A 46: Ultra-cold plasmas and Rydberg systems (with Q)

Time: Friday 11:00–12:30 Location: F 428

A 46.1 Fri 11:00 F 428

Periodic emission of entangled Rydberg atoms from superatomic Rydberg clouds — •Michael Genkin, Sebastian Wüster, Sebastian Möbius, Alexander Eisfeld, and Jan Michael Rost — MPI für Physik komplexer Systeme, 01187 Dresden, Germany

We consider a scheme in which dipole-dipole interactions between coherently Rydberg-excited atom clouds (superatoms) are used to generate periodic emission of entangled atom pairs. As demonstrated in earlier work [1], the dipole-dipole interactions between two such clouds can lead to their break up by emission of a single atom pair. In this scenario, the entire, initially coherently shared Rydberg excitation, is eventually localized on the emitted atoms. We propose a setup in which this feature is employed to generate a source for entangled atoms pairs, by periodically re-exciting the remaining ground state atoms to a superatomic state. Depending on the prepared initial state, the entanglement can be encoded either in the motion of the atoms or in the angular quantum number of the Rydberg excitation. Our preliminary findings suggest that above-kHz emission rates can be reached.

[1] S. Möbius *et al*, arXiv:1212.1267 [physics.atom-ph]

A 46.2 Fri 11:15 F 428

The Role of Conical Intersections in flexible Rydberg aggregates — •Karsten Leonhardt, Sebastian Wüster, and Jan Michael Rost — Max Planck Institute for the Physics of Complex Systems

Transport of electronic excitation is a very important mechanism in nature, e.g. Photosynthesis [1]. It was shown that in linear flexible Rydberg aggregates [2] localized excitons connects the electronic excitation and entanglement transport with atomic motion [3,4]. Here we study linear Rydberg chains perpendicular to each other in a 2D plane. Conical intersections then become relevant for the dynamics, without the need of a ring confinement [5]. We show that this feature leads to a highly nonadiabatic dynamic and an entanglement of motion.

References

[1] R. van Grondelle,V.I. Novoderezhkin, *Phys. Chem. Chem. Phys.* **8**, 793 (2006).
[2] C. Ates, A. Eisfeld, J-M. Rost, *New. J. Phys.* **10**, 045030 (2008).
[3] S. Wüster, C. Ates, A. Eisfeld, J-M. Rost, *Phys. Rev. Lett.* **105**, 195392 (2010).
[4] S. Möbius, S. Wüster, C. Ates, A. Eisfeld, J-M. Rost, *J. Phys. B.* **44**, 184011 (2011).
[5] S. Wüster, A. Eisfeld, J-M. Rost, *Phys. Rev. Lett.* **106**, 153002 (2011).

A 46.3 Fri 11:30 F 428

Electrical read out for coherent phenomena involving Rydberg atoms in thermal vapor cells — •Daniel Barredo, Harald Kübler, Renate Daschner, Robert Löw, and Tilman Pfau — 5. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70550 Stuttgart, Germany

In Rydberg ensembles, coherent excitation, control and detection of highly excited states are key requisites for proposed applications in quantum information processing. For room temperature applications, Electromagnetically Induced Transparency (EIT) has been, to date, the standard tool for coherent detection of highly excited Rydberg states [1].

Here we report on a very sensitive and scalable method to measure coherent phenomena involving Rydberg atoms in vapor cells [2]. We demonstrate that the detection of the Rydberg ionization current in a vapor cell provides a direct measure of Rydberg state populations (in contrast to coherences probed by EIT) with superior signal-to-noise ratios compared to purely optical techniques. This opens up new and alternative routes to study interacting Rydberg ensembles in thermal vapor cells. We will discuss some possible applications of this new technique and future directions.

[1] A. K. Mohapatra, T. R. Jackson, and C. S. Adams. *Phys. Rev. Lett.* **98** 113003 (2007).
[2] D. Barredo, H. Kübler, R. Daschner, R. Löw, and T. Pfau. *arXiv:1209.6550* (2012).

