A 36: Rydberg gasses II

Time: Friday 14:30–16:15 Location: HS 20

A 36.1 Fri 14:30 HS 20

Facilitation dynamics and localization phenomena in Rydberg lattice gases with position disorder — Matteo Marcuzzi[1,2], •Jiří Minář[1,2], Daniel Barredo[3], Sylvain de Léséleuc[3], Henning Labuhn[3], Thierry Lahaye[3], Antoine Browaeys[3], Emanuele Levi[1,2], and Igor Lesanovsky[1,2] — [1]School of Physics and Astronomy, University of Nottingham, United Kingdom — [2]Centre for the Mathematics and Theoretical Physics of Non-equilibrium Quantum Systems, University of Nottingham, United Kingdom — [3]Laboratoire Charles Fabry, Institut d'Optique Graduate School, CNRS, Université Paris-Saclay, France

We explore the dynamics of Rydberg excitations in an optical tweezer array under facilitation condition. Due to the finite temperature the atomic positions are randomly spread, an effect that leads to quenched correlated disorder in the interatomic interaction strengths. This drastically affects the facilitation dynamics as we demonstrate experimentally. To shed light on the role of disorder we show that the dynamics is governed by an Anderson-Fock model, i.e. an Anderson model formulated on a lattice with sites corresponding to many-body Fock states. We consider a one-dimensional atom chain and illustrate the effect of disorder experimentally in a situation in which the system maps on a two-dimensional Anderson-Fock model on a trimmed square lattice. We observe a clear suppression of excitation propagation which we ascribe to the localization of the many-body wavefunctions in Hilbert space. [arXiv:1607.06295]

A 36.2 Fri 14:45 HS 20

Calculation of Rydberg interaction potentials — •Sebastian Weber[1], Christoph Tresp[2], Henri Menke[3], Alban Urvoy[4], Ofer Firstenberg[5], Hans Peter Büchler[1], and Sebastian Hofferberth[2] — [1]ITP3, Universität Stuttgart, Germany — [2]PI5, Universität Stuttgart, Germany — [3]FKF, Max-Planck-Institut Stuttgart, Germany — [4]RLE, Massachusetts Institute of Technology, USA — [5]Weizmann Institute of Science, Israel

The long-range interaction between individual Rydberg atoms provides a powerful tool exploited in an ever-growing range of applications in quantum information science, quantum simulation, and ultracold chemistry. One hallmark of the Rydberg interaction is that both its strength and angular dependence can be finetuned with great flexibility by choosing appropriate Rydberg states and applying external electric and magnetic fields. More and more experiments are probing this interaction at short atomic distances or with such high precision that perturbative calculations as well as restrictions to the leading dipole-dipole interaction term are no longer sufficient. We discuss the full calculation of Rydberg interaction potentials including electromagnetic fields with arbitrary direction. Symmetry arguments and selection rules greatly reduce the size of the Hamiltonian matrix, enabling the direct diagonalization of the Hamiltonian up to higher multipole orders on a desktop computer. Finally, we present example calculations showing the relevance of the full interaction calculation to current experiments. Our software for calculating Rydberg potentials is made available as open-source (https://pairinteraction.github.io/).

A 36.3 Fri 15:00 HS 20

Charge-induced optical bistability in thermal Rydberg vapor — •Daniel Weller, Alban Urvoy, Andy Rico, Robert Löw, and Harald Kübler — 5. Physikalisches Institut and Center for Integrated Quantum Science and Technology, Universität Stuttgart

In this talk, we discuss the phenomenon of optical bistability in a driven ensemble of Rydberg atoms. By performing two experiments with thermal vapors of rubidium and cesium, we are able to shed light onto the underlying interaction mechanisms causing such a non-linear behavior [1]. Due to the different properties of these two atomic species, we conclude that the large polarizability of Rydberg states in combination with electric fields of spontaneously ionized Rydberg atoms is the relevant interaction mechanism. In the case of rubidium, we directly measure the electric field in a bistable situation via two-species spectroscopy. In cesium, we make use of the different sign of the polarizability for different l-states and the possibility of applying electric fields. In contrast to previous interpretations [2, 3], both these experiments allow us to rule out dipole-dipole interactions in our realization, and support our hypothesis of a charge-induced bistability.

