

Q 21 Poster Quanteneffekte

Zeit: Montag 11:00–12:30

Raum: Poster HU

Q 21.1 Mo 11:00 Poster HU

Hilbert's 17th problem and the quantumness of states — ●JAREK KORBICZ¹, IGNACIO CIRAC², JAN WEHR³, and MACIEJ LEWENSTEIN¹ — ¹Institut fuer Theoretische Physik, Universitaet Hannover, D-30167 Hannover, Germany — ²Max-Planck Institut fuer Quantenoptik, Hans-Kopfermann Str. 1, D-85748, Garching, Germany — ³Department of Mathematics, University of Arizona, 617 N. Santa Rita Ave., Tucson, AZ 85721-0089, USA

We investigate the quantumness of states of a harmonic oscillator according to existence of the positive P -representation. We derive a family of criteria based on Bochner's theorem, that involve averages of specific positive functions. For polynomial functions we relate these criteria to 17-th Hilbert's problem and discuss their physical meaning. These criteria can be interpreted in terms of *nonclassicality witnesses*. We show that every quantum state with smooth characteristic function can be detected by a polynomial that is a sum of squares of other polynomials (sos). We also discuss the hierarchy of states regarding the degree of sos polynomial that detects them. Polynomial nonclassicality witnesses allow direct experimental detection of quantumness.

Q 21.2 Mo 11:00 Poster HU

Coherent Population Transfer via the Ionization Continuum in Helium — ●THORSTEN PETERS¹, LEONID YATSENKO², KLAAS BERGMANN¹, and THOMAS HALFMANN¹ — ¹Fachbereich Physik, TU Kaiserslautern, 67663 Kaiserslautern, Germany — ²Institute of Physics, Ukrainian Academy of Sciences, prospect Nauki 46, Kiev-22, 03650, Ukraine

Coherent population transfer by stimulated Raman adiabatic passage (STIRAP) in a Λ -type level system of purely bound states is a well established technique. It has long been proposed to apply similar coupling schemes also to systems involving continuum states, i.e. to transfer population from a (bound) ground to a (bound) target state via an ionization or dissociation continuum. The effect is closely related to laser-induced continuum structures (LICS), which permit the laser-based manipulation of photofragmentation processes, but do not mediate population transfer via the continuum.

We present first experimental results, which clearly demonstrate coherent transfer of population in a STIRAP-like pulse sequence via the ionization continuum in Helium. The experimental data are compared to numerical simulations, based on a density matrix approach including ab-initio calculated atomic parameters.

Q 21.3 Mo 11:00 Poster HU

Preparation and experimental characterisation of coherent superposition states of two degenerate levels — ●MANFRED HEINZ, FRANK VEWINGER, CHRISTIAN BARTHEL, and KLAAS BERGMANN — FB Physik, TU Kaiserslautern, 67663 Kaiserslautern

We report on the preparation of superposition states of two or more degenerate levels in a $J = 2$ metastable state of Neon. In particular, we demonstrate a method for the measurement of the relative phase between the states. The superposition state can either be prepared between the magnetic sublevels $M = +1$ and $M = -1$ by using the tripod STIRAP scheme [1,2] or between the sublevels $M = 0$ and $M = \pm 2$ by the use of twin STIRAP. The relative phases of all the superposition states can be measured by coherently coupling the levels $^3P_2 \rightarrow ^3P_1$ by a linearly polarized laser, followed by a detection of the population in the $^3P_2(m = \pm 2)$ states as a function of the polarization angle of that laser [3].

[1] H. Theuer et al. *Optics Express*, 4(2):77-83, 1999[2] B. W. Shore et al. *Optics Communications*, 155:144-154, 1998[3] F. Vewinger et al. *Physical Review Letters*, 91(21), 2003

Q 21.4 Mo 11:00 Poster HU

Phase Control by Frequency Control within superposition states of multiple degenerate sublevels — ●MANFRED HEINZ, FRANK VEWINGER, CHRISTIAN BARTHEL und KLAAS BERGMANN — FB Physik, TU Kaiserslautern, 67663 Kaiserslautern

We demonstrate a method for the preparation and manipulation of superposition states of more than two degenerate levels in a robust and efficient way. We also report on the measurement of the relative phase between two levels. The experiments are performed on levels in neon. For the preparation process we use extended Tripod-STIRAP which is a vari-

ant of the well known STIRAP method [1]. The extended tripod system allows the preparation of superposition states of three or five magnetic sublevels depending on the detuning from the two-photon resonance. The relative phase between the $m = -2$ and $m = 0$ state is determined by the relative phase of the Stokes laser fields. It will also be shown that coherent superpositions can be prepared when the laser frequencies are tuned off two-photon resonance. The explicit form of the superposition state then depends on the detuning.

