A 45: Kalte Atome

Time: Friday 10:30–12:30 Location: V7.02

Group Report A 45.1 Fri 10:30 V7.02

Linear-zigzag transition in a quantum potential — •Cecilia Cormick and Giovanna Morigi — Theoretische Physik, Universität des Saarlandes, D-66041, Saarbrücken, Deutschland

We study the dynamics of a chain of ultracold ions in a pumped standing-wave optical resonator, in the regime in which a dipolar transition of the ions couples with a cavity mode. In this scenario the ions' motion is determined by the trapping potential, the Coulomb repulsion, and the quantum potential of the cavity field. In particular, we focus on the case when the chain is close to the linear-zigzag structural transition. We first consider the limit in which the cavity field represents a negligible perturbation to the motion of the ions, and study how to obtain information about the structure and dynamics of the ion chain by measuring the intensity and spectrum of the light at the cavity output. We then analyze the behaviour when the back-action of the cavity field on the ions' dynamics relevantly affects the state of the crystal and show that hysteresis may appear where in free space one expects a continuous transition.

A 45.2 Fri 11:00 V7.02

Production of Antihydrogen via Double Charge Exchange — •Andreas Müllers[1], Daniel Fitzakerley[2], Robert McConnell[3], Jochen Walz[1], Eric Hessels[2], and Gerald Gabrielse[3] — [1]Johannes Gutenberg-Universität und Helmholtz Institut Mainz — [2]York University, Toronto, Kanada — [3]Harvard University, Cambridge (MA), USA

For the ATRAP collaboration

Spectroscopy of the $1S-2S$ transition of trapped antihydrogen and comparison with the equivalent line in hydrogen will provide an accurate test of CPT symmetry. However, the established method of producing antihydrogen creates them with an average temperature much higher than the typical trap-depth of a neutral atom trap. So far, only very few antihydrogen-atoms could be confined at a time.

Therefore the ATRAP collaboration developed a different method that has the potential of producing much larger numbers of cold antihydrogen atoms, the double charge exchange: Positrons and antiprotons are stored and cooled in the same Penning trap. Laser-excited cesium atoms collide with the positrons, forming Rydberg-Positronium, a bound state of an electron and a positron. The Positronium atoms are no longer confined by the electric potentials of the Penning trap and some will drift into the neighbouring cloud of antiprotons where, in a second charge exchange collision, they form antihydrogen.

ATRAP demonstrated this method in 2004. With a newly developed Penning trap and a custom laser system we now achieved a large increase in particle numbers and efficiency.

A 45.3 Fri 11:15 V7.02

Confinement induced resonance for a driven ultracold atom gas — •Maryam Roghani and Michael Thorwart — I. Institut für Theoretische Physik, Universität Hamburg, Germany

We solve the two-particle s-wave scattering for ultracold atom gases confined in quasi-one-dimensional trapping potential which is periodically driven. The interaction between the atoms is represented in term of the Fermi pseudopotential. For an isotropic harmonic oscillator the decoupling of center of mass and relative degrees of freedom is feasible. We use the Floquet approach to show that new resonance channels open due to the harmonic modulation. Applying the Bethe-Peierls boundary condition, we obtain the general scattering solution. The binding energies and the one dimensional scattering length for this driven system are studied.

A 45.4 Fri 11:30 V7.02

Continuous Coupling of Ultracold Atoms to Ionic Plasma via Rydberg Excitation — •Torsten Manthey, Tobias Massimo Weber, Thomas Niederprüm, Philipp Langer, Vera Guarrera, Giovanni Barontini, and Herwig Ott — Research Center Optimas, Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany

We characterize the two-photon excitation of an ultracold gas of Rubidium atoms to Rydberg states analysing the induced atomic losses from an optical dipole trap. Extending the duration of the Rydberg excitation to several ms, the ground state atoms are continuously coupled to the formed positively charged plasma. In this regime we measure the n-dependence of the blockade effect and we characterise the interaction of the excited states and the ground state with the plasma.

