Q 42: Quantum Effects

Time: Thursday 11:00–13:00 Location: P 4

Q 42.1 Thu 11:00 P 4

Probing the measurement process in DTQW via recurrence — •Thomas Nitsche[1], Regina Kruse[1], Linda Sansoni[1], Martin Štefaňák[2], Tamás Kiss[3], Igor Jex[2], Sonja Barkhofen[1], and Christine Silberhorn[1] — [1]Applied Physics, University of Paderborn, Germany — [2]Department of Physics, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague, Czech Republic — [3]Institute for Solid State Physics and Optics, Wigner Research Centre for Physics, Hungarian Academy of Sciences, Hungary

The measurement process plays a crucial role in quantum mechanics as it interrupts the unitary evolution of a state. The consequences are apparent when investigating the return probability (Polya-number) of a particle in a Hadamard walk on the line [1, 2]: Depending on whether the evolution is restarted or continued after the measurement, either a transient or a recurrent evolution can be observed. We investigate both cases experimentally for the first time by introducing sinks in a time-multiplexed quantum walk setup using a fast-switching electro-optic modulator (EOM). Monitoring the evolution of the walker over 39 steps reveals the fundamental differences of the two cases as predicted by theory: In the restart-regime, the Polya-number will gradually approach unity. In contrast, the continue-regime yields an asymptotic value of the Polya-number of $2/\pi$, which is reached in good approximation after only four steps and then remains almost constant.

[1] M. Štefaňák, I. Jex, and T. Kiss, PhysRevLett **100**, 020501 (2008)
[2] F. A. Grünbaum, L. Velázquez, A. H. Werner, and R. F. Werner, Commun. Math. Phys. **320**, 543 (2013)

Q 42.2 Thu 11:15 P 4

A light-atom interface based on a high numerical aperture lens — •Matthias Steiner[1,2], Yue-Sum Chin[1], and Christian Kurtsiefer[1,2] — [1]Centre for Quantum Technologies, National University of Singapore, 3 Science Drive 2, Singapore 117543 — [2]Department of Physics, National University of Singapore, 2 Science Drive 3, Singapore 117542

Quantum interfaces between atoms and photons require engineering of the coupling. Usually, this is accomplished with optical resonators. Tightly focused free-space modes are a complementary tool for interaction engineering.

We present a light-atom interface consisting of a single Rubidium atom trapped at the focus of a high numerical aperture lens, NA=0.75. A coherent light beam probes the near-resonant interaction with the atom and we characterize the coupling strength by a reflection and a transmission measurement. We investigate the temperature dependence of the interaction in order to understand whether the residual positional spread of the atom limits the interaction strength. The resonance frequency shifts and interaction strength with the external field decreases when the atom is heated by the recoil of the scattered photons. Comparing to a simple model, we conclude that the initial temperature reduces the interaction strength by less than 10% [1].

[1] Y.-S. Chin, M. Steiner, C. Kurtsiefer, arXiv:1611.08048

Q 42.3 Thu 11:30 P 4

Genuine Quantum Signatures in Synchronization of Anharmonic Self-Oscillators — Niels Loerch[1], •Ehud Amitai[1], Andreas Nunnenkamp[2], and Christoph Bruder[1] — [1]Department of Physics, University of Basel, Basel, Switzerland — [2]Cavendish Laboratory, University of Cambridge, Cambridge, United Kingdom

We study the synchronization of a Van der Pol self-oscillator with Kerr anharmonicity to an external drive. We demonstrate that the anharmonic, discrete energy spectrum of the quantum oscillator leads to multiple resonances in both phase locking and frequency entrainment not present in the corresponding classical system. Strong driving close to these resonances leads to nonclassical steady-state Wigner distributions. Experimental realizations of these genuine quantum signatures can be implemented with trapped ions or optomechanical systems.

Q 42.4 Thu 11:45 P 4

Non-Markovianity and the physics of memory — •Nina Megier[1], Dariusz Chruściński[2], Jyrki Piilo[3], and Walter T. Strunz[1] — [1]TU Dresden — [2]Nicolaus Copernicus University in Toruń — [3]University of Turku

In our work we analyse a family of qubit CPT maps, characterized by a point within a parameter triangle. The corresponding generator of the dynamics may contain exactly one negative decoherence rate. Based on the concept of CP-divisibility such evolution is classified as non-Markovian. Nonetheless, the dynamical map can be written as a random unitary evolution or a convex combination of Markovian semigroups. Remarkably, we find a realisation based on a classical Markov process, where the probabilities are governed by a classical Pauli master equation. Such a classical Markov representation exists also for a non-P-divisible dynamics of an extended two qubit system. In both cases a description with a bipartite GKSL equation, where the ancilla state is frozen, is possible, too. These realisations show that actually there is no room for physical memory effects. Therefore, both non-CP-divisibility, but also the weaker non-P-divisibility, are sometimes questionable indicators for non-Markovianity. A reduced description may not suffice to study the physics of memory and information flow.

