Q 56: Poster III

Time: Thursday 16:00–18:30 Location: Empore Lichthof

Q 56.1 Thu 16:00 Empore Lichthof

Development of a laser system for coupling quantum gases with optical cavities — •Moonjoo Lee, Julian Leonard, Leigh Martin, Christian Zosel, Tilman Esslinger, and Tobias Donner — Institute for Quantum Electronics, ETH Zürich

Quantum gases coupled with high-finesse optical cavities opened a new way in exploring quantum many-body systems with long-range interactions. Extreme coupling rates on the order of GHz are achievable in these systems, but demand for lasers sources with wide range tunability while having very narrow linewidths.

We employ two diode lasers, one of them to probe/pump the system at 780 nm and the other to lock cavities at 830 nm. The absolute frequency of the probe laser is offset locked onto a frequency comb. Frequency stabilization to linewidths below 50 kHz is achieved by locking both lasers onto a transfer cavity. The frequency of the stabilized lasers are tunable by several GHz via wideband electro-optic modulators and one sideband is filtered out by using a cleaning cavity.

We are also presenting our progress in fabricating crossed high-finesse cavities which offer possibilities for nondestructive probing of quantum phases and for the realization of the multimode Dicke Hamiltonian.

Q 56.2 Thu 16:00 Empore Lichthof

Cavity assited momentum transfer in a Bose-Einstein condensate — •Hans Kessler, Jens Klinder, Matthias Wolke, Hannes Winter, and Andreas Hemmerich — ILP, Universität Hamburg

Conventional laser cooling relies on repeated electronic excitations by near-resonant light, which constrains its area of application to a selected number of atomic species prepared at moderate parti- cle densities. Optical cavities with a Purcell factor exceeding unity allow to implement laser cooling schemes using off-resonant light-scattering, which avoid the limitations imposed by spontaneous emis- sion. Here, we report on an atom-cavity system, combining a Purcell factor around 40 with a cavity bandwidth (9 kHz) below the recoil frequency associated with the kinetic energy transfer in a single pho- ton scattering event (14 kHz). This lets us access a yet unexplored fundamental quantum mechanical regime of atom-cavity interactions, in which the atomic motion can be manipulated by targeted dissi- pation with sub-recoil resolution. We demonstrate cavity-induced heating of a of 87Rb Bose-Einstein condensate and subsequent cooling at particle densities and temperatures incompatible with conven- tional laser cooling.

Q 56.3 Thu 16:00 Empore Lichthof

Nonthermal Fixed Points and Superfluid Turbulence in an Ultracold Bose Gas — Sebastian Erne[1,2], •Markus Karl[1,2], Steven Mathey[1,2], Boris Nowak[1,2], Nikolai Philipp[1,2], Jan Schole[1,2], and Thomas Gasenzer[1,2] — [1]Institut für Theoretische Physik, Ruprecht-Karls-Universität Heidelberg, Philosophenweg 16, 69120 Heidelberg — [2]ExtreMe Matter Institute EMMI, GSI Helmholtzzentrum für Schwerionenforschung GmbH, Planckstraße 1, 64291 Darmstadt, Germany

Turbulence appears in situations in which, *e.g.*, an energy flux goes from large to small scales where finally the energy is dissipated. As a result the distribution of occupation numbers of excitations follows a power law with a universal critical exponent. The situation can be described as a nonthermal fixed point of the dynamical equations. Single-particle momentum spectra for a dynamically evolving Bose gas are analysed using semi-classical simulations and quantum-field theoretic methods based on effective-action techniques. These give information about possible universal scaling behaviour. The connection of this scaling with the appearance of topological excitations such as solitons and vortices in one-component gases and domain walls and spin textures in multi-component systems is discussed. For the one-dimensional case, a random-soliton model provides analytical results for the spectra, and their relation to those found in a field-theory approach to strong wave turbulence is discussed. The results open a view on a possibility to study nonthermal fixed points and superfluid turbulence in experiment without the necessity of detecting solitons and vortices in situ.

Q 56.4 Thu 16:00 Empore Lichthof

The Multi-Layer Multi-Configuration Time-Dependent Hartree Method for Ultra-Cold Bosons — •Sven Krönke[1,2], Lushuai Cao[1,2], Oriol Vendrell[2,3], and Peter Schmelcher[1,2] — [1]Zentrum für Optische Quantentechnologien, Universität Hamburg, Germany — [2]The Hamburg Centre for Ultrafast Imaging, Germany — [3]Center for Free-Electron Laser Science, DESY, Hamburg, Germany

We develop and apply the multi-layer multi-configuration time-dependent Hartree method for bosons (ML-MCTDHB), which represents a highly flexible tool for investigating the quantum many-body dynamics of ultra-cold bosonic multi-species systems out of equilibrium in arbitrary dimensions.

Being an ab initio method for solving the time-dependent Schrödinger equation, ML-MCTDHB takes all correlations into account. The multi-layer feature of ML-MCTDHB allows for tailoring the wave function ansatz in order to describe intra- and inter-species correlations accurately and efficiently. To show the beneficial scaling and the efficiency of the method, we explore the correlated dynamics of three species tunneling in a double well trap. We demonstrate and analyze in detail the build up of inter- and intra-species correlations in the course of the quantum dynamics as well as signatures of equilibration.

Q 56.5 Thu 16:00 Empore Lichthof

Non-equilibrium Functional Renormalization for Driven Open Many-Body Quantum Systems — •Lukas M. Sieberer[1], Ehud Altman[2], Sebastian D. Huber[3], and Sebastian Diehl[1,4] — [1]Institute for Theoretical Physics, University of Innsbruck, 6020 Innsbruck, Austria — [2]Department of Condensed Matter Physics, Weizmann Institute of Science, Rehovot 76100, Israel — [3]Institute for Theoretical Physics, ETH Zurich, 8093 Zurich, Switzerland — [4]Institute for Quantum Optics and Quantum Information of the Austrian Academy of Sciences, 6020 Innsbruck, Austria

We study phase transitions in bosonic driven-dissipative systems with competing dissipative and unitary dynamics, describing a natural long-wavelength model for pumped quantum systems such as exciton-polariton condensates or cold atomic systems with optical Feshbach resonances. In three spatial dimensions, these systems thermalize at low frequencies and exhibit universal critical behavior governed by an interacting Wilson-Fisher fixed point. We identify a new and independent non-equilibrium critical exponent, measuring the fade-out of the microscopic competition of unitary and dissipative dynamics.

The starting point of our analysis is a description of the driven-dissipative dynamics by a Markovian many-body master equation which we map to a Keldysh functional integral partition function. The Keldysh technique provides an excellent framework to put into practice a functional renormalization group approach for the study of criticality in non-equilibrium stationary states.

Q 56.6 Thu 16:00 Empore Lichthof

Exchange-driven crystallization of Rydberg-dressed atoms — •Fabio Cinti[1], Massimo Boninsegni[2], Nils Henkel[1], and Thomas Pohl[1] — [1]Max Planck Institute for the Physics of Complex Systems, 01187 Dresden, Germany — [2]Department of Physics, University of Alberta, Edmonton, Alberta, Canada T6G 2J1

We study the physics of Bosonic atoms with long-range interactions, induced by optical dressing to high-lying Rydberg states. Using first-principle quantum Monte Carlo techniques, we construct the finite-temperature phase diagram, which is shown to be universal over a wide range of experimentally relevant parameters that promote superfluid, supersolid as well as insulating crystal phases. Surprisingly, we find that quantum exchange, which commonly tends to cause delocalization, stabilizes the crystalline phase as compared to an analogous quantum system composed distinguishable particles. We provide an intuitive picture for the mechanism behind this unexpected behavior and draw a connection to the peculiar shape of the interaction potential induced by Rydberg-dressing.

