A 28: Poster: Ultra-cold plasmas and Rydberg systems (with Q)

Time: Tuesday 16:30–18:30 Location: Spree-Palais

A 28.1 Tue 16:30 Spree-Palais

Towards a strongly interacting gas of Strontium Rydberg atoms — •Luc Couturier[1,2], Chang Qiao[1], Valentin Ivannikov[2], Yuhai Jiang[1], and Matthias Weidemüller[1,2] — [1]USTC, Xiupu Road 99, Pudong New Distinct, Shanghai 201315, People Republic of China — [2]Physikalisches Institut, Universität Heidelberg, INF 226 69120 Heidelberg

So far Rydberg atom experiments have mainly focused on alkali metals. However different proposals pointed out the possibility to use alkaline earth metal elements as a two electron Rydberg system allowing trapping of Rydberg atoms and providing thus new schemes for quantum computation [1] as well as interesting applications in many-body quantum physics [2] or for the study ultracold neutral plasma [3]. For these purposes strontium is one of the best candidates, most of the optical spectroscopy and cooling transitions being within reach of commercial lasers, but also exhibiting favorable BEC formation schemes due to the existence of a very narrow transition characteristic of the alkaline earth metals. We present plans for a new experiment on strontium Rydberg atoms being set up at the University of Science and Technology of China.

[1] Mukherjee, R. *et al.* J. Phys. B 44(18), 184010 (2011)
[2] Stellmer, S. *et al.* Phys. Rev. A 87.1 013611 (2013)
[3] Bannasch, G. *et al.* PRL 110(25), 253003.(2013)

A 28.2 Tue 16:30 Spree-Palais

Aggregate formation in off-resonantly driven Rydberg gases — •Martin Gärttner, David Schönleber, and Jörg Evers — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

The dynamics of a cloud of ultra-cold two-level atoms is studied at off-resonant laser driving to a Rydberg state. We find that resonant excitation channels lead to strongly peaked spatial correlations associated with the buildup of asymmetric excitation structures. These aggregates can extend over the entire ensemble volume, but are in general not localized relative to the system boundaries. We identify characteristic features in the spatial excitation density, the Mandel Q parameter, higher statistical moments, and the total number of excitations. Moreover, the influence of decoherence on the aggregate formation mechanism is studied. We conclude that in the presence of strong decoherence the aggregates grow sequentially around an initial grain. In the strongly dissipative regime a rate-equation description can be employed. This allows us to study large ensembles of atoms and to directly compare our findings to recent experimental observations [1].

[1] Schempp *et al.*, arXiv:1308.0264 (2013)

A 28.3 Tue 16:30 Spree-Palais

Measurements and numerical calculations of ^{87}Rb Rydberg Stark Maps — •Jens Grimmel, Markus Mack, Florian Karlewski, Malte Reinschmidt, Florian Jessen, and József Fortágh — Physikalisches Institut, Universität Tübingen, Germany

Rydberg atoms are extremely sensitive to electric fields and consquently have a rich Stark spectrum. We present high precision frequency measurments of Stark Maps for Rubidium Rydberg atoms with principal quantum numbers between 26 and 75. A two photon measurement scheme creates Rydberg atoms inbetween two electrodes of a capacitor in a glass vapor cell. The exact transition frequency at a given field strength is determined by scanning the coupling laser and observing the apperance of an electromagnetically induced transparency window. The two lasers are phase locked to a frequency comb. The Stark Maps were numerically calculated based on the method of [M. Zimmerman et al., Phys. Rev. A 20, 2251-2275 (1979)], and match the data to within 1MHz.

A 28.4 Tue 16:30 Spree-Palais

Optical control of Rydberg aggregates embedded in a dense atomic gas — •Sebastian Wüster[1], Michael Genkin[1], Alexander Eisfeld[1], and Shannon Whitlock[2] — [1]Max Planck Institute for the Physics of Complex Systems, Dresden — [2]Physikalisches Institut, Universität Heidelberg

We find that Rydberg impurities created within a host cold atom cloud realize a system in which excitation transport can be monitored and through the same mechanism continuously tuned between the quantum coherent, classically diffusive and quantum Zeno regimes.

Controllable decoherence and monitoring are both provided by state dependent interactions of the impurities with the background gas, which is electromagnetically rendered transparent [1,2].

We describe the physical process through which the coupling to the background gas de-coheres the quantum excitation transport taking place among the impurities (aggregate), and find that the de-coherence time is naturally reached once enough information is gathered on the excitation location, thus collapsing the wave function. Using an effective description for the aggregate alone, we then investigate how various regimes of transport can be realized.

[1] G. Günter, M. R. de Saint-Vincent, H. Schempp, C. S. Hofmann, S. Whitlock, and M. Weidemüller, Phys. Rev. Lett. 108, 013002 (2012).

[2] B. Olmos, W. Li, S. Hofferberth, and I. Lesanovsky, Phys. Rev. A 84, 041607(R) (2011).

