Q 23: Ultracold Plasmas and Rydberg Systems I (with A)

Time: Tuesday 11:00–13:00 Location: C/kHS

Q 23.1 Tue 11:00 C/kHS

Quantum simulation of energy transport with embedded Rydberg aggregates — •David W. Schönleber[1], Alexander Eisfeld[1], Michael Genkin[1], Shannon Whitlock[2], and Sebastian Wüster[1] — [1]Max-Planck-Institut für Physik komplexer Systeme, 01187 Dresden — [2]Physikalisches Institut, Universität Heidelberg, 69120 Heidelberg

We show that an array of ultracold Rydberg atoms embedded in a laser driven background gas can serve as an artificial molecular aggregate for simulating exciton dynamics and energy transport with a controlled environment. Spatial disorder and decoherence introduced by the interaction with the background gas atoms can be controlled by the laser parameters. This allows for an almost ideal realization of a Haken-Reineker-Strobl type model for energy transport, providing a possible platform for quantum simulation of photosynthetic light harvesting complexes. Physics can be monitored using the same mechanism that provides control over the environment. The degree of decoherence is traced back to information gained on the excitation location through the monitoring, turning the setup into an experimentally accessible model system for studying the effects of quantum measurements on the dynamics of a many-body quantum system.

Q 23.2 Tue 11:15 C/kHS

Signatures of directed percolation in strongly-dephased Rydberg atoms — •Matteo Marcuzzi, Emanuele Levi, Beatriz Olmos, Weibin Li, Juan Garrahan, and Igor Lesanovsky — School of Physics and Astronomy, University of Nottingham, Nottingham, NG7 2RD, UK

The directed percolation universality class possibly represents the simplest instance of a genuine non-equilibrium phase transition from an absorbing state to a fluctuating active phase and is typically thought to be as fundamental as the Ising universality class is for equilibrium. However, until rather recently, no clear evidence of this transition had been found in experiments. This presentation aims to show that signatures of directed percolation can be observed in a strongly interacting ensemble of Rydberg atoms subject to intense dephasing noise. Thanks to the high degree of tunability offered by cold atomic techniques, this approach should allow for the experimental probing of directed percolation in all physical dimensions.

Q 23.3 Tue 11:30 C/kHS

Universal Nonequilibrium Properties of Dissipative Rydberg Gases — Matteo Marcuzzi[1], •Emanuele Levi[1], Sebastian Diehl[2,3], Juan. P. Garrahan[1], and Igor Lesanovsky[1] — [1]School of Physics and Astronomy, University of Nottingham, Nottingham NG7 2RD, United Kingdom — [2]Institute for Theoretical Physics, University of Innsbruck, A-6020 Innsbruck, Austria — [3]Institut für Theoretische Physik, Technische Universität Dresden, 01062 Dresden, Germany

We investigate the out-of-equilibrium behavior of a dissipative gas of Rydberg atoms that features a dynamical transition between two stationary states characterized by different excitation densities.

We determine the structure and properties of the phase diagram and identify the universality class of the transition, both for the statics and the dynamics. We show that the proper dynamical order parameter is in fact not the excitation density and find evidence that the dynamical transition is in the "model A" universality class.

This sheds light on some relevant and observable aspects of dynamical transitions in Rydberg gases. In particular it permits a quantitative understanding of a recent experiment [C. Carr, Phys. Rev. Lett. 111, 113901 (2013)] which observed bistable behavior as well as power-law scaling of the relaxation time. The latter emerges not due to critical slowing down in the vicinity of a second order transition, but from the nonequilibrium dynamics near a so-called spinodal line.

Q 23.4 Tue 11:45 C/kHS

Hybridization of Rydberg orbitals by molecule formation — •Anita Gaj, Alexander T. Krupp, Philipp Ilzhöfer, Thomas Schmid, Robert Löw, Sebastian Hofferberth, and Tilman Pfau — University of Stuttgart, Stuttgart, Germany

The bond in ultralong-range Rydberg molecules results from scattering between a Rydberg electron and ground state atoms in an ultracold gas. In our setup we can selectively excite rovibrational states of D-state molecules. We study their binding energies and the shape of the binding potential at the crossing of two m_j states in an external electric field. The degeneracy of the electronic orbitals leads to stronger binding energies and new symmetries of the bound molecular states. As a consequence the Rydberg orbitals hybridize due to the molecular bond.