Q 56.7 Thu 16:00 Empore Lichthof

Evolution of Bose-Einstein condensates in a gravitational cavity — •Javed Akram[1] and Axel Pelster[2] — [1]Fachbereich Physik, Freie Universität Berlin, Germany — [2]Fachbereich Physik, Technische Universität Kaiserslautern, Germany

We investigate both the static and dynamic properties of weakly interacting Bose-Einstein condensates (BEC) in an one-dimensional gravitational cavity. There the effect of gravity is compensated by an exponentially decaying potential, which is created by the total internal reflection of an incident laser beam from the surface of a dielectric serving as a mirror for the atoms. By solving the underlying Gross-Pitaevskii equation with a variational Gaussian condensate wave function, we derive a coupled set of differential equations for the width and the height of the condensate. By considering small deflections around the respective equilibrium positions, we determine the collective excitations of the BEC. Furthermore, we analyze how the BEC cloud expands ballistically due to gravity after switching off the evanescent laser field.

Q 56.8 Thu 16:00 Empore Lichthof

Supersolidity in rotating Rydberg-dressed Bose-Einstein condensates — •Nils Henkel[1], Fabio Cinti[1], Piyush Jain[2], Guido Pupillo[3,4], and Thomas Pohl[1] — [1]Max Planck Institute for the Physics of Complex Systems, Dresden — [2]Department of Physics, University of Alberta, Edmonton, Alberta, Canada — [3]IQOQI and Institute for Theoretical Physics, University of Innsbruck, 6020 Innsbruck, Austria — [4]ISIS and IPCMS, Université de Strasbourg and CNRS, Strasbourg, France

We study two-dimensionally confined Bose-Einstein condensates in which long-range soft-core interactions are induced by optical dressing to high-lying Rydberg states [1]. Based on Quantum Monte Carlo simulations, we demonstrate that this system facilitates the preparation of supersolid states and show that many of their features can be described within a simplified mean field approach. Using the latter we investigate the rotation-induced formation of vortex structures [2]. Our calculations reveal an interesting interplay of length scales of the supersolid crystal and the vortex lattice which leads to a rich spectrum of spatial patterns. For certain parameters we find a commensurate vortex lattice superimposed on the underlying supersolid crystal, which provides an experimental means to probe superfluidity and thereby to verify supersolidity in such systems.

[1] N. Henkel, R. Nath and T. Pohl, Phys. Rev. Lett. **106**, 195302 (2010)
[2] N. Henkel et al., Phys. Rev. Lett. **108**, 265301 (2012)

Q 56.9 Thu 16:00 Empore Lichthof

Periodic Potentials for photon gases in dye-filled optical microcavities — •Tobias Damm, David Dung, Julian Schmitt, Cesar Cabrera, Frank Vewinger, Jan Klaers, and Martin Weitz — Institut für Angewandte Physik, Universität Bonn

In earlier works of our group, a thermalized photon gas and a transition to a Bose-Einstein condensate of photons has been realized in a dye-filled optical microcavity. A number-conserving thermalization of the photon gas in this system is achieved by repeated absorption and emission processes of dye-molecules.
Here we report on a method to imprint a spatially periodic or even arbitrary confining potential onto the photon gas. We add a second dye species with very low quantum efficiency whose absorption is spectrally shifted from the observed spectral regime of the condensate. By spatially controlled optical irradiation with a laser beam tuned to the absorption resonance of the "heating" dye, a variable modulation of the refrective index inside the cavity is achieved due to the thermo-optical effect. With this method double-well potentials as well as periodic lattices seem to be possible, and we plan to investigate Josephson oscillation and the Mott Insulator with effectively interacting photon gases in the medium.

Q 56.10 Thu 16:00 Empore Lichthof

Bogoliubov modes at the edge of a BEC — Aboulaye Diallo and •Carsten Henkel — Institute of Physics and Astronomy, Universität Potsdam

The quantum field theory of Bose-Einstein condensed gases can be efficiently built from the solutions to the Bogoliubov-de Gennes (BdG) equations. Indeed, they provide the quantum depletion of the condensate at zero temperature, the density of thermally excited particles, and higher correlation properties like the anomalous average. We study BdG solutions at the edge of a condensate, as a generalization of the wave mechanics in a linear potential. The condensate is described by a generalized Airy function (second Painlevé transcendant) that connects smoothly to the Thomas-Fermi profile [1]. The BdG equations are solved numerically and compared to the local density approximation. We apply symplectic techniques from Hamiltonian mechanics to enforce physical (stable) solutions. The scattering phase of the BdG modes helps to clarify the role of the potential well near the condensate boundary that appears in the Hartree-Fock approximation.

[1] F. Dalfovo, L. Pitaevskii, and S. Stringari, *Phys. Rev. A* **54** (1996) 4213; D. Margetis, *Phys. Rev. A* **61** (2000) 055601.

Q 56.11 Thu 16:00 Empore Lichthof

Characterization of solitonic states in a trapped ultracold Bose gas — •Sebastian Erne[1,2], Boris Nowak[1,2], and Thomas Gasenzer[1,2] — [1]Institut für Theoretische Physik, Ruprecht-Karls-Universität Heidelberg, Philosophenweg 16, 69120 Heidelberg — [2]ExtreMe Matter Institute EMMI, GSI Helmholtzzentrum für Schwerionenforschung GmbH, Planckstraße 1, 64291 Darmstadt, Germany

We study the dynamics of solitonic excitations in a finite size ultracold Bose gas out of equilibrium in one spatial dimension and propose an interpretation of this state in terms of turbulence. Of particular interest are non-trivial finite size effects found in the momentum distribution, in the form of characteristic multi-peak structures. We analytically describe the state within a model of randomly distributed solitons and address the possibilities for an experimental observation of the solitonic state via statistical simulations using the classical field equations. Different scenarios including an anharmonicity of the trapping potential and the measurement of the one particle momentum distribution through the free expansion of the gas are discussed. The results give detailed insight into the dynamics of solitons in these systems.

Q 56.12 Thu 16:00 Empore Lichthof

Dynamics of quantum-systems with localized dissipation — •Andreas Vogler, Ralf Labouvie, Felix Stubenrauch, Giovanni Barontini, Vera Guarrera, and Herwig Ott — Research Center OPTIMAS, Fachbereich Physik, Technische Universität Kaiserslautern

This Poster addresses the experimental investigation of various quantum systems, subjected to localized dissipative defects.
In our experiment, we are employing a tightly focussed scanning electron-beam, which ionizes atoms of an atomic cloud by electron-impact ionization. The produced ions are then extracted by means of electrostatic optics and detected. This allows us to probe atomic density distributions with high temporal and spatial resolution. Furthermore, the electron-beam is a versatile tool to manipulate the atomic ensemble. It yields the possibility for localized dissipative defects and the preparation of non-equilibrium states. The obtained ion-signal shows the system's reaction on the defect, and allows to measure pair-correlations and Zeno-like behaviour. In addition, subsequently obtained density-profiles allow for a in-vivo investigation. We probe various quantum-systems, ranging from weakly interacting BECs to strongly interacting 1D gases in optical lattices.

