Q 28: Poster – Ultra-cold Plasmas and Rydberg Systems (joint session A/Q)

Time: Tuesday 14:00–16:00 Location: Tent

Q 28.1 Tue 14:00 Tent

Study of Rydberg states in ultra cold ytterbium — •Alexander Miethke, Nele Koch, and Axel Görlitz — Institut für Experimentalphysik, Heinrich-Heine-Universität, Düsseldorf, Deutschland

In recent years Rydberg atoms with their special features, like dipole-dipole interaction or van-der-Waals blockade, have become more and more important for quantum optics. Particularly ultra cold Rydberg atoms are of great interest for the investigation of long range interaction.

A special feature of ytterbium is that due to its two valance electrons atoms in Rydberg states can be easily manipulated and imaged using optical fields. A first step towards studies of ultra cold ytterbium is to gain precise knowledge on the Rydberg states.

Here we present the study of the Rydberg states of ultra cold ytterbium. Using a Micro-Channel-Plate to detect the Rydberg atoms it is possible to measure lifetimes and hyperfine structures of several states (n=35-90). In addition we could measure the energy and polarizability of s, p and d states in the region of high principal quantum numbers n (n=70-90). Using a second stage trap we are able to cool the atoms down to several *K to reduce their distances and investigate interactions.

Q 28.2 Tue 14:00 Tent

Avalanche events and universality crossover on a dynamical network in a driven, dissipative Rydberg gas — •Simon Ohler, Daniel Brady, and Michael Fleischhauer — RPTU Kaiserslautern-Landau, Germany

In an off-resonantly laser-driven gas of Rydberg atoms, it is known that there exists an absorbing-state phase transition. In the spreading phase the gas is saturated with Rydberg excitations, whereas in the absorbing phase Rydberg excitations stay isolated. At the critical point separating the two, which is the attractor of the dynamics via the self-organized criticality (SOC) mechanism, one can observe scale-free avalanche events where a single Rydberg seed excitations leads to a cascade effect. We numerically investigate the response of a critical gas of atoms under such a minimal perturbation and observe a scale-free avalanche-response irrespective of the thermal motion of the gas. Determining the exponents of power-law avalanche distributions we confirm that the universality class of the associated absorbing-state phase transition changes as a function of temperature. Additionally, we consider the emerging network structure that determines the dynamics and quantify the degree to which this excitation graph is dynamical.

Q 28.3 Tue 14:00 Tent

Continuous observation of non-equilibrium phase transitions in facilitated Rydberg avalanches — •Patrick Mischke, Fabian Isler, Jana Bender, Thomas Niederprüm, and Herwig Ott — Department of Physics and research center OPTIMAS, RPTU Kaiserslautern-Landau

We investigate the facilitation dynamics in a Rydberg system and the phase transition resulting from the interplay between driving strength and excitation decay.

In an off-resonantly driven cloud of atoms, the strong dipole-dipole interactions between two Rydberg states compensates the laser detuning for a specific interatomic distance. For high enough driving strength, this results in a spreading of correlated excitations. We investigate the non-equilibrium steady state phase transition between this active phase and the absorbing phase in which the spread of excitations is suppressed.

Non-destructive phase-contrast imaging is employed to continuously monitor the ground state density of our sample. Time resolved ion detection enables the characterization of excitation avalanches around the critical point of the phase transition. We use this information to extract the relevant universal exponents.

Q 28.4 Tue 14:00 Tent

High precision spectroscopy of trilobite Rydberg molecular series — •Markus Exner[1], Richard Blättner[1], Rohan Srikumar[2], Matt Eiles[3], Peter Schmelcher[2], and Herwig Ott[1] — [1]RPTU, Kaiserslautern — [2]Zentrum für Optische Quantentechnologie, Hamburg — [3]Max Planck Institute for the Physics of Complex Systems, Dresden

Trilobite Rydberg molecules consist of a highly excited Rydberg atom and a perturber atom in the electronic ground state. The underlying binding mechanism is based on the scattering interaction between the Rydberg electron and the perturber. These molecules exhibit extreme properties: their dipole moments are in the kilo-Debye range, and their molecular lifetimes may exceed the lifetimes of the close by atomic Rydberg states. We use three-photon photoassociation and a reaction microscope to perform momentum-resolved spectroscopy on trilobite ^{87}Rb Rydberg molecules for principal quantum numbers n=22,24,25,26,27. The large binding energies and the high spectroscopic resolution of 10^{-4} allow us to benchmark theoretical models. Previous models relied on exact diagonalization, which suffered from basis-dependent convergence problems. Using a recent basis-independent theoretical method based on Green*s functions, which accounts for all relevant spin interactions, we fit the measured spectra. This enables a new estimate of the involved low-energy scattering lengths. However, with the precision of our experiment, we encounter conceptual issues, suggesting that the fundamental modeling of the molecular Hamiltonian has reached the limits of its predictive power.

Q 28.5 Tue 14:00 Tent

Experimental setup for the generation of atomic Rydberg states with chiral signatures — •Miles DeWitt[1], Stefan Aull[1], Steffen Giesen[2], Moritz Göb[1], Peter Zahariev[1,3], Robert Berger[2], and Kilian Singer[1] — [1]Experimental Physics 1, Institute of Physics, University of Kassel, Heinrich-Plett-Str. 40, 34132 Kassel, Germany — [2]Berger Group, Institute of Chemistry, University of Marburg, Hans-Meerwein-Str. 4, 35043 Marburg, Germany — [3]Institute of Solid State Physics, Bulgarian Academy of Sciences, Tzarigradsko Chaussee 72, 1784 Sofia, Bulgaria

We present an experimental setup for the preparation and detection of Rydberg states with chiral properties [1] using a novel excitation scheme. We have achieved the loading of Rubidium atoms from a MOT to a crossed dipole trap, to carry out subsequent two-photon excitation into Rydberg states. The dipole trap has been characterized in terms of atom number and temperature using absorption imaging. Subsequently, a superposition of circular states can be generated to realize Rydberg wave functions with chiral signatures. The design of a field ionization setup for state selective detection is presented.

[1] S. Y. Buhmann et al., Quantum sensing protocol for motionally chiral Rydberg atoms, New J. Phys., **23**, 8, 8 (2021).

Q 28.6 Tue 14:00 Tent

Construction of a versatile platform for Rydberg atom experiments — •Aaron Thielmann, Sven Schmidt, Suthep Pomjaksilp, Thomas Niederprüm, and Herwig Ott — Department of Physics and research center OPTIMAS, RPTU Kaiserslautern-Landau

In recent years, atomic arrays emerged as a ground-breaking platform in quantum physics. These setups feature single-atom control and offer large flexibility to study quantum information processing and many-body physics in different geometric configurations.

We present a new experimental setup utilizing a stainless steel chamber and in-vacuum electrodes, allowing to produce arrays of single atoms or small samples, while having as much control over sorrounding parameters as possible. We use holographically generated tweezer traps from an SLM at a wavelength of 1064nm, which are projected together with additional addressing beams through a high resolution objective into the vacuum chamber. This opens the possibility to site-selectively excite and deexcite the atoms, thus enabling the investigation of transport with controlled dissipation in arbitrarily arranged arrays of Rubidium atoms. Additional features include electric and magnetic field control in combination with an ion detector as well as the ability for global application of microwave and optical fields.