[1] B.W. Shore et al. *Advances of Atomic, Molecular and Optical Physics*, 46:55-190, 2003

Q 21.5 Mo 11:00 Poster HU

Multiphotonen-Quanteninterferenzen in der Wechselwirkung von Atomen mit Licht — ●MARTIN KIFFNER, JÖRG EVERS und CHRISTOPH H. KEITEL — Max-Planck-Institut für Kernphysik, Postfach 10 39 80, 69029 Heidelberg

In der Wechselwirkung von Atomen mit Licht führen Quanteninterferenzen zu einer Fülle von interessanten Effekten, deren Anwendungen in vielen Bereichen der Laserphysik aktuell diskutiert werden.

Wir betrachten atomare Systeme mit wenigen relevanten Niveaus, die durch Ein-oder Mehrphotonenprozesse getrieben werden [1]. Ziel ist es, Eigenschaften dieser Systeme wie z.B. spontane Emission oder das Absorptionsverhalten durch extern induzierte Interferenzeffekte zu manipulieren [2]. Dabei soll versucht werden, die üblichen Bedingungen wie nahezu entartete Übergänge mit nicht-orthogonalen Dipolmomenten zu umgehen, da diese nur schwer in realen Systemen erfüllt werden können.

Mit Hilfe von Multiphoton-Prozessen können außerdem dipol-verbote Übergänge angeregt werden. Dies eröffnet die Möglichkeit, Systeme mit wenigen Niveaus zu einem geschlossenen System zu koppeln, dessen Eigenschaften durch die relative Phase der treibenden Felder gesteuert werden können.

[1] F. H. M. Faisal, *Theory of Multiphoton Processes*, Plenum Press, New York (1987).[2] J. Evers and C. H. Keitel, *Spontaneous-emission suppression via multiphoton quantum interference*, J. Phys. B: At. Mol. Opt. Phys. **37**, 2771 (2004).

Q 21.6 Mo 11:00 Poster HU

Factorization of numbers using chirped pulses — ●WOLFGANG MERKEL¹, HOLGER MACK¹, ERIC LUTZ¹, GERHARD PAULUS², BERTRAND GIRARD³, and WOLFGANG P. SCHLEICH¹ — ¹Abteilung für Quantenphysik, Universität Ulm, D-89069 Ulm — ²Texas A&M University, College Station — ³Universite Paul Sabatier, Toulouse

In this work we present a physical system that combines wavepacket dynamics and number theory. It has been shown that Gauss-sums, which involve quadratic phase factors, may be utilized to obtain the prime factor components of a given number N [1]. As the physical system we choose a two-photon transition which is driven by a chirped laser pulse [2]. In addition to a ground and an excited state the underlying level scheme contains a harmonic manifold of intermediate states. Quantum interference of multiple excitation paths is the key mechanism of this factorization scheme. We show how quadratic phase factors enter and present a recipe to encode the number N and reveal its prime components.

[1] H. Mack, M. Bienert, F. Haug, M. Freyberger, and W.P. Schleich, *phys. stat. sol. (b)* **233**, No. 3, 408-415 (2002)[2] B. Chatel, J. Degert, S. Stock, and B. Girard, *Phys. Rev. A* **68**, 041402(R) (2003)

Q 21.7 Mo 11:00 Poster HU

Correlations in S-Waves — ●RÜDIGER MACK, ALEXANDER WOLF, KARL VOGEL, and WOLFGANG P. SCHLEICH — Abteilung für Quantenphysik, Universität Ulm, Germany

An s-state consists mainly of interference. Wigner functions express the interference nature of quantum mechanics in negative domains of phase space. These domains strongly depend on the number of dimensions and manifest themselves in the time evolution of the average separation $\langle r \rangle$ of the s-wave from the origin. Especially in $D = 2$ dimensions the wave first contracts and then expands. We investigate different initial s-waves in order to enlarge this contraction effect. Moreover we address the question of the existence of an optimum wave function.

Q 21.8 Mo 11:00 Poster HU

Entanglement of formation and negative domains of Wigner functions — ●ALEXANDER WOLF¹, JENS PEDER DAHL², and WOLFGANG P. SCHLEICH¹ — ¹Abteilung für Quantenphysik, Universität Ulm, Albert-Einstein Allee 11, D-89069 Ulm, Germany — ²Chemical Physics, Department of Chemistry, Technical University of Denmark, DTU 207, DK-2800 Kgs. Lyngby, Denmark

We analyze entanglement of formation and negative domains of Wigner functions in their dependence on the number of dimensions. Here, we focus on *s*-waves, that is, wave functions that only depend on a hyperradius.