Q 56.13 Thu 16:00 Empore Lichthof

Towards local probing of ultracold Fermi gases — •Jonas Siegl, Kai Morgener, Wolf Weimer, Klaus Hueck und Henning Moritz — Institut für Laserphysik, Universität Hamburg Luruper Chaussee 149, 22761 Hamburg

Ultracold fermionic gases are an ideal model system for the study of quantum many-body phenomena. Of particular interest are two-dimensional strongly correlated systems which can exhibit superfluidity and Berezinskii-Kosterlitz-Thouless-type transitions.
Here we present our new experimental setup aimed at studying two-dimensional strongly interacting Fermi gases. Lithium atoms are laser-cooled and transferred into a resonator enhanced dipole trap. Due to the large volume and depth of this resonator trap, we achieve transfer efficiencies of up to 50%. For final evaporative cooling to quantum degeneracy, we transfer the atoms into a running wave dipole trap.
The atoms will be studied and controlled with a high resolution imaging system for which we have achieved a resolution of 660nm. The current status of the experiment will be presented.

Q 56.14 Thu 16:00 Empore Lichthof

Towards ultracold fermions in a 2D honeycomb lattice — •Thomas Paintner, Daniel Hoffman, Tobias Lupfer, Wladimir Schoch, Wolfgang Limmer, Benjamin Deissler und Johannes Hecker Denschlag — Universität Ulm, Institut für Quantenmaterie, Albert-Einstein-Allee 45, 89081 Ulm

We are setting up a new experiment with ultracold fermionic atoms in a two-dimensional honeycomb lattice to investigate intriguing phenomena which are either related to relativistic quantum physics(e.g. Zitterbewegung, Klein tunnelling) or to condensed matter physics (quantum

criticality, quantum spin liquid). This system has the underlying geometry of graphene, but can be tuned and controlled in a much greater range. In the experiment, a degenerate Fermi gas of ^{6}Li will be created after laser cooling in a magneto-optical trap (MOT) and subsequent evaporative cooling in the vicinity of a Feshbach resonance in a strong optical dipole trap. The atoms will then be transferred optically into a glass cell, where they will be loaded into a two-dimensional honeycomb potential. We plan to use a site-resolved imaging technique in order to manipulate the particles and analyze their distribution in the lattice. We will show the experimental progress towards a degenerate Fermi gas.

Q 56.15 Thu 16:00 Empore Lichthof

A Versatile Setup for the Investigation of Ytterbium Quantum Gases — •A. Thobe, S. Dörscher, B. Hundt, A. Kochanke, C. Becker, and K. Sengstock — Zentrum für Optische Quantentechnologien, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

Quantum gases of alkaline-earth like atoms such as Calcium, Strontium and Ytterbium (Yb) open up exciting new possibilities for the study of many body physics in optical lattices, ranging from SU(N) symmetric spin Hamiltonians to the Kondo Lattice Model.
Here, we present a new setup for the investigation of bosonic and fermionic Yb quantum gases in a triangular optical lattice. This is the first apparatus to prepare quantum gases of an alkaline earth like element in a 2D/3D-MOT scheme. Atoms from the 2D-MOT, operating on the broad $^1S_0 \rightarrow {}^1P_1$ transtition, are directly loaded into the 3D-MOT operating on a narrow intercombination line. The atoms are then loaded into a crossed dipole trap, where they are evaporatively cooled to quantum degeneracy. With this setup we routinely produce BECs of $1 \cdot 10^5$ atoms and Fermi gases of $2 \cdot 10^4$ atoms at $T/T_F = 0.35$. Moreover, we report on an ultrastable laser system for precision spectroscopy on the ultranarrow $^1S_0 \rightarrow {}^3P_0$ clock transition in Yb. This laser will serve as a versatile tool for interaction sensing and selective addressing of atoms in a wavelength tunable, state selective, triangular optical lattice, which we are currently implementing.
This work is supported by DFG within SFB 925 and GrK 1355, as well as EU FETOpen (iSense).

Q 56.16 Thu 16:00 Empore Lichthof

Characterization of a new broad Feshbach Resonance in 40K — •Maria Langbecker, Dominik Vogel, Jasper Simon Krauser, Nick Fläschner, Jannes Heinze, Sören Götze, Klaus Sengstock, and Christoph Becker — Universität Hamburg, Institut für Laser-Physik, Luruper Chaussee 149, 22761 Hamburg, Germany

Quantum gases offer a wide range of applications in the field of quantum simulation due to the high tunability of crucial system parameters. One important tool are Feshbach resonances which can be used to widely control the interaction between atoms by tuning their scattering lengths.

Here we report on different methods to characterize the position, width and zero crossing of a new broad Feshbach resonance in 40 K in a spin mixture of mf = +1/2, -1/2. We identify the resonance position to be centered at 389 G with a width of 26 G. We compare loss measurements with molecule formation and the emergence of spin waves. We find that our spin-wave meassurements constitute a well suited method to determine the position as well as the zero crossing of a Feshbach resonance.

Our results open the route for future studies of high-spin mixtures of fermionic Potassium. This work is supported by DFG within FOR 801.

Q 56.17 Thu 16:00 Empore Lichthof

Single-branch theory of ultracold Fermi gases with artificial Rashba spin-orbit coupling — Daniel Maldonado-Mundo, •Manuel Valiente, and Patrik Ohberg — SUPA, IPaQs, Heriot-Watt University, Edinburgh, UK

We consider interacting ultracold fermions subject to Rashba spin-orbit coupling. We construct a single-branch interacting theory for the Fermi gas when the system is dilute enough so that the positive helicity branch is not occupied at all in the non-interacting ground state. We show that the theory is renormalizable in perturbation theory and therefore yields a model of polarized fermions that avoids a multi-channel treatment of the problem. Our results open the path towards a much more straightforward approach to the many-body physics of cold atoms subject to artificial vector potentials.

Q 56.18 Thu 16:00 Empore Lichthof

A K-Rb setup for studying Fermions in optical flux lattices — •Lucia Duca[1,2], Tracy Li[1,2], Monika Schleier-Smith[1,2], Martin Reitter[1,2], Josselin Bernardoff[1,2], Hendrik Lüschen[1,2], Martin Boll[1,2], Jens Philipp Ronzheimer[1,2], Immanuel Bloch[1,2], and Ulrich Schneider[1,2] — [1]Fakultät für Physik, Ludwig-Maximilians-Universität, 80799 München, Germany — [2]Max-Planck-Institut für Quantenoptik, 85748 Garching, Germany

We present an apparatus for studying a two-dimensional degenerate Fermi gas in the presence of a strong artificial magnetic field. In this double species experiment, fermonic ^{40}K atoms are first sympathetically cooled to quantum degeneracy in a bath of bosonic ^{87}Rb atoms. The fermions are then adiabatically compressed into a single layer of a 1D-lattice, creating an isolated 2D system.

The artificial magnetic field will be realized by means of an optical flux lattice [1], which combines a spatially varying Raman coupling with a spin-dependent potential. Their combination produces a magnetic length on the order of the optical wavelength. This high-magnetic-flux system is a good candidate to access the quantum Hall regime with ultracold atoms.

We present our plans for implementing the optical flux lattice and characterizing its topological character by probing its band structure. The current status of this experimental setup and our novel 2D lattice configuration are also presented.

[1] N.R. Cooper, Phys. Rev. Lett. 106, 175301 (2011).