A 45.5 Fri 11:45 V7.02

Accelerated split-operator method for GPU simulations of 3D atomic dynamics — •Lee J. O' Riordan[1,3], Neil Crowley[1], Tadhg Morgan[1], Thomas Fernholz[2], Peter Krüger[2], and Thomas Busch[1,3] — [1]Department of Physics, University College Cork, Ireland — [2]School of Physics & Astronomy, University of Nottingham, UK — [3]Quantum Systems Unit, OIST, Okinawa, Japan

Precise control over the external degrees of freedom of cold atomic systems for applications in quantum technologies often requires a fully three dimensional description. For numerical simulations this usually means large grids leading to long processing times, making highly scalable parallel approaches essential for obtaining results within useful timescales. We present a study into two sets of codes developed for the purpose of simulating the adiabatic dynamics of a single atom on a multi-waveguide atom chip. The first is a CPU approach utilising MPI and FFTW, and the second is a modern GPU-based approach. We find that the GPU approach offers a potential reduction in calculation time of up to an order of magnitude, making detailed simulations of even large structures realistic. The example we are investigating aims to show Coherent Tunneling Adiabatic Passage (CTAP) in a system of waveguides on an atom chip. Due to the absence of Rabi oscillations in this process, very large transfer fidelities can be achieved. All results we present closely mirror experimentally realistic systems and we present strategies we have developed to combat currently existing problems with other experimental approaches in order to fulfil the conditions to observe CTAP.

A 45.6 Fri 12:00 V7.02

Ultracold atoms in a disordered quantum potential — •Hessam Habibian[1,2], Simone Paganelli[1], and Giovanna Morigi[1,2] — [1]Universitat Autónoma de Barcelona, Spain — [2]Universität des Saarlandes, Germany

Self-organization of matter has been reported in experiments confining atomic gases in high-Q cavities [1]. When the atoms scatter laser photons into the cavity mode, they can form periodic patterns that maximize elastic scattering into the cavity [2]. It was predicted that the quantum ground state of these patterns can exhibit the properties of a Mott-Insulator state [3]. Here, we consider the case in which the atoms are confined along the cavity axis by classical fields and scatter laser photons into a cavity mode but, contrarily with previous works, we assume that the lattice periodicity and the phase of the scattered field are *incommensurate*. The model thus exhibits disorder whose features depend on the atomic density and on the pump laser intensity. We identify the regimes where the ground state is either incompressible or compressible. In the latter case we study when the atomic phase is a Bose glass and when it is a superfluid.

[1] A. Black, et al., Phys. Rev. Lett. 91, 203001 (2003); K. Baumann, et al., Nature 464, 1301 (2010).
[2] P. Domokos, H. Ritsch, Phys. Rev. Lett. 89, 253003 (2002).
[3] S. Fernandez-Vidal, et al., Phys. Rev. A 81, 043407 (2010).

A 45.7 Fri 12:15 V7.02

A self-optimizing experimental apparatus — •Ilka Geisel[1], Stefan Jöllenbeck[1], Jan Mahnke[1], Kai Cordes[2], Wolfgang Ertmer[1], and Carsten Klempt[1] — [1]Institut für Quantenoptik, Leibniz Universität Hannover — [2]Institut für Informationsverabeitung, Leibniz Universität Hannover

Even though most parameters in a typical cold atom experimental setup are controlled by one computer program, optimization is still usually done by hand. One has to find the correlations between unknown parameters in the experiment in order to reach the optimum. Systematically scanning the whole parameter space will quickly become impossible as one goes to higher dimensions.

The logical step is to use an automated optimization procedure. The demands on such a program include finding the global optimum and being robust against experimental noise while reaching a sensible solution within a small number of experimental cycles. We present a genetic algorithm based on Differential Evolution, which quickly finds the optimum even with strong experimental noise. Relying only on basic mathematics it requires little computing power and is easy to implement.

Using the algorithm we improved our magneto-optical trap in a nine dimensional partly correlated parameter space by over 20%. A simulation allows for studying the behavior of the algorithm under different noise levels and parameters and thus reaching the optimal configuration for optimizing a wide range of experimental tasks.