physics, Chair of Photonics, University of Potsdam, Am Neuen Palais 10, D-14469 Potsdam

Parametric down conversion (PDC), is frequently used for the generation of correlated photon pairs in several quantum optic applications like quantum cryptography or quantum imaging. In this process the two photons of the pair are generated via the spontaneous decay of one pump photon. Both photons, signal and idler, are strongly correlated because of conservation of energy and momentum regarding their wavelength and propagation direction. The spectrum of the down-converted light, only limited by the phase matching conditions, could spread over several hundreds of nanometres.

We investigated pulsed PDC in Beta Barium Borat (BBO) crystals. The crystals are cut for type I phase matching. Type I phase matching results in emission cones of the signal and idler photons, which are centred around the propagation direction of the pump photon. The aperture angle of the cone is a function of the wavelength of signal and idler photons as well as of the angle of incidence of the pump photon. We measured the rate of coincidence for different cone angles and wavelengths. In these measurements the pump geometry and crystal length was varied. As a result we get the normalized coincidence rate as a function of the PDC spectrum and of the cone radius.

Q 61.7 Do 16:30 Poster C

Two photon interference of multimode waveguided parametric downconversion. — •Andreas Eckstein and Christine Silberhorn — Max-Planck-Nachwuchsgruppe Integrierte Quantenoptik, Erlangen, Deutschland

A typical bosonic property of light is two-photon bunching, i. e. the probability of two single photons taking the same path at a beam-splitter is higher than can be classically explained. This is known as HOM interference. To generate the required single photons, PDC is typically employed. Surprisingly, by superposition of different spectral modes, the reverse behavior can be induced: The photons are more likely to split up than classically predicted. We present the observation of the interaction of two spatial modes of an optical waveguide used for PDC in a HOM interference experiment leading to two-photon anti-bunching. We develop a theoretical model for this interaction and explore the feasibility of this tool to study the dispersion properties of the waveguide.

Q 61.8 Do 16:30 Poster C

Wignerfunktion zur Beschreibung der Riemann-Zeta-Funktion — •Cornelia Feiler, Rüdiger Mack und Wolfgang P. Schleich — Institut für Quantenphysik, Universität Ulm

Das Wellenpaket mit dem Anfangszustand $|\psi\rangle = \sum_{n=1}^{\infty} \frac{1}{n^\sigma}|n\rangle$ befindet sich in einem Potential mit logarithmisch verteilten Eigenwerten zu den Eigenzuständen $|n\rangle$. Seine Zeitentwicklung wird durch eine der Wignerfunktion ähnliche Darstellung in Winkel- und Wirkungsvariablen beschrieben. Solche Wellenpakete können verwendet werden, um durch Autokorrelationsmessungen die Riemann-Zeta-Funktion zu beschreiben.

Q 61.9 Do 16:30 Poster C

Non-linear processes in pulse propagation through closed-loop systems — •Robert Fleischhaker and Jörg Evers — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, D-69117 Heidelberg, Germany

We discuss laser-driven atomic systems where the applied fields form a closed interaction loop. In general the properties of such closed-loop systems depend on the relative phase of the driving fields, which allows for a convenient manipulation of the optical properties. But on the other hand, these systems only reach a steady state in the long time limit, if the applied fields fulfill the so-called multiphoton resonance condition. If one of the laser fields is a pulsed probe field, then this condition is necessarily violated due to the finite frequency width of the probe pulse. To overcome this, recently the time-dependent properties of a four-level double-lambda type system have been investigated [1]. The time dependent solution to linear order in the probe field coupling has been found with the help of a Floquet decomposition. Using this formalism, here, we analyze non-linear effects in the probe field pulse propagation through closed-loop media. As an additional advantage of the Floquet decomposition, the various Floquet components can be interpreted as individual contributions to the medium response, thus providing insight into the physical origin of the results.

[1] M. Mahmoudi and J. Evers, Phys. Rev. A. in print (quant-ph/0609206)

Q 61.10 Do 16:30 Poster C

An ultracold gas of Rydberg atoms — •Janne Denskat, Christian Giese, Thomas Amthor, Markus Reetz-Lamour, and Matthias Weidemüller — Physikalisches Institut Universität Freiburg, Hermann-Herder-Str.3, 79104 Freiburg

We report on the investigation of different interaction and excitation phenomena in ultracold Rydberg gases. With our setup we confine ^{87}Rb atoms in a magneto-optical trap and excite a part of the atomic cloud into Rydberg levels via a two-photon process (780 nm and 480 nm). We present experimental details and results of the latest works. These include coherent Rabi oscillations between ground and Rydberg state [1] and stimulated rapid adiabatic passage, transferring 90% of the gas into Rydberg states [2], ionization induced by van der Waals forces [3], the understanding of the coherent dynamics of resonant energy transfer processes [4] and the dipole blockade in a mesoscopic gas.