Q 56.19 Thu 16:00 Empore Lichthof

Correlations in one dimensional few-fermion systems — •Gerhard Zürn[1], Andre N. Wenz[1], Simon Murmann[1], Vincent Klinkhamer[1], Andrea Bergschneider[1], Thomas Lompe[1,2], and Selim Jochim[1,2] — [1]Physikalisches Institut Universität Heidelberg — [2]ExtreMe Matter Institute EMMI, GSI Darmstadt

We present experiments on few-fermion systems of ^{6}Li atoms in quasi one dimensionally confining potentials with tunable interaction. In one measurement we perform radio frequency spectroscopy to measure the energy of a single impurity particle interacting repulsively with a defined number of identical majority particles of different spin ($|\downarrow\uparrow\cdots\uparrow\rangle$). We study the crossover from a few-particle system to a many-particle system by adding majority particles one by one. We observe that already four majority particles are enough to describe the properties of the impurity by that of a polaron-like particle, i.e. by a single impurity dressed by a 1D Fermi sea. We have also performed measurements in the so-called super-Tonks regime and studied spin correlations in these systems. We have found strong indications that the system exhibits ferromagnetic correlations. Investigating attractively interacting systems we observe that for increasing interaction strength the pair correlations in the system increases. This correlation leads to a strong odd-even effect of the single particle dissociation energy similar to the one observed for nuclei.

Q 56.20 Thu 16:00 Empore Lichthof

Exploring Few-fermion Systems in a Tunable Potential — •Andrea Bergschneider, Vincent Klinkhamer, Simon Murmann, Gerhard Zürn, Thomas Lompe, and Selim Jochim — Physikalisches Institut der Universität Heidelberg

In the past two years we have built up an experimental setup to deterministically prepare small ensembles of ultracold fermions in a well-defined quantum state and use it to explore the physics of quasi-1D few-fermion systems [1, 2].

Here, we present a new setup featuring a high-resolution objective and a two-dimensional acousto-optic deflector. This upgrade gives us the capability to dynamically vary the shape of the trapping potential. We can change the aspect ratio of the confinement from quasi-1D or quasi-2D to 3D and hence continuously investigate the energetic shell structures in few-particle systems as a function of dimensionality and interaction strength. The new setup also allows the creation of multiple-well potentials and thus the investigation of few-site Hubbard physics as a bottom-up approach towards quantum magnetism.

[1] F. Serwane et al., Science 332 (336) (2011)
[2] G. Zürn et al., PRL 108, 075303 (2012)

Q 56.21 Thu 16:00 Empore Lichthof

Setup for an ultracold Bose-Fermi mixture of ^{133}Cs and ^{6}Li — •Stephan Häfner, Marc Repp, Rico Pires, Juris Ulmanis, Robert Heck, Arthur Schönhals, Eva Kuhnle, and Matthias Weidemüller — Physikalisches Institut, Ruprecht- Karls-Universität Heidelberg, Heidelberg, Germany

A mixture of ultracold ^{133}Cs and ^{6}Li atoms and molecules close to quantum degeneracy permits to study many different aspects of few and many body physics. Feshbach resonances provide a precise tunability of interspecies interactions [1]. The LiCs mixture is a particulary promising candidate to observe Efimov states [2], since it has a small universal scaling factor. Besides, the LiCs dimer has the largest dipole moment of 5.5 Debye of all stable alkali combinations [3], which can be exploited to form dipolar molecules via Feshbach association and study dipolar effects.

In this poster we will present the experimental approach and the current status of our experimental apparatus for cooling and trapping of fermionic Li and bosonic Cs atoms. The present procedure combines various cooling methods, including double species Zeeman slowing, Raman sideband cooling and forced evaporation out of an optical dipole trap that allows to prepare a Bose-Fermi mixture at microklevin temperatures.

[1] M. Repp et al., Phys. Rev. A, in press
[2] E. Braaten and H.-W. Hammer, Annals of Physics 322, 120 (2007)
[3] J. Deiglmayr et al., Phys. Rev. A 82, 032503 (2010)

Q 56.22 Thu 16:00 Empore Lichthof

Feshbach Resonances of ^{6}Li and ^{133}Cs — •Arthur Schönhals[1], Marc Repp[1], Rico Pires[1], Juris Ulmanis[1], Stephan Häfner[1], Robert Heck[1], Eva Kuhnle[1], Matthias Weidemüller[1], and Eberhard Tiemann[2] — [1]Physikalisches Institut, Ruprecht-Karls Universität Heidelberg, Germany — [2]Institut für Quantenoptik, Leibniz Universität Hannover, Germany

In this poster we present the first observation of interspecies Feshbach resonances of an ultracold Bose-Fermi mixture of ^{6}Li and ^{133}Cs in their energetically lowest spin states [1]. The mixture was prepared and loaded into an optical dipole trap, where resonances were detected as spin selective atom losses. In this way nineteen loss features could be observed and were assigned to s-and p-wave resonances by using a coupled-channel calculation. In addition, the results were compared with the Asymptotic Bound State Model.

Several of the s-wave resonances offer prospects for the investigation of a series of Efimov states, for which the mixture of ^{6}Li and ^{133}Cs is an excellent candidate due to the large mass ratio of $m_{Cs}/m_{Li} = 22$ that results in an universal scaling factor of 4.88 for $^{133}Cs_2{}^{6}Li$ [2,3].

[1] M.Repp et al., accepted for publication in Phys. Rev. A. (R), (2012)
[2] J. P. D'Incao & B.D. Esry, Phys. Rev. A **73**, 030703 (2006)
[3] E.Braaten and H.-W. Hammer, Annals of Physics **322**, 120 (2007)

Q 56.23 Thu 16:00 Empore Lichthof

Light induced spin-orbit coupling for ultra-cold neutral atoms — •Felix Kösel, Sebastian Bode, Michael Schmidt, Holger Ahlers, Katerine Posso Trujillo, Naceur Gaaloul, and Ernst M. Rasel — Institut für Quantenoptik, Hannover, Deutschland

We present the experimental efforts we pursue towards engineering a 2D spin-orbit-coupling [1] of a neutral Rubidium Bose-Einstein condensate (BEC). Using multiple Raman transitions to couple cyclically three hyperfine Zeeman states of the atoms, an effective gauge field is predicted to be created which resembles the one occurring in spintronic systems [2]. Such an artificial interaction could be used to build advanced solid state simulators with non-Abelian character in a versatile cold-atom system. The first experimental steps realized to build a BEC machine featuring a hybrid source concept [3] are presented. Possible experimental issues that could prevent a successful implementation or signature detection are discussed.

[1] Y.-J. Lin, K. Jiménez-García, and I. B. Spielman, Nature (London) 471, 83-86 (2011). [2] H. C. Koo et al., Science 325, 1515 (2009). [3] Y.-J. Lin, A. R. Perry, R. L. Compton, I. B. Spielman, and J. V. Porto, Phys. Rev. A 79, 063631 (2009).

Q 56.24 Thu 16:00 Empore Lichthof

Matter-wave scattering from interacting ultracold bosons in optical lattices — •Klaus Mayer, Alberto Rodriguez, and Andreas Buchleitner — Institut f. Physik, Universität Freiburg, Germany

We study matter-wave scattering from a system of ultracold bosons in a one-dimensional optical lattice, described by a Bose-Hubbard Hamiltonian. The phase transition from the superfluid state to the Mott Insulator is clearly displayed in the decay of the inelastic component of the scattering cross-section for increasing onsite interaction U [1]. In order to understand the role of interactions in this process, we perform a Bogoliubov expansion for small U and obtain an analytical expression for the cross-section in the weakly-interacting regime. We identify the different contributions to the inelastic scattering signal in terms of one- and two-quasiparticle excitations above the condensate in the superfluid phase. To support the analytical description, we present numerical results obtained from exact diagonalization methods.