A 28.5 Tue 16:30 Spree-Palais

Time resolved optical detection of Rydberg state population — •Markus Mack[1], Florian Karlewski[1], Nóra Sándor[1,2], Jens Grimmel[1], Florian Jessen[1], Daniel Cano[1], and József Fortágh[1] — [1]Physikalisches Institut der Universität Tübingen, Germany — [2]Wigner Research Center for Physics, Budapest, Hungary

The population of Rydberg states is typically determined by selective field ionization (SFI), which destroys the sample of Rydberg atoms. We have investigated an essentially non-destructive method to probe the excitation of single Rydberg states by time resolved optical absorption measurements without the use of SFI. Numerical predictions for the time-dependent transmission signal under the conditions for electromagnetically induced transparency (EIT) are compared to experimental data.

A 28.6 Tue 16:30 Spree-Palais

Spectroscopy of Rydberg pair states in an ultracold cesium gas — Heiner Sassmannshausen and •Johannes Deiglmayr — ETH Zurich, Laboratory of Physical Chemistry, Zurich, Switzerland

We have recently setup an experiment which allows us to study transitions between Rydberg states by high-resolution millimeter-wave spectroscopy under conditions where the stray electric and magnetic fields are reduced to below 1 mV/cm and 2 mG, respectively. Measurements of the hyperfine-splitting of atomic Rydberg states with principal quantum number beyond n=100, showing transform-limited linewidths of better than 20 kHz, demonstrated the performance of the setup [1].

Recently an optical dipole trap was added to the setup to investigate the Rydberg excitation in denser samples of ultracold atoms. We have observed the excitation of dipole-forbidden pair-states, which we attribute to the formation of so called "macro dimers" [2]. The current status of these experiments will be presented.

[1] H. Sassmannshausen, F. Merkt, J. Deiglmayr, Phys. Rev. A 87, 032519 (2013) [2] S.M. Farooqi, et al., Phys. Rev. Lett. 91, 183002 (2003)

A 28.7 Tue 16:30 Spree-Palais

Interacting Spin-1 chains from multi-level Rydberg atoms — •Rick van Bijnen[1], Rejish Nath[1,2,3], Volckmar Nebendahl[3], Igor Lesanovsky[4], Andreas Laeuchli[3], and Thomas Pohl[1] — [1]Max Planck Institute for the Physics of Complex Systems, D-01187 Dresden, Germany — [2]Indian Institute of Science Education and Research, Pune-411021, India — [3]Institut für Theoretische Physik, Universität Innsbruck, Technikerstr. 25, A-6020 Innsbruck, Austria — [4]School of Physics and Astronomy, University of Nottingham, Nottingham, NG7 2RD, United Kingdom

Ultracold, highly excited Rydberg atoms exhibit extremely strong and tunable interactions, making them promising candidates for quantum information and quantum simulation purposes. In particular, Rydberg atoms can provide a very close experimental realisation of interacting spin-1/2 systems, represented by the atomic ground- and Rydberg states. So far, most studies involve a single Rydberg S-state, featuring isotropic van der Waals interactions. Here, we consider laser excitation of two distinct Rydberg S-states, representing an interacting spin-1 system. We discuss additional interactions appearing in this system for varying principal quantum numbers and investigate the resulting phase diagram which reveals a range of interesting non-classical ground states, even in the absence of laser driving.

A 28.8 Tue 16:30 Spree-Palais

Second-generation apparatus for Rydberg-atoms in a Bose-Einstein condensate — •Udo Hermann, Huan Nguyen, Michael Schlagmüller, Graham Lochead, Robert Löw, Sebastian Hofferberth, and Tilman Pfau — 5. Physikalische Institut, Universität Stuttgart

The giant size and large polarizability of Rydberg-atoms, resulting in strong long-range Rydberg-Rydberg interactions, make them ideal for studying many-body cooperative effects. In particular, the effect of highly excited Rydberg atoms on the density distribution of a Bose-Einstein condensate has opened the door to study Rydberg electron wave functions. In addition, Förster like energy transport in light harvesting complexes can be simulated with this system.

Here we present a new experimental apparatus for the creation and dynamic study of Rydberg-atoms in dense, ultra-cold atomic ensembles. Specific design goals of this new setup are single ion-detection capability, sub-micron optical resolution, precise electric field control and high flexibility in creating both magnetic and optical trapping potentials. We discuss how these different aspects are combined in a single, compact experimental realization and present the first results.

A 28.9 Tue 16:30 Spree-Palais

Dissipative Binding of Lattice Bosons through Distance-Selective Pair Loss — •Benjamin Everest, Michael R. Hush, and Igor Lesanovsky — University of Nottingham, Nottingham, UK

The generation of correlated many body states in cold atomic gases is currently of great interest. In this setting, atoms excited to Rydberg states have proven to be a useful tool as they display strong coherent long-range interactions which can also be used to generate non-local dissipation [1]. Here we explore how such an unusual dissipation mechanism fosters the formation of coherent long lived states for bosons trapped in an optical lattice. This system is modelled with a dissipative master equation with Lindblad jump operators of a form such that two atoms separated by a specific critical distance will be removed. When this dissipation competes with coherent hopping, this can lead to bound complexes of atoms whose internal dynamics is linked directly to their motion. Previously this was shown for hard core bosons and we have now extended this model to bosons with finite interaction strength. This system features a manifold of bound complexes and a more intricate dynamical behaviour.

[1] C. Ates, B. Olmos, W. Li and I. Lesanovsky. Dissipative Binding of Lattice Bosons through Distance-Selective Pair Loss. *Physical Review Letters*, 109(23):233003, December 2012