Q 64: Poster: Ultracold Plasmas and Rydberg Systems (with A)

Time: Thursday 17:00–19:00 Location: C/Foyer

Q 64.1 Thu 17:00 C/Foyer

Entangled Motion Using Rydberg Blockade - From Single Atoms to Atom Clouds — Sebastian Möbius, •Michael Genkin, Sebastian Wüster, Alexander Eisfeld, and Jan Michael Rost — MPI for the Physics of Complex Systems, Dresden

When excited to Rydberg states, atoms are subject to strong long range interactions, e.g. van-der-Waals or resonant dipole-dipole interactions. They give rise to strong correlations and state-dependent atomic motion. These two effects occur jointly when one considers resonant dipole-dipole interactions between atom clouds which are in the van-der-Waals blockade regime. We study the Rydberg excitation exchange and atomic motion for such a setup and distinguish between two possibilities to introduce the Rydberg excitation into the clouds: A resonant two-photon transition, which leads to a coherent collective state, or an off-resonant coupling which yields a small admixture of Rydberg state properties to the atoms. This determines whether a single atom pair or the entire cloud is set in motion by the dipole-dipole forces. Both scenarios are interesting for potential applications in entanglement protocols. We present two examples: A source of pairwise entangled atoms which can be ejected on-demand, and a mesoscopic Schrödinger cat, where the entanglement is encoded in the motion. It prevails for several microseconds and is maintained over a distance of several micrometers.

Q 64.2 Thu 17:00 C/Foyer

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]Laboratoire de Physique Quantique, Strasbourg, France — [3]Department for Quantumoptics and Quantuminformatics, Wigner Research Center for Physics, Budapest

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 64.3 Thu 17:00 C/Foyer

Characteristics of Rydberg aggregation in vapor cells — •Alban Urvoy[1], Fabian Ripka[1], Igor Lesanovsky[2], Donald W. Booth[3], James P. Shaffer[3], 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 — [3]Homer L. Dodge Department of Physics and Astronomy, The University of Oklahoma, 440 West Brooks Street, Norman, Oklahoma 73019, USA

Vapor cells present the advantage of offering compact and flexible experimental arrangements, as well as parameter regimes that are complementary to cold atom experiments. Several important results have already been obtained with van-der-Waals interacting Rydberg atoms in vapor cells [1,2], in spite of the strong effects due to thermal motion of the atoms.

Here we present our results at higher densities on the excitation dynamics of Rydberg aggregates in a vapor cell [3]. In particular, we will focus on the specifics of the aggregation in our configuration. We will examine the influence of complex Rydberg interactions at these high densities, such as the symmetry-breaking dipole-quadrupole interaction. We will also discuss the definition of aggregates when thermal motion is non-negligible and the influence of having predominantly motional dephasing rather than laser dephasing.

[1] T. Baluktsian, B. Huber, et al., PRL **110**, 123001 (2013)
[2] C. Carr et al., PRL **111**, 113901 (2013)
[3] A. Urvoy et al., arXiv:1408.0039 [physics.atom-ph] (2014)

Q 64.4 Thu 17:00 C/Foyer

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.

Q 64.5 Thu 17:00 C/Foyer

Patterned Rydberg excitation and ionisation with a spatial light modulator — •Rick van Bijnen[1,2], Cornee Ravensbergen[1], Servaas Kokkelmans[1], and Edgar Vredenbregt[1] — [1]Eindhoven University of Technology, Eindhoven, Netherlands — [2]Max Planck Institute for the Physics of Complex Systems, Dresden, Germany

We demonstrate the ability to excite atoms at well-defined, programmable locations in a magneto-optical trap, either to the continuum (ionisation), or to a Rydberg state [1]. To this end, excitation laser light is shaped into arbitrary intensity patterns with a spatial light modulator. These optical patterns are sensitive to aberrations of the phase of the light field, occuring while traversing the optical beamline. These aberrations are characterised and corrected without observing the actual light field in the vacuum chamber. In addition, our detection system allows for spatially resolved single ion detection, which we use to directly measure correlation functions.