[1] Phys. Rev. A 94, 063820
[2] Phys. Rev. Lett. 111 113901
[3] Phys. Rev. A 93, 063863

A 36.4 Fri 15:15 HS 20

Quantum optics with a single Rydberg superatom — •Asaf Paris-Mandoki[1], Christoph Braun[1,2], Florian Christaller[1,2], Ivan Mirgorodskiy[1], Christoph Tresp[1,2], and Sebastian Hofferberth[1,2] — [1]5. Phys. Inst. and Center for Integrated Quantum Science and Technology, Universität Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany — [2]Department of Physics, Chemistry and Pharmacy, University of Southern Denmark, 5230 Odense M, Denmark

We discuss our recent experiments coupling an optical medium smaller than a single Rydberg blockade volume to a few-photon probe field. Due to the large number of atoms in the blockaded volume and the efficient coupling to the probe light mode, we achieve coherent coupling between the probe field and the effective Rydberg "superatom" even if the probe pulse contains only a few photons.

Fast dephasing between the internal degrees of freedom of the superatom allows us to realize a free-space single-photon absorber, which deterministically absorbs exactly one photon from an input pulse. We show that this system can be used for the subtraction of one photon from the input pulse over a wide range of input photon numbers. On the other hand, in the absence of dephasing, the fully blockaded ensemble undergoes collective Rabi oscillations. This enables us to study the dynamics of a single two-level system strongly coupled to a quantized light field in free space.

A 36.5 Fri 15:30 HS 20

A versatile, high-power laser system around 460nm for Rydberg excitation of ultracold potassium — •Alda Arias, Stephan Helmrich, Christoph Schweiger, Lynton Ardizzone, Graham Lochead, and Shannon Whitlock — Physikalisches Institut, Universität Heildeberg, Im Neuenheimer Feld 226, 69120 Heidelberg

The development of precise laser sources over the past few decades has enabled almost full control over the ground state properties of ultracold atoms, as well as single-atom electronic properties including Rydberg states. In this talk I will present a versatile laser source emitting more than 1.5W of single frequency light around 460nm. The system consists of a commercial Titanium-Sapphire laser with resonant cavity frequency doubling, stabilized to an external reference cavity and a saturated absorption spectroscopy reference. This laser system is ideally suited for atomic physics experiments such as two-photon excitation of Rydberg states of potassium with principal quantum numbers $n > 18$. We perform two-photon spectroscopy of the Rydberg states of ultracold potassium in a magneto-optical trap, observing strong loss features that corresponds to the excitation of s and d states, as well as transitions to dipole forbidden p and higher-l states caused by mixing from a small electric field.

A 36.6 Fri 15:45 HS 20

Monte-Carlo approach to calculate ionization dynamics of dense plasmas within particle-in-cell simulations — •Dong Wu and Stephan Fritzsche — Helmholtz Institut Jena

A physical model based on a Monte-Carlo approach is proposed to calculate the ionization dynamics of dense plasmas within particle-in-cell simulations, and where the impact (collision) ionization (CI), electron-ion recombination (RE) and ionization potential depression (IPD) by surrounding plasmas are taken into consideration self-consistently. When compared with other models, which are applied in the literature for plasmas near thermal equilibrium, the temporal relaxation of ionization dynamics can also be simulated by the proposed model. Besides, this model is general and can be applied for both single elements and alloys with quite different compositions. The proposed model is implemented into a particle-in-cell (PIC) code, with (final) ionization equilibriums sustained by competitions between CI and its inverse process (i.e., RE). Comparisons between the full model and model without IPD or RE are performed. Our results indicate that for bulk aluminium at temperature of 1 to 1000 eV, i) the averaged ionization degree increases by including IPD; while ii) the averaged ionization degree is significantly over estimated when the RE is neglected. A direct comparison from the PIC code is made with the existing models for the dependence of averaged ionization degree on thermal equilibrium temperatures, and shows good agreements with that generated from Saha-Boltzmann model or/and FLYCHK code.

A 36.7 Fri 16:00 HS 20

Long-range quantum gate via Rydberg states of atoms in a thermal microwave cavity — •Lorinc Sárkány[1], József Fortágh[1], and David Petrosyan[2,3] — [1]Eberhard Karls Universität Tübingen, Physikalisches Institut, Auf der Morgenstelle 14, D-72076 Tübingen, Germany — [2]Institute of Electronic Structure and Laser, FORTH, GR-71110 Heraklion, Crete, Greece — [3]Aarhus Institute of Advanced Studies, Aarhus University, DK-8000 Aarhus C, Denmark

We propose a universal quantum gate based on two spatially separated Rydberg atoms coupled through a non-resonant microwave cavity, which may be in any superposition or mixture of photon number states. Quantum interference of different transition paths from the two-atom ground to the double-excited Rydberg states involving a single microwave photon exchange through the cavity makes both the transition amplitude and resonance largely insensitive to cavity excitations. Our scheme for attaining ultra-long-range interactions and entanglement also applies to mesoscopic atomic ensembles in the Rydberg blockade regime and is scalable to many ensembles trapped within a centimeter-sized microwave resonator.