[1] M. Reetz-Lamour *et al.*, submitted
[2] J. Deiglmayr *et al.*, Opt. Comm. 264, 293 (2006)
[3] T. Amthor *et al.*, Phys. Rev. Lett., in press
[4] S. Westermann *et al.*, Eur. Phys. J. D 40, 37 (2006)

Q 61.11 Do 16:30 Poster C

Towards negative refraction in the optical frequency domain — •Peter P. Orth, Jörg Evers, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

Materials with a negative index of refraction have received increasing interest over the last years [1] and a particular aim is to obtain negative refraction in the optical frequency range. As an alternative approach to metamaterials, recently, it was proposed to use dense atomic ensembles with a level structure that allows both for magnetic and electric response at the same frequency, as required for a negative index of refraction [2,3]. These systems nevertheless suffer from difficulties such as requiring extremely high densities and posing strict constraints on the level scheme. Here, we discuss negative refraction in extended atomic level schemes. Our aim is to gain better control over the medium response, and to relax the stringent conditions on the atomic structure.

[1] S. Linden und M. Wegener, Physik Journal **5**, 29 (2006).
[2] M. Ö. Oktel and Ö. E. Müstecapioglu, Phys. Rev. A **70**, 053806 (2004).
[3] Q. Thommen and P. Mandel, Phys. Rev. Lett. **96**, 053601 (2006).

Q 61.12 Do 16:30 Poster C

Geometry-dependence of dipole-dipole interaction — •Sandra Isabelle Schmid and Jörg Evers — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

If atoms are nearby on a length scale given by the involved transition wavelength, the collective dynamics is influenced by the dipole-dipole interaction between the atoms. Recently, it was found that in particular the dipole-dipole coupling of transitions with orthogonal dipole moments, which was neglected in most previous works, can crucially influence the system dynamics [1,2]. Here, we discuss the geometrical properties of this dipole-dipole interaction in atomic ensembles of experimental interest by considering various atom pair setups. We find that especially in lower-dimensional samples the dipole-dipole interaction of transitions with orthogonal dipole moments cannot be neglected.

[1] G. S. Agarwal and A. K. Patnaik, Phys. Rev. A 63, 043805 (2001).
[2] J. Evers, M. Kiffner, M. Macovei and C. H. Keitel, Phys. Rev. A 73, 023804 (2006)

Q 61.13 Do 16:30 Poster C

Stern-Gerlach experiment for slow light — •Leon Karpa[1,2] and Martin Weitz[1,2] — [1]Institut für Angewandte Physik der Universität Bonn, Wegelerstr. 8, 53115 Bonn, Germany — [2]Physikalisches Institut der Universität Tübingen, Auf der Morgenstelle 14, 72076 Tübingen, Germany

Electromagnetically induced transparency allows for light transmission through dense atomic media by means of quantum interference of absorption amplitudes [1]. Media exhibiting electromagnetically induced transparency have interesting properties, such as very slow group velocities [2]. Associated with the slow light propagation are quasiparticles, so-called dark polaritons, which are mixtures of a photonic and an atomic contribution [3]. In contrast to the properties of a free photon, it can be demonstrated that these excitations behave as particles with a nonzero magnetic moment. We report on ongoing experiments in which circularily polarized light passing through a rubidium gas cell under EIT conditions is deflected by a small magnetic field gradient [4]. The deflection angle is proportional to the propagation time of an optical pulse through the cell. The observed beam deflection can be understood by assuming that dark state polaritons have an effective magnetic moment. Our experiment can be described in terms of a Stern-Gerlach experiment for the dark polaritons.

[1] See e.g.: E. Arimondo, Prog. Opt. **35**, 257 (1996)
[2] See e.g.: L. V. Hau et al. Nature (London) **397**, 594 (1999)
[3] M. Fleischhauer and M. D. Lukin, Phys. Rev. Lett. **84**, 5094 (2000)
[4] L. Karpa and M. Weitz, Nature Physics **2**, 332 (2006)

Q 61.14 Do 16:30 Poster C

Laser assisted dynamics of the electron pair in harmonium: photoexcitation, energy absorption, and transparency. — •Oleg Kidun and Dieter Bauer — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

It is known that the dynamics of two (Coulomb-interacting) nonrelativistic electrons confined by a parabolic potential and driven by a classical, intense laser field (in dipole approximation) is exactly soluble. We calculate the time-dependent population of the harmonic oscillator two-electron states and the energy absorbed from the laser. It turns out that the key entity on which all observables sensitively depend is the modulus square of the Fourier-transformed vector potential of the laser field, evaluated at the harmonic oscillator frequency. The system is transparent to laser field configurations for which this entity vanishes. We discuss the Poisson statistics behavior of the transition probabilities and analyze the conditions for the complete survival and full depletion of the initial state.