Q 23.5 Tue 12:00 C/kHS

Quantum magnetism and topological ordering via Rydberg-dressing near Förster-resonances — •Rick van Bijnen and Thomas Pohl — Max Planck Institute for the Physics of Complex Systems, Dresden

We devise a cold-atom approach to realizing a broad range of bi-linear quantum magnets [1]. Our scheme is based on off-resonant single-photon excitation of Rydberg P-states, whose strong interactions and state-mixing are shown to yield controllable XYZ-interactions between effective spins, represented by different atomic ground states. Exploiting distinctive features of Förster-resonant Rydberg atom interactions, we obtain large spin-interactions, up to three orders of magnitude in excess of corresponding decoherence rates. We illustrate the concept on a spin-1 chain implemented with cold Rubidium atoms, and demonstrate that this permits the dynamical preparation of topological magnetic phases. Generally, the described approach provides a viable route to exploring quantum magnetism with dynamically tuneable (an)isotropic interactions as well as variable space- and spin-dimensions in cold-atom experiments.

[1] arXiv:1411.3118

Q 23.6 Tue 12:15 C/kHS

State-selective all-optical population detection of Rydberg atoms — •Florian Karlewski[1], Markus Mack[1], Jens Grimmel[1], Nóra Sándor[2,3], and József Fortágh[1] — [1]Physikalisches Institut der Universität Tübingen — [2]Department for Quantumoptics and Quantuminformatics, Wigner Research Center for Physics, Budapest — [3]Laboratoire de Physique Quantique, Strasbourg, France

We present an all-optical protocol for detecting population in a selected Rydberg state of alkali atoms. The detection scheme is based on the interaction of the atoms with two laser pulses: one weak probe pulse which is resonant with the transition between the ground state and first excited state, and a relatively strong pulse which couples the first excited state to the selected Rydberg state. We show that by monitoring the absorption signal of the probe laser over time, we can imply the initial population of the Rydberg state. We also present the results of a proof-of-principle measurement performed on a cold gas of ^{87}Rb atoms, as well as applications in studies of the lifetimes of Rydberg states under various environment conditions.

Q 23.7 Tue 12:30 C/kHS

Aggregation of Rydberg excitations in a dense thermal vapor cell — •Alban Urvoy[1], Fabian Ripka[1], Igor Lesanovsky[2], Tilman Pfau[1], and Robert Löw[1] — [1]5. Physikalisches Institut , Universität Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart Germany — [2]School of Physics and Astronomy, University of Nottingham, Nottingham, NG7 2RD, UK

Rydberg atoms in dense gases are of growing interest, due to the rich many-body physics enabled by the strong interactions. In particular, the effect of Rydberg aggregation, which relies on off-resonant excitation to spatially correlated ensembles of atoms, is currently studied [1,2] as it exhibits interesting correlations, as e.g. in soft-matter systems [3].

We present our experimental results on the excitation dynamics of such Rydberg aggregates in a vapor cell at room temperature [4]. The scaling laws for the characteristic timescale of the excitation process are consistent with a model based on an effective Master equation. Moreover we show that our measurements are very sensitive to the interaction potentials. We are able to observe the influence dipole-quadrupole interactions.

We will also discuss the use of this sensitivity to probe various interactions of the Rydberg atoms.

[1] H. Schempp et al., PRL **112**, 013002 (2014)

[2] N. Malossi et al., PRL **113**, 023006 (2014)
[3] I. Lesanovsky and J.P. Garrahan, PRA **90**, 011603(R) (2014)
[4] A. Urvoy et al., arXiv:1408.0039 [physics.atom-ph] (2014)

Q 23.8 Tue 12:45 C/kHS

Measurements and numerical calculations of ^{87}Rb Rydberg Stark Maps — •Jens Grimmel[1], Markus Mack[1], Florian Karlewski[1], Florian Jessen[1], Malte Reinschmidt[1], Ahmad Rizehbandy[1], Nóra Sándor[2,3], and József Fortágh[1] — [1]Physikalisches Institut der Universität Tübingen — [2]Department of Quantumoptics and Quantuminformatics, Wigner Research Center for Physics, Budapest, Hungary — [3]Laboratoire de Physique Quantique, ISIS, Strasbourg, France

Rydberg atoms are extremely sensitive to electric fields and consequently have a rich Stark spectrum. We present measurements and numerical calculations of Stark shifts for Rydberg states of 87Rb. We extended the numerical method of [M. Zimmerman et al., Phys. Rev. A 20, 2251-2275 (1979)] to allow for a calculation of the transition strength from low lying states to Stark shifted Rydberg states. The results from these calculations are compared to high precision measurements of Stark Maps for Rubidium Rydberg atoms with principal quantum numbers up to 70 and electric fields ranging beyond the classical ionization threshold. An electromagnetically induced transparency measurement scheme is used to detect Rydberg states inbetween two electrodes of a capacitor in a glass vapor cell.