[1] S. Sanders, F. Mintert, E. Heller, Phys. Rev. Lett. **105**, 035301 (2010)

Q 56.25 Thu 16:00 Empore Lichthof

Non-equilibrium Self-energy-functional theory and conserving approximations — •Felix Hofmann and Michael Potthoff — I. Institut für Theoretische Physik – Universität Hamburg, Hamburg, Deutschland

The self-energy-functional theory [1] provides a general framework for the systematic construction of non-perturbative, thermodynamically consistent approximations in order to study strongly correlated systems in the thermodynamical limit in and out of equilibrium and proves to respect certain conservation laws [2]. On the space of self-energies a functional can be constructed which is stationary at the physical self-energy and equals the physical grand canonical potential when evaluated at the latter. Without approximating the (formally unknown) functional, the variational principle can be evaluated by restricting the self-energies to a subspace of (numerically) solvable reference systems. This is done self consistently, such that the results are obtained in the thermodynamical limit. By choosing appropriate classes of reference systems, theories like variational-cluster-approach (VCA) and dynamical-mean-field-theory (DMFT) can be derived from SFT as well as improved variants. Likewise, SFT allows for studying phases and phase transitions (by numerical means) as for example the Mott metal-insulator transition, magnetic phase transitions or the transition from antiferromagnetic to the superconducting phase in Hubbard-like and spin models.

[1] M. Potthoff, AIP Conf. Proc. 1419, pp. 199-258 (2011)
[2] F. Hofmann and M. Potthoff, to be published

Q 56.26 Thu 16:00 Empore Lichthof

Orbital Physics with Ultracold Atoms in Higher Bands of an Optical Lattice — •Thorge Kock, Arne Ewerbeck, Robert Büchner, Matthias Ölschläger, Georg Wirth, and Andreas Hemmerich — Institut für Laser-Physik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

Atoms trapped in optical lattices have been used successfully to study many-body phenomena. However, the shape that bosonic ground-state wavefunctions can take is limited, apparently compromising the usefulness of this approach. Such limitations, however, do not apply to excited states of bosons. The study of atomic superfluids realized in higher Bloch bands, where orbital degrees of freedom are essential, can bring the world of optical lattices closer to relevant condensed matter systems. We discuss our observations of extremely long coherence times, chiral superfluid order and topological features in higher bands in a square optical lattice.

Q 56.27 Thu 16:00 Empore Lichthof

Bloch oscillations of particles with long-range interactions — •Christopher Gaul[1,2], Antonio Rodriguez[3], Rodrigo P. A. Lima[4], and Francisco Domínguez-Adame[1] — [1]GISC, Departamento de Física de Materiales, Universidad Complutense, E-28040 Madrid, Spain — [2]CEI Campus Moncloa, UCM-UPM, Madrid — [3]GISC, Departamento de Matemática Aplicada y Estadística, Universidad Politécnica, E-28040 Madrid, Spain — [4]Instituto de Física, Universidade Federal de Alagoas, Maceió, AL 57072-970, Brazil

As the two-particle problem has traditionally provided valuable insights into the full many-body phenomena, we study two particles in a lattice potential subject to an external field and to a long-range interaction. Using the semiclassical approximation, we find chaotic behavior in general, limited by several regular regimes: (i) Bloch oscillations in the relative motion, driven by the interaction, (ii) open trajectories, and (iii) independent oscillations of far away particles, driven by the external field.

Q 56.28 Thu 16:00 Empore Lichthof

Anisotropic superfluidity of bosons in optical Kagome superlattice — Tao Wang[1,2], Xue-Feng Zhang[1], •Axel Pelster[1], and Sebastian Eggert[1] — [1]Fachbereich Physik, Technische Universität Kaiserslautern, Germany — [2]Harbin Insititute of Technology, Harbin,

China

We study the quantum phase transitions for the extended Bose-Hubbard model with bosons on a Kagome superlattice which can be implemented by enhancing the long wavelength laser in one direction of the optical lattice [1]. To this end we combine the virtues of a Mean-Field theory with the Laudau theory of Ref. [2] and work out a multi-component effective potential method. By comparing the corresponding analytic results with extensive quantum Monte-Carlo simulations, we find that several striped solids emerge in this system. Due to the blockade effect of such a striped order, the resulting superfluid density turns out to be anisotropic and thus, reveals its tensional property [3]. Finally, we discuss the complete quantum phase diagram.

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[2] F. E. A. dos Santos and A. Pelster, Phys. Rev. A **79**, 013614 (2009)

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Q 56.29 Thu 16:00 Empore Lichthof

Quasirelativistic atomic Bose-Einstein Condensate in an Optical Lattice — •Martin Leder, Christopher Grossert, Tobias Salger, Sebastian Kling, and Martin Weitz — Institute for Applied Physics, University of Bonn, Germany

A proof-of-principle experiment simulating effects predicted by relativistic wave equations with ultracold atoms in a bichromatic optical lattice that allows for a tailoring of the dispersion relation is reported [1]. In this lattice, for specific choices of the relativistic phases and amplitudes of the lattice harmonics the dispersion relation in the region between the first and the second excited band becomes linear, as known for ultrarelativistic particles. One can show that the dynamics can be described by an effective one-dimensional Dirac equation [2].

We experimentally observe the analog of Klein-Tunneling, the penetration of relativistic particles through a potential barrier without the exponential damping that is characteristic for nonrelativistic quantum tunneling [3]. Both linear (relativistic) and quadratic (nonrelativistic) dispersion relations are investigated, and significant barrier transmission is only observed for the relativistic case.

References

[1] T. Salger, C. Grossert, S. Kling, and M. Weitz, Phys. Rev. Lett. 107, 240401 (2011)

[2] D. Witthaut, T. Salger, S. Kling, C. Grossert, and M. Weitz, Phys. Rev A 84, 033601 (2011)

[3] O. Klein, Z.Physik 53, pp. 157-165 (1929)

Q 56.30 Thu 16:00 Empore Lichthof

Spin interactions in ultracold many-body systems — •Johannes Zeiher[1], Peter Schauss[1], Takeshi Fukuhara[1], Sebastian Hild[1], Marc Cheneau[1], Manuel Endres[1], Christian Gross[1], Stefan Kuhr[3], and Immanuel Bloch[1,2] — [1]Max-Planck-Institut für Quantenoptik, 85748 Garching, Germany — [2]Fakultät für Physik, Ludwig-Maximilians-Universität München, 80799 München, Germany — [3]University of Strathclyde, Department of Physics, SUPA, Glasgow G4 0NG, United Kingdom

Spin Hamiltonians are used to explain a variety of different phenomena in solid state physics. Quantum simulation of such systems with ultracold gases promises deeper insight in the emerging physics.

Here we report on the realization of two kinds of effective spin Hamiltonians with ultracold Rubidium atoms in optical lattices.

Single site resolved detection enabled the direct measurement of a single spin impurity immersed into a bath of opposite spins. The measurement revealed coherent superexchange dynamics in the Heisenberg regime as well as evidence for polaronic behavior in the superfluid regime.

In a second experiment we used Rydberg atoms to realize long-range interacting effective spin systems. By high resolution optical detection we observed the emergence of spatially ordered patterns upon laser excitation of a dense 2D gas. The results pave the way towards quantum simulation of novel long-range interacting quantum systems with ultracold atoms.

