A 49: Ultra-cold plasmas and Rydberg systems

Time: Friday 14:00–15:30 Location: V57.03

A 49.1 Fri 14:00 V57.03

Dynamical phases and intermittency of a dissipative Rydberg lattice gas — •Cenap Ates, Beatriz Olmos, Juan P. Garrahan, and Igor Lesanovsky — School of Physics and Astronomy, The University of Nottingham, Nottingham, NG7 2RD, United Kingdom

Taking into account the radiative decay of Rydberg states, we use a Rydberg lattice gas to implement a dissipative quantum Ising model. For a certain range of values of the spin-spin coupling, transverse magnetic field and dissipation rate, we identify a first order dynamical phase transition between active and inactive *dynamical phases*. We demonstrate that dynamical phase-coexistence becomes manifest in an intermittent behavior of bath quanta emission. Moreover, we illuminate the connection between the dynamical order parameter that quantifies activity, and the longitudinal magnetization that conventionally serves as static order parameter. We investigate the dynamical phases of the system using the concept of "thermodynamics of quantum jump trajectories" on a mean field level. The physical picture thus obtained is fully supported by Quantum Jump Monte Carlo simulations.

A 49.2 Fri 14:15 V57.03

Realization of Newton's cradle with interaction-blockaded atom clouds — Sebastian Möbius[1], •Michael Genkin[1], Sebastian Wüster[1], Alexander Eisfeld[1,2], and Jan Michael Rost[1] — [1]Max-Planck-Institut für Physik komplexer Systeme, 01187 Dresden, Germany — [2]Harvard University, Cambridge, MA 02138, USA

The remarkable properties of Rydberg atoms, such as long lifetimes, large polarizability and strong long-range interactions, make them a promising medium for quantum transport. As recently proposed [1], beyond classical (energy, momentum) also purely quantum mechanical (coherence, entanglement) properties can be adiabatically transported along a flexible chain of Rydberg atoms, reminiscent of Newton's cradle. However, an experimental realization of such a single atom chain is quite challenging. Here, we extend the scheme to a chain of Rydberg-blockaded atom clouds and study their dynamics induced by resonant dipole-dipole interactions. We first consider frozen nuclei, where dephasing due to static disorder is observed. Subsequently, we include atomic motion in the framework of a quantum-classical hybrid method. It is found that in such a setup only one atom from each trap would effectively participate in the transfer dynamics, and the bulk clouds remain stationary. We conclude that blockaded atom clouds facilitate an experimental realization of the Newton's cradle type of entanglement transport, since they overcome the need for single atoms.

[1] S. Wüster, C. Ates, A. Eisfeld and J.M. Rost, Phys. Rev. Lett. 105, 053004 (2010)

A 49.3 Fri 14:30 V57.03

Amplifying single impurities immersed in a gas of ultracold atoms — •Beatriz Olmos[1], Weibin Li[1], Sebastian Hofferberth[2], and Igor Lesanovsky[1] — [1]Midlands Ultracold Atom Research Centre (MUARC), School of Physics and Astronomy, University of Nottingham, Nottingham, NG7 2RD, United Kingdom — [2]5. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, D-70569 Stuttgart, Germany

We present a method for amplifying a single or scattered impurities immersed in a background gas of ultracold atoms so that they can be optically imaged and spatially resolved. Our approach relies on a Raman transfer between two stable atomic hyperfine states that is conditioned on the presence of an impurity atom. The amplification is based on the strong interaction among atoms excited to Rydberg states. We perform a detailed analytical study of the performance of the proposed scheme with particular emphasis on the influence of inevitable many-body effects.

A 49.4 Fri 14:45 V57.03

Many body physics using alkaline-earth atoms — •Rick Mukherjee[1], James Millen[2], Rejish Nath[3], Matthew Jones[2], and Thomas Pohl[1] — [1]Max Planck Institute for the Physics of Complex Systems, Dreden, Germany — [2]Durham University, United Kingdom — [3]Institute for theoretical physics, University of Innsbruck

We show that alkali earth metals offer a promising possibility of trapping ions as well as atoms in ground and highly excited Rydberg states in a common lattice potential [1]. Considering optical core-dressing, we identify experimentally accessible magic wavelengths to achieve this simultaneous trapping for the case of Strontium. We discuss various loss mechanisms and show that the additional lattice potential does not induce additional lifetime limitations even for rather large trapping frequencies. By exploiting the Rydberg interactions, applications for studying many-body dynamics such as generating many-body entanglement are also discussed.

[1] R Mukherjee, J Millen, R Nath, M Jones, T Pohl J. Phys. B 44, 184010 (2011)

A 49.5 Fri 15:00 V57.03

Three-Photon Rydberg Excitation in a Thermal Vapour — •Christopher Carr, Kevin Weatherill, and Charles Adams — Department of Physics, Durham University, Durham, DH1 3LE, England

We perform three-photon excitation to highly excited Rydberg states in a thermal Caesium vapour. The three-photon excitation scheme provides a coherent and non-destructive probe of the Rydberg state using inexpensive diode lasers at convenient wavelengths.

We have demonstrated the compensation of Doppler broadening by velocity-dependent light shifts in three-photon Rydberg electromagnetically induced transparency (EIT). Additionally, we study the strong atom-atom interactions which occur at high atomic densities by confining the atomic sample in a thin cell. These interactions lead to asymmetric frequency-shifted lineshapes in the absorption spectrum.

References:

[1] S. Reynaud, *et al.*, Phys. Rev. Lett **42** 756 (1979)
[2] R P Abel, *et al.*, Phys. Rev. A **84** 023408 (2011)
[3] C Carr, *et al.*, Polarization spectroscopy of an excited state transition, accepted for publication in Optics Letters (2011)

A 49.6 Fri 15:15 V57.03

A fat Schrödinger's cat of Rydberg dressed atomic clouds — Sebastian Möbius, Michael Genkin, Alexander Eisfeld, •Sebastian Wüster, and Jan-Michael Rost — Max Planck Institute for the Physics of Complex Systems, Nöthnitzer Strasse 38, 01187 Dresden, Germany

We propose Schrödinger's cat-states of hundreds of atoms, in a spatial superposition of locations micrometers apart, which would come closer to the original than even the impressive recent experimental progress, e.g. [1].

In Rydberg dressed ultra-cold gases, ground state atoms inherit properties of the admixed Rydberg state, such as long-range hyperfine state-dependent interactions [2-4]. We present an idea, how a pair of atomic clouds can evolve into a spatial Schrödinger's cat state under the influence of these interactions. The two clouds, containing about 50-100 atoms each, are then in a coherent superposition of two discrete locations, separated by micrometers. The same interactions responsible for this spatial state, can also be exploited to create the initially required entanglement in hyperfine space.

[1] S. Gerlich et al., Nature Comm. 2, 263 (2011).
[2] L. Santos, G. V. Shlyapnikov, P. Zoller, and M. Lewenstein, Phys. Rev. Lett. 85, 1791 (2000).
[3] M. Müller, L. Liang, I. Lesanovsky, and P. Zoller, New J. Phys. 10, 093009 (2008).
[4] S. Wüster, C. Ates, A. Eisfeld, and J. Rost, New J. Phys. 13, 073044 (2011).