Q 42.5 Thu 12:00 P 4

Dopplerfreie drei-Photonen Kohärenz in Quecksilberdampf — •Benjamin Rein, Jochen Schmitt und Thomas Walther — TU Darmstadt, Institut für Angewandte Physik, AG Laser und Quantenoptik, Schlossgartenstr. 7, D-64289 Darmstadt

Lasing without inversion (LWI) ist eine auf kohärenter Anregung basierende Technik, die es prinzipiell ermöglicht, Laserstrahlung bis in den tiefen VUV-Bereich zu erzeugen. Bisherige LWI-Experimente wurden in atomaren drei-Niveau Systemen durchgeführt, in denen der LWI-Effekt durch die Dopplerverbreiterung im Medium „auswischt“, wenn der Wellenlängenunterschied zwischen Kopplungslaser und LWI-Laserübergang mehr als einige Nanometer beträgt.

Quecksilber bietet ein vier-Niveau System, in dem es möglich ist, die Dopplerverbreiterung durch eine geschickte geometrische Anordnung der Laserstrahlen zu kompensieren und somit das Potential bietet, erstmals LWI im UV-Bereich bei 253,7 nm zu realisieren. Die kohärente Anregung erfolgt bei Wellenlängen von 435,8 nm und 546,1 nm.

Es werden Messungen der dopplerfreien drei-Photonen Resonanz vorgestellt, sowie erste Messungen in einer *amplification without inversion* Konfiguration. Ein detailliertes theoretisches Modell zeigt, dass das Gesamtsystem das Potential für erste LWI-Messungen im UV-Bereich besitzt.

Q 42.6 Thu 12:15 P 4

Intrinsic quantum chaos in the complex atomic system of protactinium — •Pascal Naubereit[1], Victor Flambaum[2,3], Dominik Studer[1], Anna Viatkina[2], and Klaus Wendt[1] — [1]Institute of Physics, Johannes Gutenberg University, 55128 Mainz, Germany — [2]Helmholtz Institute Mainz, 55128 Mainz, Germany — [3]School of Physics, University of New South Wales, Sydney 2052, Australia

Quantum chaos, initially experienced in scattering resonances of nuclei, today is a widely discussed phenomenon observed in various complex quantum systems. In this talk we discuss the occurrence and experimental investigation of intrinsic quantum chaos within the highly complex atomic system of protactinium, as expressed in the arrangement of levels. The resulting repulsion of individual states can be traced back to chaotic mixing of a very large number of single electron states, which arise from the five easily excitable electrons within up to four different open valence shells. In order to analyze a reasonable fraction of energy levels of given parity and angular momentum, the highly complex spectrum of the protactinium atom was probed experimentally in different ranges of excitation energy by using multi-step laser resonance ionization spectroscopy. Together with the available literature data we can reproduce a complete overview of excited states of the protactinium atom from ground state up to energies above the first ionization potential. By investigation of the most pronounced indicator, the repulsion of states, we derive how intrinsic quantum chaos in this system evolves with energy and emphasize its significance already at moderate excitation energy.

Q 42.7 Thu 12:30 P 4

Localization and Multifractality in Disordered Long-Range Hopping Models — •Xiaolong Deng[1], Vladimir Kravtsov[2], Georgy Shlyapnikov[3], and Luis Santos[1] — [1]ITP, Leibniz Universität Hannover, Germany — [2]ICTP, Trieste, Italy — [3]LPTMS, Orsay, France

We study disordered single-particle lattice model with long-range hops. We prove that all of eigenstates are localized in one- and two-dimensional isotropic systems. In three dimensional systems we show the mobility edge separating delocalized and localized states.

Q 42.8 Thu 12:45 P 4

Nuclear motion is classical — •Irmgard Frank — Theoretische Chemie, Universität Hannover

The Born-Oppenheimer approximation suffers from strong and not fully understood drawbacks. One might believe, that ninety years after its invention one could omit it and compute ionic and electronic motion together having big computers. However, as the Schrödinger equation has similarities with the diffusion equation, the resulting nuclear wavefunction diffuses. The resulting potential for the electrons allows them to further diffuse again, etc., the result being a homogeneous gas of electrons and nuclei. We show that this can be avoided in a very simple way by describing the nuclei right from the beginning as classical point particles which obey the Newton equations. This approximation works well for the region of normal energies and is superior to a quantum chemical description of the nuclei.