Q 56.31 Thu 16:00 Empore Lichthof

Direct Measurement of the Zak phase in Topological Bloch Bands — •Monika Aidelsburger[1,2], Marcos Atala[1,2], Julio T. Barreiro[1,2], Dmitry Abanin[3], Takuya Kitagawa[3], Eugene Demler[3], and Immanuel Bloch[1,2] — [1]Fakultät für Physik, Ludwig-Maximilians-Universität, Schellingstr. 4, 80799 Munich, Germany — [2]Max-Planck Institute of Quantum Optics, Hans-Kopfermann Str. 1, 85748 Garching, Germany — [3]Department of Physics, Harvard University, 17 Oxford Str., Cambridge, MA 02138, USA

Geometric phases can characterize the topological properties of Bloch bands. In one-dimensional periodic potentials the topological invariant is given by the Zak phase – the Berry phase acquired during an adiabatic motion of a particle across the Brillouin zone. Here we will present the direct measurement of the Zak phase for a dimerized optical lattice, which models polyacetylene. The experimental protocol consists of a combination of Bloch oscillations and Ramsey interferometry. This work establishes a new general approach for probing the topological structure of Bloch bands in optical lattices.

Q 56.32 Thu 16:00 Empore Lichthof

Experimental Realization of Strong Effective Magnetic Fields with Ultracold Atoms in Optical Superlattices — •Marcos Atala[1,2], Monika Aidelsburger[1,2], Yu Ao Chen[1,2], Sylvain Nascimbène[3], Stefan Trotzky[1,2], and Immanuel Bloch[1,2] — [1]Fakultät für Physik, Ludwig-Maximilians-Universität, Schellingstr. 4, 80799 Munich, Germany — [2]Max Planck Institute of Quantum Optics, Hans-Kopfermann Str. 1, 85748 Garching, Germany — [3]Laboratoire Kastler Brossel, CNRS, UPMC, Ecole Normale Supérieure, 24 rue Lhomond, 75005 Paris, France

Ultracold atoms in optical lattices are promising candidates to study quantum many-body phenomena, such as the integer or fractional quantum Hall effect. Here we report about the experimental realization of strong effective magnetic fields, on the order of one flux quantum per plaquette, with ultracold atoms using photon assisted tunneling in an optical superlattice. When hopping in the lattice, the accumulated phase shift by an atom is equivalent to the Aharonov-Bohm phase of a charged particle exposed to a large staggered magnetic field. We studied the nature of the ground state from ist momentum distribution and observed that the frustration induced by the magnetic field can lead to a degenerate ground state for noninteracting particles. A local measurement performed in a lattice of isolated plaquettes directly revealed the quantum cyclotron orbit of a single atom exposed to the magnetic field.

Q 56.33 Thu 16:00 Empore Lichthof

Intrinsic Photoconductivity of Ultracold Fermions in Optical Lattices — •Jannes Heinze[1], Jasper Simon Krauser[1], Nick Fläschner[1], Bastian Hundt[1], Sören Götze[1], Alexander Itin[1,2,3], Ludwig Mathey[1,2], Klaus Sengstock[1,2], and Christoph Becker[1,2] — [1]Institut für Laser-Physik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany — [2]Zentrum für Optische Quantentechnologien, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany — [3]Space Research Institute, Russian Academy of Sciences, Moscow, Russia

Photoconductivity describes the change of a material's conductivity following an excitation with photons. If the photon energy is resonant with a band transition, electrons are excited from the valence band to the conduction band and an initial insulator becomes conducting. We present measurements of an analog to a persistent alternating photocurrent in an ultracold gas of fermionic atoms in an optical lattice (arXiv:1208.4020). A small fraction of the atoms is excited to the second excited band using lattice amplitude modulation, leaving holes in the lowest band. Both hole and particle excitations have a defined quasimomentum. The subsequent dynamics is induced and sustained by an external harmonic confinement. While atoms in the excited band exhibit long-lived oscillations with a momentum dependent frequency a strikingly different behavior is observed for holes in the lowest band. An initial fast collapse is followed by subsequent periodic revivals. Both observations are fully explained by mapping the system onto a nonlinear pendulum. This work is supported by DFG within FOR801.

Q 56.34 Thu 16:00 Empore Lichthof

Ultracold fermions in honeycomb optical lattices — •Thomas Uehlinger[1], Daniel Greif[1], Gregor Jotzu[1], Leticia Tarruell[1,2], and Tilman Esslinger[1] — [1]Institute for Quantum Electronics, ETH Zurich, 8093 Zurich, Switzerland — [2]LP2N UMR 5298, Univ. Bordeaux 1, Institut d'Optique and CNRS, 351 cours de la Libération, 33405 Talence, France

Ultracold Fermi gases have emerged as a versatile tool to simulate condensed matter phenomena. For example, the control of interactions in optical lattices has lead to the observation of Mott insulating phases. However, the topology of the lattice is equally important for the proper- ties of a solid. A prime example is the honeycomb lattice of graphene, where the presence of topological defects in momentum space - the Dirac points - leads to extraordinary transport properties.

We report on the investigation of Dirac points of a quantum degenerate Fermi gas of ^{40}K atoms confined in the honeycomb structure of an optical lattice with tunable topology. The lattice is created by superimposing a square lattice with an interfering superlattice, which can be continuously adjusted to create square, triangular, dimer und honeycomb structures. The band structure is studied in detail using Bloch oscillations, particularly addressing the double passing of the two Dirac points. We also report on the investigation of the effect of interactions when loading a two-component repulsively interacting Fermi gas into the newly accessible lattice geometries.

Q 56.35 Thu 16:00 Empore Lichthof

Negative absolute temperature and out-of-equilibrium dynamics of interacting bosons in optical lattices — •Michael Schreiber[1,2], Simon Braun[1,2], Jens Philipp Ronzheimer[1,2], Daniel Garbe[1,2], Sean Hodgman[1,2], Immanuel Bloch[1,2], and Ulrich Schneider[1,2] — [1]LMU München — [2]MPQ Garching

Absolute temperature is usually bound to be strictly positive. However, in systems with an upper energy bound, negative absolute temperature states are possible, in which the occupation probability of states increases with their energy. We realised a negative absolute temperature state for motional degrees of freedom using ultracold bosonic ^{39}K atoms in an optical lattice.

This new state strikingly revealed itself by strong occupation peaks at maximum kinetic energy. We found that the negative absolute temperature state is as stable as the corresponding positive temperature state. We also studied how coherence emerges in a slow quench from an incoherent attractive Mott insulator at negative temperature and compared it to the positive temperature case.

Additionally, we investigated the out-of-equilibrium expansion dynamics of interacting bosons in one- and two-dimensional Hubbard systems. We found that the fastest, ballistic expansions occur in the integrable limits. For non-integrable systems the expansion slows down significantly as diffusive dynamics set in.

Q 56.36 Thu 16:00 Empore Lichthof

Superexchange dynamics of ultracold high-spin fermions — •Ole Jürgensen, Dirk-Sören Lühmann, and Klaus Sengstock — Institut für Laserphysik, Universität Hamburg

Superexchange interactions are of fundamental relevance for quantum magnetism and are believed to play an important role in high-T_c superconductivity.

We theoretically study the dynamics of high-spin fermions loaded in a one-dimensional optical lattice. In shallow lattices, spin-changing collisions allow for the melting of an initially prepared two-component band-insulator. The exact time evolution shows that particle-number fluctuations are strongly suppressed in shallow lattices and the dynamics is goverened by spin-exchange processes.

This unique system therefore allows for the direct study of superexchange interactions with high amplitudes in the abscence of direct tunneling processes.

