A 13: Ultracold plasmas and Rydberg systems II (with Q)

Time: Monday 14:00–15:30 Location: DO24 1.101

A 13.1 Mon 14:00 DO24 1.101

Critical slow down of a dissipative phase transition in a 2D Rydberg lattice gas — •Michael Höning[1], Wildan Abdussalam[2], Thomas Pohl[2], and Michael Fleischhauer[1] — [1]Fachbereich Physik and Forschungszentrum OPTIMAS, Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany — [2]Max Planck Institute for the Physics of Complex Systems, Dresden, Germany

We study two dimensional lattice systems of atoms driven near resonance to strongly interacting Rydberg states. In general dipole blockade gives rise to strong short range correlations of excitations. Dynamical Monte-Carlo simulations of equivalent rate equation models show that for specific driving schemes a phase transition of the steady state to true long range order occurs. The phase diagram is however markedly different from mean-field predictions.

At the phase transition a discrete lattice symmetry is broken and it is found that the system undergoes a critical slow down. The dissipative gap of the system closes in the ordered phase, while in the paramagnetic region relaxation occurs on time scales of single site physics. This behavior is analogous to the formation and dynamics of domain walls in classical Ising models of magnetism. The stationary state of the driven lattice gas is nonetheless protected from local disturbances as they relax on short time scales.

A 13.2 Mon 14:15 DO24 1.101

Rydberg Excitation in Hollow Core Fiber — •Kathrin S. Kleinbach[1], Georg Epple[1,2], Tijmen G. Euser[2], Nicolas Y. Joly[2], Tilman Pfau[1], Philip St.J. Russell[2], and Robert Löw[1] — [1]5. Physikalisches Institut, Universität Stuttgart, Stuttgart, Germany — [2]Max Planck Institute for the Science of Light, Erlangen, Germany

Rydberg atoms exhibit large polarizabilities, long-range interactions and the Rydberg blockade effect. These special properties can be employed in sensitive electric field sensors or as optical non-linearities down to the single photon level. A promising way to reach applicability in technically feasible devices even at room temperature is the excitation of Rydberg atoms inside hollow core fiber, which can bring together highly excited atomic gases with the features and advantages of optical wave guiding structures. The confinement of the atoms and the light fields results in a perfect atom-light coupling.

We perform coherent three-photon excitation to Rydberg states in a cesium vapor confined in kagomé structured hollow core photonic crystal fiber and capillaries with various core diameters. Spectroscopic signals are detected for main quantum numbers up to n=46 exhibiting sub-Doppler features. The observation of line shifts inside the fiber with respect to a reference cell can be assigned to stray electric fields by comparison with well-known scaling laws of Rydberg states. By increasing the number density, and with this the optical density, inside the fiber we are able to eliminate almost all shifts. A detailed understanding of the origin and the disappearance of the shifts will be essential for the successful development of miniaturized fiber-devices.

A 13.3 Mon 14:30 DO24 1.101

Creation, excitation and ionization of a superatom — •Tobias Weber, Thomas Niederprüm, Torsten Manthey, Oliver Thomas, Vera Guarrera, and Giovanni Barontini — Research Center OPTIMAS, Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany

We have prepared and studied a single, isolated superatom consisting of a mesoscopic atomic sample with several hundred atoms, coupled to collective Rydberg states. We probe the created excitation blockade by ionizing the superatom. This results in an anti-bunched ion emission which has many similarities to the resonance fluorescence of a single atom. We determine an effective blockade radius for the $51P$-state and demonstrate the collective character of the excitation. The rich internal level structure of the superatom can be further exploited to create pairs of excitations within the superatom. The resulting ion bunching signal shows record values up to $g^{(2)}(0) = 30$. Varying coupling strength and detuning, we observe a significant change in the excitation dynamics, indicating an excitation regime transition. Our results open new possibilities to quantum optical experiments with Rydberg blockaded samples.