A 46.4 Fri 11:45 F 428

Observation of spatially ordered structures in a two-dimensional Rydberg gas — •Peter Schauss[1], Marc Cheneau[1], Manuel Endres[1], Takeshi Fukuhara[1], Sebastian Hild[1], Ahmed Omran[1], Thomas Pohl[2], Christian Gross[1], Stefan Kuhr[1,3], and Immanuel Bloch[1,4] — [1]Max-Planck-Institut für Quantenoptik, 85748 Garching — [2]Max-Planck-Institut für Physik komplexer Systeme, 01187 Dresden — [3]University of Strathclyde, SUPA, Glasgow G4 0NG, UK — [4]Ludwig-Maximilians-Universität, 80799 München

The ability to control and tune interactions in ultra-cold atomic gases has paved the way for the realization of new phases of matter with short-range interactions. Rydberg atoms are highly suited to extend the scope to long-range interacting systems due to the much stronger van der Waals forces between them.

Here we report on the experimental observation of strong correlations between laser-excited Rydberg atoms using a high-resolution optical detection scheme.

The measurements reveal the emergence of spatially ordered excitation patterns with random orientation, but well-defined geometry in the high-density components of the prepared many-body state. In combination with single-site addressing the developed Rydberg atom imaging techniques will enable further well-controlled experiments with Rydberg gases on the single-atom level.

[1] P. Schauß et al., Nature 491, 87 (2012)

A 46.5 Fri 12:00 F 428

Generating Lévy stable disorder from a random enviroment — •Sebastian Möbius[1], Sebastiaan M. Vlaming[1,2], Victor A. Malyshev[2], Jasper Knoester[2], and Alexander Eisfeld[1] — [1]Max Planck Institute for Physics of Complex Systems, Nöthnitzer Strasse 38, D-01187 Dresden, Germany — [2]Centre for Theoretical Physics and Zernike Institute for Advanced Materials, University of Groningen, Nijenborgh 4, 9747 AG Groningen, The Netherlands

Assemblies of molecules or atoms, that are coupled via long range resonant transition dipole-dipole interaction, exhibit extraordinary absorption properties. In the presence of an environment, that leads to static Gaussian energy fluctuations of the individual constituents, a narrowing of the absorptions band is observed. Recent studies [1] have shown, that Levy stable distributions (LSD), a generalization of the Gaussian case, may also lead to a broadening of the absorption band.

Assemblies of Rydberg exited atoms are an ideal system, to experimentally study the proposed effects of the LSD. The large polarizability of Rydberg atoms allow for a strong interaction with an environment, e.g. polar background gas. The resulting energy fluctuations, due to Stark shifts, will be distributed according to a LSD.

[1] A. Eisfeld, S.M. Vlaming, V.A. Malyshev, J. Knoester, PRL **105**, 137402 (2010)

A 46.6 Fri 12:15 F 428

Coherent molecule formation in anharmonic waveguides due to inelastic confinement-induced resonances — •Simon Sala[1], Gerhard Zürn[2], Thomas Lompe[2], Andre N. Wenz[2], Simon Murmann[2], Friedhelm Serwane[2], Selim Jochim[2], and Alejandro Saenz[1] — [1]AG Moderne Optik, Institut für Physik, Humboldt-Universität zu Berlin, Newtonstrasse 15, 12489 Berlin, Germany — [2]Physikalisches Institut, Ruprecht-Karls-Universität Heidelberg, Germany

Ultracold atomic systems of reduced dimensionality show intriguing phenomena like fermionization of bosons in the Tonks-Girardeau gas or confinement-induced resonances (CIR). The latter allow for a manipulation of the effective 1D interaction strength in a 3D system of large anisotropy. It was proposed [1] that inelastic CIR, which originate from a coupling of center-of-mass and relative motion due an anharmonicity of the trapping potential, lead to losses in a recent experiment. However, also other mechanism were proposed to explain the losses. Here, it is demonstrated that the coupling of center-of-mass and relative motion leads to a coherent coupling of a state of an unbound atom pair and a molecule in agreement with the theory predicting inelastic CIR. Performing an experiment with exactly two particles allows for a direct observation of molecules under exclusion

of three-body losses. Moreover, it is shown that molecule formation is absent at an elastic CIR. This has consequences for the interpretation of loss experiments in low dimensional systems.

[1] S. Sala et al., Phys. Rev. Lett. 109, 073201 (2012).