Q 56.37 Thu 16:00 Empore Lichthof

Quantum magnetism of ultracold fermions in an optical lattice — •Gregor Jotzu[1], Daniel Greif[1], Thomas Uehlinger[1], Leticia Tarruell[1,2], and Tilman Esslinger[1] — [1]Institute for Quantum Electronics, ETH Zurich, 8093 Zurich, Switzerland — [2]2 LP2N UMR 5298, Univ. Bordeaux 1, Institut d'Optique and CNRS, 351 cours de la Lib

Interactions between electrons lead to fascinating magnetic phenomena including antiferromagnets, RVB states and spin liquids. However, even simple model hamiltonians for these interactions have proven notoriously difficult to solve. Ultracold fermions in optical lattices have emerged as a new tool to investigate such models, including the the celebrated Fermi-Hubbard hamiltonian. Whilst charge-ordering in systems simulating this models has been successfully investigated, magnetic order could so far not be observed due to the low temperatures required. Here we present the first observation of quantum magnetism of fermions in an optical lattice. Local order appears when loading a low-temperature gas into the lattice and is detected by projecting pairs of neighbouring sites on a singlet or triplet wavefunction. Using a tunable geometry lattice, we create dimerized and anisotropic cubic lattices. There the exchange energy of certain links is stronger, which drastically enhances magnetic correlations between sites they connect. We investigate the dependence of the correlations on the entropy and geometry of the system. In the regime where a second order high-temperature series is still reliable, we find good agreement with theory.

Q 56.38 Thu 16:00 Empore Lichthof

Interferometric optical lattice for higher bands of ultracold quantum gases — •Raphael Eichberger, Matthias Ölschläger, Georg Wirth, and Andreas Hemmerich — Institut für Laserphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

We present a new setup of a bipartite optical square lattice for ultracold quantum gases. The symmetrie of the lattice potential depends on the time phase difference between two optical standing waves and the individual intensity of the four involved laser beams. To achieve the full control of these parameters we build up a new kind of Michelson-Interferometer.

With this interferometric optical lattice we want to excite ultracold atoms - Bosons and Fermions - into higher bands and study new interesting many body phenomena. Here, we report on basic ideas and our recent progress.

Q 56.39 Thu 16:00 Empore Lichthof

Glass Physics in Open Quantum Systems: A Keldysh Path Integral Approach — •Michael Buchhold[1], Philipp Strack[2], and Sebastian Diehl[1,3] — [1]Institute for Theoretical Physics, University of Innsbruck, A-6020 Innsbruck, Austria — [2]Department of Physics, Harvard University, Cambridge MA 02138 — [3]Institute for Quantum Optics and Quantum Information of the Austrian Academy of Sciences, A-6020 Innsbruck, Austria

We investigate non-equilibrium phase transitions in an open cavity system with random atom-photon couplings and cavity photon loss. This system shows normal and superradiant phases, as well as a transition to an atomic spin glass phase for fluctuating atom-photon couplings. The physical behavior close to the glass transition reflects the strong competition between relaxational and reversible dynamics, including low frequency thermalization and the non-equilibrium scaling behavior at the transition.
For a theoretical describtion, we develop a functional integral approach in Keldysh framework, tailored to describe steady state properties and non-equilibrium time-evolution for open quantum many-body systems. This approach allows to combine the strengths of functional integral methods, including perfect access to critical phenomena in large systems, with well established methods from quantum optics, as for instance the input-output formalism and further detection schemes. This is used to show how the above mentioned results can be detected in cavity QED experiments.

Q 56.40 Thu 16:00 Empore Lichthof

Coherent excitation of interacting Rydberg gases at room temperature — •Andreas Kölle, Bernhard Huber, Thomas Baluktsian, Robert Löw, and Tilman Pfau — 5. Physikalisches Institut, Universität Stuttgart

Glass cells filled with thermal rubidium vapor are proposed to be promising candidates for a large variety of quantum devices. These devices are based on a long range Rydberg-Rydberg interaction which has been demonstrated in various ultra cold experiments. In order to translate these results to a hot ensemble of atoms, effects like reduced life time and atomic motion have to be taken into account.

We present evidence for van-der Waals interaction between Rydberg atoms in thermal vapor. Using a pulsed two-photon excitation scheme on the ns time scale we overcome problems of thermal motion on the order of the interaction length and limited coherence time. The resulting Rabi oscillations are compared to a simple 3 - level single atom model including a dephasing due to the Rydberg-Rydberg interaction.

In addition we present results on merging the pulsed excitation with a four-wave-mixing scheme resulting in a pulsed coherent light source. Our progress towards the creation of non classical light based on Rydberg interaction will be shown.

Q 56.41 Thu 16:00 Empore Lichthof

Macroscopic quantum tunneling of Bose-Einstein condensates — •Torsten Schwidder, Matin Kaufmann, Holger Cartarius, Jörg Main, and Günter Wunner — 1. Institut für Theoretische Physik, Uni Stuttgart

Macroscopic quantum tunneling of Bose-Einstein condensates is investigated using a Gaussian variational ansatz. The quantum statistical decay of the condensate wave function is examined by means of a semiclassical approximation to Feynman's path integral formalism, considering only the Euclidean action of the bounce trajectory and fluctuations around it. The imaginary time dynamics is described by a set of coupled differential equations for the Gaussian parameters, and the bounce trajectory is determined using a multi-shooting algorithm. Furthermore, the contributions of the fluctuations are obtained from the eigenvalues of the monodromy matrix. We discuss various methods for calculating the fluctuation determinant.

Q 56.42 Thu 16:00 Empore Lichthof

A versatile quantum gas mixture experiments for investigation of non-linear physics — •Alexander Grote, Markus Pfau, Harald Blazy, Juliette Simonet, Patrick Windpassinger, and Klaus Sengstock — Institut für Laserphysik, Universität Hamburg, 22761 Hamburg, Germany

Solitons are among the most studied excitations within a wide range of nonlinear systems. Stabilized by a balance between dispersion and nonlinearity, solitons are wave packets that exhibit some exceptional generic features such as form stability and particle-like properties. Research with ultracold quantum gases provides a sophisticated toolbox to produce very pure and well-controllable nonlinear systems that offer unique possibilities to study soliton dynamics. We report here on the phase imprinting technique allowing for the creation of dark solitons in a ^{87}Rb condensate.

Our experimental apparatus is capable to realize degenerated mixtures of bosonic (^{87}Rb or ^{39}K) and fermionic (^{40}K) species, which also allow for multi-component quantum gases with mixed statistics. This novel experimental setup allows to develop external collaborations within the guest program of Center of Quantum Technologies (ZOQ - Hamburg). The apparatus also plays a central role in the education of undergraduate students at the Universität Hamburg allowing to get an attractive insight into the latest development in quantum optics. This work is supported by Universität Hamburg , ZOQ and Studiengebühren UHH.

Q 56.43 Thu 16:00 Empore Lichthof

Breakdown of Kohn theorem near Feshbach resonance — •Hamid Al-Jibbouri[1] and Axel Pelster[2] — [1]Fachbereich Physik, Freie Universität Berlin, Germany — [2]Fachbereich Physik, Technische Universität Kaiserslautern, Germany

We study the collective excitation modes of a harmonically trapped Bose-Einstein condensate in the vicinity of a Feshbach resonance at zero temperature [1]. To this end we solve the underlying Gross-Pitaevskii equation by using a Gaussian variational approach and obtain the coupled set of ordinary differential equations for the widths and the center of mass of the condensate. A linearization shows that the dipole mode frequency changes when the bias magnetic field approaches the Feshbach resonance.