[1] arXiv:1407.6856

Q 64.6 Thu 17:00 C/Foyer

Enhanced relaxation rate of atom counting statistics in weakly interacting Rydberg lattices — •Wildan Abdussalam[1], Laura Gil[1], Igor Lesanovsky[2], and Thomas Pohl[1] — [1]Max Planck Institute for the Physics and Complex Systems — [2]School of Physics and Astronomy, The University of Nottingham

We study the dynamics of spin lattices with power-law interactions driven by coherence laser-coupling under decoherence processes. We determine and analyse the atom counting statistics induced by dephasing, due to both homogeneous and inhomogeneous laser phase noises, via master equation and quantum stochastic methods. We find that the relaxation rate of atom counting statistics for the homogeneous laser noise increases when the weakly Rydberg-Rydberg interaction is applied. Meanwhile, the relaxation rate remains the same in the case of inhomogeneous laser noise.

Q 64.7 Thu 17:00 C/Foyer

Long-range Rydberg molecules – Rydberg-Rydberg and Rydberg–ground-state interactions — •Johannes Deiglmayr, Heiner Sassmannshausen, and Frédéric Merkt — Laboratory of Physical Chemistry, ETH Zürich, Switzerland

We report on two recent observations in our experiments with ultracold Cs atoms [1]. First, we discuss the observation of dipole-quadrupole interactions between two Rydberg atoms. Because the dipole-quadrupole interaction does not conserve the electronic parity, the conservation of total parity requires that the excitation of dipole-quadrupole-coupled pair states in our experiments [2] is accompanied by an entanglement of electronic and rotational motions of the atom pair, which is facilitated by the near-degeneracy of even- and odd-L partial waves.

Second, we report on the experimental characterization of singlet-scattering channels in long-range Rydberg molecules composed of a

Rydberg and a ground-state atom. We observe the formation of such molecules by photoassociation spectroscopy near $n\mathrm{p}_{3/2}$ resonances (n=26-34). The spectra reveal two types of molecular states recently predicted by Anderson *et al.* [PRL **112**, 163201 (2014)]: Deeply bound pure triplet states and more weakly bound states with mixed singlet and triplet character. The experimental observations are well described by a model including s-wave scattering, the hyperfine interaction of the ground-state atom and the fine-structure of the Rydberg atom.

[1] H. Saßmannshausen, F. Merkt, J. Deiglmayr, PRA **87**, 032519 (2013); [2] J. Deiglmayr, H. Saßmannshausen, P. Pillet, and F. Merkt, PRL **113**, 193001 (2014)

Q 64.8 Thu 17:00 C/Foyer

Limits for Light Modulation by Stark Shifting Rydberg EIT and Superradiance in Thermal Vapor Cells — •Harald Kübler, Margarita Reschke, Mohamad Abdo, Alban Urvoy, Robert Löw, and Tilman Pfau — 5. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart, Germany

Over the past few years, the usage of atomic vapors has become more and more relevant in technological applications. The demonstration of coherent dynamics on the nanosecond scale [1] opened the field for high frequency applications.

We demonstrate our progress towards a light modulator based on Rydberg EIT, where the Rydberg state can be shifted by an external RF field. We investigate the limitations on the modulation frequency as well as the limitations on the modulation depth.

One limiting factor in systems with high Rydberg densities is Superradiance. The wavelength of Rydberg to Rydberg transitions can be on the order of 1cm, meaning that a lot of Rydberg excitations are within the volume of one wavelength. These excitations can decay collectively and this can become the dominant decay process. We study the decay dynamics of this process in a thermal vapor cell and compare the experimental results to a rate equation model.

[1] Huber et al., *PRL* **107**, 243001 (2011)

Q 64.9 Thu 17:00 C/Foyer

Constrained diffusion in noisy lattice gases of polar molecules — •Benjamin Everest — University of Nottingham, Nottingham, UK

Strongly correlated many body states in cold molecular gases are at present in the focus of intense research. Motivated by this we investigate the dynamics of a lattice system in one and two dimensions in which particles tunnel between lattice sites and interact via a van-der-Waals potential. We are particularly interested in the limit of strong dephasing in which the dynamics can be described by a classical master equation with constrained diffusion[1]. While the steady state features a uniform distribution of the particle density, the dynamics is rather intricate showing a variety of different timescales. We focus our investigations mainly on the case in which there is initially a dense particle cluster which is dissolved with time. We will present a simple classical model which captures the main features of this dissolution and compare the interacting and non-interacting cases.

[1] I. Lesanovsky, and J. P. Garrahan, Phys. Rev. Lett. **111**, 215305 (2013)