Q 21.9 Mo 11:00 Poster HU

Storing and Manipulating Light and Atoms Using Tapered Optical Fibers — ●FLORIAN WARKEN¹, VICTOR BALYKIN², DIETMAR HAUBRICH¹, YANN LOUYER¹, DIETER MESCHÉDE¹, and ARNO RAUSCHENBEUTEL¹ — ¹Institut für Angewandte Physik, Universität Bonn, Wegelerstr. 8, 53115 Bonn — ²Institute for Spectroscopy, Troitsk, Moscow reg., 142190, Russia

Tapered optical fibers (TOFs) offer interesting perspectives for controlling and confining light fields. We seek to tailor these properties through microstructuring in order to realize high Q whispering gallery mode resonators for cavity quantum electrodynamic experiments. Furthermore, we aim use the evanescent fields around optical wavelength sized TOFs in order to capture, store, and detect cold atoms. First experimental results as well as future perspectives of our project will be presented.

Financial support by the DFG research unit 557 is gratefully acknowledged.

Q 21.10 Mo 11:00 Poster HU

Hamiltonian Ratchets using Optical Lattices — ●SARAH SCHRÖDER¹, ERIC LUTZ¹, FERRUCCIO RENZONI², and WOLFGANG P. SCHLEICH¹ — ¹Abteilung für Quantenphysik, Universität Ulm, Germany — ²Department of Physics and Astronomy, University College London, United Kingdom

Thermal ratchets show a directed current due to rectification of noise. In some systems chaotic dynamics can mimic the effects of thermal fluctuations. Here we investigate the experimental realisation of a chaotic Hamiltonian ratchet in a two-dimensional optical lattice and analyse the mechanism leading to a directed current in this deterministic system.

Q 21.11 Mo 11:00 Poster HU

Tunneling of single atoms in a double well potential — ●ELISABETH KIERIG, RALF STÜTZLE, THOMAS HÖRNER, and MARKUS K. OBERTHALER — Kirchhoff-Institut für Physik, Universität Heidelberg, Im Neuenheimer Feld 227, 69120 Heidelberg

One of the most intriguing phenomena in quantum mechanics is tunneling in a double well potential. Some time ago it was discovered that coherent driving of a bistable potential allows to suppress tunneling completely [1].

In our experimental setup we add the light shift potentials of two standing light waves with periodicity λ and $\lambda/2$ to create a periodic array of double well potentials. The coherent population of the double wells is achieved by a very well collimated metastable argon beam impinging perpendicularly onto the standing light waves. This allows to study the dynamics of a single atom in one double well by analyzing the diffraction pattern in the far field. The driving is realized in a straight forward manner by changing the relative phase between the two standing light waves.

The use of an additional standing light wave resonant with the open transition of metastable argon allows the preparation of a matter wave that is localized periodically only on one side of the double wells. This is an ideal initial condition for the observation of tunneling and suppression of tunneling.

[1] F. Grossmann, T. Dittrich, P. Jung, and P. Hänggi, Phys. Rev. Lett. **67**, 516 (1991)

Q 21.12 Mo 11:00 Poster HU

High-precision measurement of atomic lifetimes and Cavity-QED with single trapped Ca⁺-Ions — ●CARLOS RUSSO¹, CHRISTOPH BECHER¹, AXEL KREUTER¹, GAVIN LANCASTER¹, ANDREAS MUNDT¹, HARTMUT HÄFFNER¹, CHRISTIAN ROOS¹, WOLFGANG HÄNSEL¹, FERDINAND SCHMIDT-KALER^{1,2}, and RAINER BLATT^{1,3} — ¹Institut für Experimentalphysik, Universität Innsbruck, Technikerstraße 25, A-6020 Innsbruck, Austria — ²Abteilung Quanten-Informationsverarbeitung, Albert Einstein Allee 11, Universität Ulm, D-89069 Ulm — ³Institut für Quantenoptik und Quanteninformation, Österreichische Akademie der Wissenschaften, Technikerstraße 25, A-6020 Innsbruck, Austria

We report on measurements of the lifetimes of the 3d ²D_{5/2} and 3d ²D_{3/2} metastable states of a single laser-cooled ⁴⁰Ca⁺ ion in a linear Paul trap. We introduce a new measurement technique based on high-efficiency quantum state detection after coherent excitation to the D_{5/2} state or incoherent shelving in the D_{3/2} state, and subsequent free, unperturbed spontaneous decay. The result for the natural lifetime of the D_{5/2} state of 1168(9) ms agrees excellently with the most precise published value. The lifetime of the D_{3/2} state is measured with a single ion for the first time and yields 1176(11) ms which improves the statistical uncertainty of previous results by a factor of four.

Coupling of the single Ca⁺ ion to a high finesse optical cavity allows for the realization of cavity-QED experiments towards the deterministic generation of single photons. We will report on the status of these experiments.