A 8: Ultra-cold atoms, ions and BEC (joint session A/Q)

Time: Monday 16:15–17:45 Location: S HS 1 Physik

A 8.1 Mon 16:15 S HS 1 Physik

Rydberg Excitation of Ultracold Atoms Interacting with Trapped Ions — •Norman V. Ewald, Thomas Feldker, Henrik Hirzler, Matteo Mazzanti, Henning A. Fürst, and Rene Gerritsma — Universiteit van Amsterdam, Amsterdam, Netherlands

We report on the observation of interactions between ultracold Rydberg atoms and ions in a Paul trap [1]. The observed inelastic collisions, manifested in charge transfer between the Rydberg atoms and ions, exceed Langevin collisions for ground state atoms by almost three orders of magnitude in rate. This indicates a huge increase in interaction strength. The ion loss spectrum exhibits a long tail on the red side of the Rydberg resonance which we attribute to the electric field of a single ion. We study the effect of the bare Paul trap's electric fields on the Rydberg excitation spectra. Furthermore, we demonstrate Rydberg excitation on a dipole-forbidden transition with the aid of the electric field of a single trapped ion. Our results demonstrate the possibility of tuning interactions between ultracold atoms and ions by laser coupling to Rydberg states. These techniques may allow to create spin-spin interactions between atoms and ions [2] and to overcome recently observed heating due to ionic micromotion in atom-ion hybrids [3,4].

[1] N. V. Ewald, T. Feldker, H. Hirzler, H. Fürst, and R. Gerritsma, *arXiv*:1809.03987 (2018). [2] T. Secker, R. Gerritsma, A. W. Glätzle, and A. Negretti, *Phys. Rev. A* **94**, 013420 (2016). [3] T. Secker et al., *Phys. Rev. Lett.* **118**, 263201 (2017). [4] Z. Meir et al., *Phys. Rev. Lett.* **117**, 243401 (2016).

A 8.2 Mon 16:30 S HS 1 Physik

Rydberg blockade induced by a single ion — •Thomas Dieterle, Felix Engel, Marian Rockenhäuser, Christian Hölzl, Sophia Ten Huisen, Robert Löw, Tilman Pfau, and Florian Meinert — 5. Physikalisches Institut and Center for Integrated Quantum Science and Technology IQST, Universität Stuttgart

Ultracold Rydberg atoms with their strong mutual interactions provide an interesting platform for e.g. quantum simulation or quantum information exploiting the so-called Rydberg blockade. A similar concept applies to hybrid systems of Rydberg atoms and ions leading to single charge-induced blockade phenomena over macroscopic distances.

We demonstrate the excitation blockade of a single Rydberg atom by a single low-energy ion. The ion is produced from a single Rydberg excitation in an ultracold sample exploiting a novel optical two-photon ionization scheme, especially suited for the creation of very low-energy ions. We precisely control the ion's motion by applying small electric fields to analyze the blockade mechanism for a range of principal quantum numbers. Finally, we demonstrate the applicability of the ion as a high-sensitivity single-atom based electric field sensor.

Our method may in the future be used for controlling cold collisions, chemistry or charge mobilities in ion-atom mixtures.

A 8.3 Mon 16:45 S HS 1 Physik

Rydberg spectroscopy in an atom-ion hybrid trap — •Shinsuke Haze[1], Joschka Wolf[1], Markus Deiss[1], Limei Wang[1], Georg Raithel[2], Christian Fey[3], Frederic Hummel[3], Florian Meinert[4], Peter Schmelcher[3], and Johannes Hecker Denschlag[1] — [1]Institut für Quantenmaterie, Universität Ulm, 89069 Ulm, Germany — [2]Department of Physics, University of Michigan, Ann Arbor, MI 48109, USA — [3]Zentrum für Optische Quantentechnologien, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany — [4]Physikalisches Institut and Center for Integrated Quantum Science and Technology, Universität Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany

Hybrid atom-ion trap has been a key technology for intriguing applications such as cold chemistry, molecular physics and so on. The good controllability of ion's and atomic states provides an opportunity for studying atom-ion interaction in an unprecedented regime. Here, we demonstrate Rydberg spectroscopy of rubidium atoms within an atom-ion hybrid trap, where an optical dipole trap and a Paul trap are combined for simultaneous trapping of neutral and charged particles. This versatility enables for capturing an ionized product following an optical excitation to Rydberg states. The trapped ions elastically collide with the rubidium atoms leading to an atom loss, which gives rise to a high sensitivity of observing the underlying Rydberg excitation. In this presentation, we show results for spectroscopy of Rydberg states, where we measured avoided level crossings. We will discuss our data by comparing with the calculated Stark map of Rydberg states.

A 8.4 Mon 17:00 S HS 1 Physik

Quench dynamics of Rydberg dressed atoms in two-dimensional optical lattices — •Yijia Zhou[1] and Weibin Li[1,2] — [1]School of Physics and Astronomy, University of Nottingham, University Park, Nottingham, NG7 2RD, UK — [2]Centre for the Theoretical Physics and Mathematics of Quantum Non-equilibrium Systems, The University of Nottingham, Nottingham, NG7 2RD, UK

Recent experiments have demonstrated that long-range interactions can be induced by laser dressing ground state atoms to electronically excited Rydberg states. When trapped in optical lattices, this permits us to realize extended Bose-Hubbard models with tunable interactions. In this work, we study quench dynamics of the dressed atoms in a two-dimensional optical lattice. Here, by decreasing the lattice potential height, the tunneling rate increases from a Mott insulator to supersolid and then superfluid phases. Using a Gutzwiller approach, we find a sudden birth of superfluid order parameters after Mott-supersolid phase boundary. However, superfluid order parameter does not increase monotonically due to the supersolid phase as an intermediate state, which is largely affected by long-range interactions. The details of the exotic dynamics can be observed by, e.g., time-of-flight experiments. Our study paves a route to exploring non-equilibrium many-body physics with Rydberg dressed atoms in lattice systems.

A 8.5 Mon 17:15 S HS 1 Physik

State Selective Field Ionization in Asymmetric Geometries — •Alexander Müller[1], Titus Franz[1], Sebastian Geier[1], Andre Salzinger[1], Annika Tebben[1], Clément Hainaut[1], Nithiwadee Thaicharoen[1], Gerhard Zürn[1], and Matthias Weidemüller[1,2] — [1]Physikalisches Institut, University Heidelberg, 69120 Heidelberg, Germany — [2]Shanghai Branch, University of Science and Technology of China, Shanghai 201315, China

Precise control of field ionization ramps enables time resolved detection of different Rydberg states, making the method state selective. In our Experiment the ion detector is tilted and off-centered from the axis of the field electrodes to increase optical accessibility, but in cost of simple ion trajectories.

This talk will present our implementation of electric potentials to ionize the Rydberg states selectively and at the same time guide the ions to the detector. Limitations of the method in terms of suitable states and local Rydberg densities will be discussed.

A 8.6 Mon 17:30 S HS 1 Physik

Investigation of Förster resonant energy transfer between polar molecules and Rydberg atoms — •Martin Zeppenfeld and Ferdinand Jarisch — MPI für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching

A quantum hybrid system composed of polar molecules and Rydberg atoms provides wideranging opportunities for future experiments, ranging from control and readout of molecular states to quantum information processing. As a first step, we have investigated Förster resonant energy transfer between molecules and Rydberg atoms at room temperature [1]. This includes a detailed analysis of Rydberg states involved in the molecule-Rydberg-atom interactions via mm-wave state transfer and investigation of electric field dependent collisions. We will also discuss progress on the next-generation experiment involving cold molecules and ultracold atoms.

[1] F. Jarisch *et al.*, New J. Phys. **20**, 113044 (2018).