A 13.4 Mon 14:45 DO24 1.101

Exploring the phase diagram of a spatially ordered Rydberg gas — •Johannes Zeiher[1], Peter Schauss[1], Sebastian Hild[1], Takeshi Fukuhara[1], Marc Cheneau[2], Manuel Endres[1], Frauke Seesselberg[1], Tommaso Macri[3], Thomas Pohl[3], Christian Gross[1], and Immanuel Bloch[1,4] — [1]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Straße 1, 85748 Garching, Germany — [2]Laboratoire Charles Fabry - Institut d'Optique, Palaiseau, France — [3]Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Straße 38, 01187 Dresden, Germany — [4]Fakultät für Physik, Ludwig-Maximilians-Universität München, Schellingstraße 4, 80799 München, Germany

Rydberg gases offer the possibility to study long-range correlated many-body states due to their strong van der Waals interactions. In our setup, we optically excite Rydberg atoms and detect them with submicron resolution, which allows us to measure spatial correlations of resulting ordered states. Starting from a two dimensional array of ground state atoms in an optical lattice, we couple to a Rydberg state in a two-photon excitation scheme. Using numerically optimized pulse shapes for coupling strength and detuning, we deterministically prepare the crystalline state in this long-range interacting many-body system. Control of the spatial configuration of the initial state is of great importance for the investigation of the phase diagram. To achieve this, we developed an experimental scheme based on single site addressing allowing for preparation of initial states with sub-Poisson number fluctuations.

A 13.5 Mon 15:00 DO24 1.101

Observing the dynamics of dipole-mediated energy transport by interaction enhanced imaging — •Georg Günter, Hanna Schempp, Martin Robert-de-Saint-Vincent, Vladislav Gavryusev, Stephan Helmrich, Christoph S. Hofmann, Shannon Whitlock, and Matthias Weidemüller — Physikalisches Institut, Universität Heidelberg, Im Neuenheimer Feld 226, 69120, Heidelberg, Germany

Electronically highly excited (Rydberg) atoms experience quantum-state changing interactions similar to Förster processes found in complex molecules, offering a model system to study the nature of dipole-mediated energy transport under the influence of a controlled environment. We demonstrate a non-destructive imaging method to monitor the migration of electronic excitations with high time and spatial resolution using electromagnetically induced transparency on a background gas acting as an amplifier[1]. The many-body dynamics is determined by the continuous spatial projection of the electronic quantum state under observation and features an emergent spatial scale of micrometer size induced by Rydberg-Rydberg interactions[2].

[1] G. Günter et al., Phys. Rev. Lett. 108, 013002 (2012)
[2] G. Günter et al., Science 342, 954 (2013)

A 13.6 Mon 15:15 DO24 1.101

Generating heavy-tailed disorder in Rydberg aggregates — •Sebastian Möbius[1], Sebastiaan M. Vlaming[1], Victor A. Malyshev[2], Jasper Knoester[2], and Alexander Eisfeld[1] — [1]Max Planck Intitute for physics of complex systems, Dresden, Germany — [2]Centre for Theoretical Physics and Zernike Institute for Advanced Materials, University of Groningen, Netherlands

Molecular aggregates exhibit extraordinary absorption properties, depending on their geometrical conformation and inter-monomeric coupling. The narrowing of the absorption band for J-aggregates can be well described by diagonal Gaussian static disorder for individual site energies. Recent studies by Eisfeld et. al [1] have shown, that Levy stable distributions (LSD), a generalization of the Gaussian case, may also lead to a broadening of the absorption band.

Recent developments in generating and trapping highly excited Rydberg atoms, allow for quantum simulations of these molecular aggregates. We show that the interaction of Rydberg atoms with a background gas leads to heavy-tailed disorder in the energy spectrum. Depending on the species of the background gas and the preparation of the system different kinds of heavy-tailed disorder can be observed, including LSD.

[1] A. Eisfeld, S.M. Vlaming, V.A. Malyshev, J. Knoester, PRL 105, 137402 (2010)