A 15: Ultracold Plasmas and Rydberg Systems II (joint session Q/A)

Time: Monday 16:15–17:30 Location: K 2.013

A 15.1 Mon 16:15 K 2.013

Metastable decoherence-free subspaces and electromagnetically induced transparency in interacting many-body systems — •Katarzyna Macieszczak[1,2], YanLi Zhou[3], Sebastian Hofferberth[4], Juan P. Garrahan[1,2], Weibin Li[1,2], and Igor Lesanovsky[1,2] — [1]School of Physics and Astronomy, The University of Nottingham, Nottingham NG7 2RD, United Kingdom — [2]Centre for the Mathematics and Theoretical Physics of Quantum Non-equilibrium Systems, University of Nottingham, Nottingham NG7 2RD, United Kingdom — [3]College of Science, National University of Defense Technology, Changsha 410073, China — [4]Department of Physics, Chemistry and Pharmacy, University of Southern Denmark, Odense, Denmark

We investigate the dynamics of a generic interacting many-body system under conditions of electromagnetically induced transparency (EIT). This problem is of current relevance due to its connection to nonlinear optical media realised by Rydberg atoms. In an interacting system the structure of the dynamics and the approach to stationarity become far more complex than in the case of conventional EIT as a metastable decoherence-free subspace emerges, whose dimension for a single Rydberg excitation grows linearly in the number of atoms. We discuss the effective slow nonequilibrium dynamics, which features coherent and dissipative two-body interactions, and renders the typical assumption of fast relaxation invalid. We also show how this scenario can be utilised for the preparation of collective entangled dark states and the realisation of general unitary dynamics within the spin-wave subspace.

A 15.2 Mon 16:30 K 2.013

Realization of a XXZ-model using Rydberg atoms — •Renato Ferracini Alves[1], Miguel Ferreira Cao[1], Titus Franz[1], Martin Gärttner[2], Asier Piñeiro Orioli[3], Andre Salzinger[1], Adrien Signoles[1], Nithiwadee Thaicharoen[1], Shannon Whitlock[1,4], Gerhard Zürn[1], Jürgen Berges[3,5], and Matthias Weidemüller[1,6] — [1]Physikalisches Institut, Universität Heidelberg, Germany — [2]Kirchhoff-Institut für Physik, Universität Heidelberg, Germany — [3]Institut für Theoretische Physik, Universität Heidelberg, Germany — [4]IPCMS and ISIS, University of Strasbourg and CNRS, Strasbourg, France — [5]ExtreMe Matter Institute EMMI, Darmstadt, Germany — [6]Shanghai Branch, University of Science and Technology of China, Shanghai, China

Cold Rydberg gases are a suitable platform for studying quantum many body dynamics, due to its strong and long range interactions. Questions regarding thermalization in closed quantum systems and relaxation dynamics after a quench can be addressed experimentally. This project investigates the many body dynamics of a few thousand disordered Rydberg atoms. In particular we realize a Heisenberg XXZ spin model by mapping two interacting Rydberg states to an effective spin 1/2 system. Coupling these states with a phase-controlled microwave radiation, allows us to perform arbitrary global initial state-preparation and, together with state selective ionization, a state-tomographic detection. With these techniques we extract the magnetization and study its time evolution. In this talk we will focus on recent measurements of the spin dynamics after a quench.

A 15.3 Mon 16:45 K 2.013

Quasi-particle spectra of bosonic Rydberg-dressed many-body phases — •Andreas Geissler[1], Yongqiang Li[2], Weibin Li[3], Ulf Bissbort[4], and Walter Hofstetter[1] — [1]Institut für Theoretische Physik, Johann Woalfgang Goethe-Universität, Frankfurt/Main — [2]Department of Physics, National University of Defense Technology, Changsha, China — [3]School of Physics and Astronomy, University of Nottingham — [4]SUTD, Singapore

As recent experiments have demonstrated the feasibility of Rydberg dressing [1], even in a lattice system [2], the stage is set for realizing (long predicted) exotic states of matter in ultracold gases. Our latest results (simulated in real-space bosonic dynamical mean-field theory RB-DMFT) have shown a rich diversity of crystalline and supersolid quantum phases, both close to resonant driving [3] and in the weak dressing limit [4]. While in the former case we predict a reduction of the Rydberg fraction compared to single atom dressing, we show in the latter case how a two-species mixture can make the realization of a supersolid more accessible. Based on these results we applied a quasi-particle method based on linearized Gutzwiller dynamics (Gqp), to predict various spectral functions for both cases and in an experimentally feasible regime. As RB-DMFT also predicts spectral properties, it serves as a benchmark for Gqp. We furthermore characterize the various observed gapped and ungapped quasi-particle modes.

[1] Y.-Y. Jau et al., Nat. Phys. 12, 71-74 (2016) [2] J. Zeiher et al., Nat. Phys. 12, 1095-1099 (2016) [3] A. Geißler et al., Phys. Rev. A 95, 063608 (2017) [4] Y. Li et al., arXiv:1705.01026

A 15.4 Mon 17:00 K 2.013

Localisation dynamics in a disordered Rydberg ladder — •Maike Ostmann[1,2], Jiri Minar[1,2], Matteo Marcuzzi[1,2], and Igor Lesanovsky[1,2] — [1]School of Physics and Astronomy, University of Nottingham, Nottingham, NG7 2RD, United Kingdom — [2]Centre for the Mathematics and Theoretical Physics of Quantum Non-equilibrium Systems, University of Nottingham

Rydberg lattice systems are currently studied in a number of laboratories worldwide as they constitute a promising platform for quantum information processing and the quantum simulation of many-body systems out of equilibrium. We are studying the transport of excitations in Rydberg systems under the so-called facilitation condition, where the excitation of an atom to a Rydberg state is strongly enhanced by an excited neighbour. In particular we are interested in understanding the impact of disorder caused by the uncertainty of the atomic positions within the individual lattice sites. In a recent work, a connection between localisation in real space and configuration (Fock) space was established. Building on this, we are investigating the localisation phenomena in a Rydberg ladder forming a so-called Lieb lattice in configuration space. A Lieb lattice supports a macroscopically degenerate flat band which gives rise to localised eigenstates in the absence of disorder. We are exploring the influence of the disorder on these localised eigenstates. Introducing disorder to our system leads to a non-monotonic behaviour of the localisation as a function of the interaction strength. Furthermore, we are studying how different types of disorder effect the scaling of the localisation length.

A 15.5 Mon 17:15 K 2.013

Self-consistent theory of energy diffusion in ultracold Rydberg gases — •Katharina Hess, Andreas Buchleitner, and Thomas Wellens — Physikalisches Institut, Albert-Ludwigs-Universität Freiburg, Herman-Herder-Straße 3, 79104 Freiburg, Deutschland

Due to their high degree of controllability, gases of ultracold Rydberg atoms are a good testbed to study fundamental questions of transport in spatially disordered quantum networks. In this talk, we will examine the transfer of a single Rydberg excitation mediated by coherent dipole-dipole interactions. We show that the dipole blockade effect can be used to change the character of transport from subdiffusive to diffusive [1]. In the latter case, we apply a self-consistent diagrammatic approach [2] in order to determine the value of the diffusion constant.

[1] T. Scholak, T. Wellens and A. Buchleitner, Phys. Rev. A 90, 063415 (2014)

[2] T. Wellens and R. A. Jalabert, Phys. Rev. B 94, 144209 (2016)