[1] E. R. F. Ramos, F. E. A. dos Santos, M. A. Caracanhas, and V. S. Bagnato, Phys. Rev. A **85**, 033608 (2012)

Q 56.44 Thu 16:00 Empore Lichthof

Bose-Einstein condensation in compact astrophysical objects — •Christine Gruber[1] and Axel Pelster[2] — [1]Fachbereich Physik, Freie Universität Berlin, Germany — [2]Fachbereich Physik, Technische Universität Kaiserslautern, Germany

We discuss the possible occurrence of Bose-Einstein condensates (BECs) in astrophysical contexts, i.e. in compact objects such as neutron stars and white dwarfs. As unlikely as it may seem, conditions in such environments allow for the formation of BECs due to a favorable combination of temperature and density. To this end it is of interest to investigate the condensation of bosonic particles under the influence of gravitational interactions in the framework of a Hartree-Fock theory. Results can be compared to observations through the predicted density profiles and masses of the objects.

[1] O.G. Benvenuto and M.A. Vito, J. Cosmol. Astropart. Phys. **2**, 033 (2011)

[2] P. Chavanis and T. Harko, Phys. Rev. D **86**, 064011 (2012)

Q 56.45 Thu 16:00 Empore Lichthof

Dipolar Bose-Einstein condensates with periodically modulated contact interaction — •Branko Nikolić[1], Antun Balaž[2], and Axel Pelster[3] — [1]Fachbereich Physik, Freie Universität Berlin, Germany — [2]SCL, Institute of Physics Belgrade, University of Belgrade, Serbia — [3]Fachbereich Physik, Technische Universität Kaiserslautern, Germany

Harmonically trapped Bose-Einstein condensates (BECs) with a sufficiently strong dipolar interaction possess both a stable and an unstable equilibrium. Following Ref. [1] we investigate how the stability of both equilibria change under parametric excitation by a periodic modulation of the s-wave scattering length [2]. To this end we perform both an analytical linear and a numerical nonlinear stability analysis for the Thomas-Fermi solution of the underlying Gross-Pitaevskii equation [3]. We find that parametric excitation can stabilize a previously unstable dipolar BEC and vice versa. We even find indications that bistability may exist for a certain choice of driving amplitude and frequency.

[1] W. Cairncross and A. Pelster, eprint `arXiv:1209.3148`

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Q 56.46 Thu 16:00 Empore Lichthof

Elastic and inelastic collisions of single neutral impurity atoms immersed in an ultracold cloud — •Farina Kindermann[1,2], Nicolas Spethmann[1,2], Dieter Meschede[2], and Artur Widera[1] — [1]FB Physik, TU Kaiserslautern, Erwin Schrödinger Str. 46, 67663 Kaiserslautern — [2]Institut für angewandte Physik, Universität Bonn, Wegelerstr. 8, 53115 Bonn

Recently hybrid systems immersing single atoms in a many body system have been a subject of intense interest. Here we present an example of controlled doping of an ultracold Rubidium cloud with single neutral Cesium impurity atoms. We observe thermalization of 'hot' Cs atoms by elastic interaction with an ultracold Rb gas, employing different schemes of measuring the impurities' energy distribution. Inelastic collisions are restricted to a single three-body recombination channel allowing us to precisely determine the three-body loss coefficient in good agreement with theory.

The poster will present details of the experimental setup, sequence and data analysis needed to extract the interspecies scattering length and three-body loss coefficient from the thermalization dynamics and loss rates measured.

Q 56.47 Thu 16:00 Empore Lichthof

Spin waves and Collisional Frequency Shifts of Trapped-Atom Clocks — Wilfried Maineult[1], Christian Deutsch[2], Kurt Gibble[3], Jakob Reichel[2], and •Peter Rosenbusch[1] — [1]LNE-SYRTE, Observatoire de Paris, France — [2]LKB, Ecole Normale Supérieure, Paris, France — [3]Pennsylvania State University, USA

The indistinguishability of identical particles is most fundamental to quantum statistics. It imposes exchange (anti-)symmetry and leads to intriguing phenomena like Bose attraction and Pauli pressure. We study the exchange interactions in a trapped atom clock on a chip (TACC). The clock, designed to operate with magnetically trapped ^{87}Rb atoms aims at stability 10 times better than commercial clocks.

Contrary to standard atomic clocks, where the atoms are in free flight, the trap increases the density $10^4\times$ and hence the effects of interactions. In addition, we reach ultra-low temperatures, where interactions become purely s-wave. Under these ideal conditions, we have observed the opening of an energy gap between the symmetric and anti-symmetric 2-body-wavefunction describing colliding atoms. The energy gap inhibits dephasing such that extraordinarily long coherences times (58 s) can be reached [PRL 105, 020401 (2010), PRL 106, 240801 (2011)]. Here we present a direct spectroscopic measurement of the energy gap and demonstrate its inextricable link with spin waves [PRL 109, 020407 (2012)]. We also demonstrate a counter-intuitive dependence of the clock frequency on the area of the 2nd pulse in Ramsey spectroscopy. Our findings are equally relevant to optical lattice clocks and quantum information processing with small-ensemble qubits.

Q 56.48 Thu 16:00 Empore Lichthof

Stability of Rotating Bose Gases at Finite Temperature — •Holger Hauptmann[1,2], Patrick Navez[2], Holger Kantz[1], and Walter T. Strunz[2] — [1]Max-Planck-Institut für Physik komplexer Systeme, Dresden — [2]Technische Universität Dresden

We investigate the stability of the relative motion between a Bose-Einstein condensate and its thermal cloud for a gas with repulsive self-interaction at finite temperature in a harmonic trap. The thermal cloud is described by a semi-classical Bose-Einstein distribution. The condensate obeys the Gross-Pitaevskii equation. Stirring the system at low frequencies leads to a rotation of the thermal cloud with a resting condensate. We are looking for the critical angular velocity between condensate and thermal cloud for which the system becomes unstable.

Q 56.49 Thu 16:00 Empore Lichthof

Absorption and Transfer properties of quantum aggregates under the influence of Lévy-stable disorder — •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

Molecular aggregates exhibit extraordinary absorption properties, depending on their geometrical conformation and inter-monomeric coupling. The shape of the narrow absorption band for J-aggregates can be well described by diagonal Gaussian static disorder for individual site energies. Aggregates consisting of large molecules are usually embedded in complex environments, making it impossible to separate individual contribution to the energy fluctuations.

Recent developments in generating and trapping highly excited Rydberg atoms, allow for quantum simulations of molecular aggregates. By controlling the environment, e.g. a polar background gas, static disorder besides Gaussian can be studied. We analyze on how the environment generates disorder distributions with heavy tails, so called Lévy-stable distributions. We also show that the Lévy distributions lead to even a broadening of the absorption band [1] as well as a subdiffusive exciton transfer.

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

Q 56.50 Thu 16:00 Empore Lichthof

Numerical solutions of Gross-Pitaevskii equation for a disordered Bose condensed gas — •Tama Khellil[1], Antun Balaž[2], and Axel Pelster[3] — [1]Fachbereich Physik, Freie Universität Berlin, Germany — [2]SCL, Institute of Physics Belgrade, University of Belgrade, Serbia — [3]Fachbereich Physik, Technische Universität Kaiserslautern, Germany

We present a numerical study of a Bose-condensed gas in a harmonic trapping potential and a Gaussian-distributed disorder potential in one dimension at zero temperature. The underlying Gross-Pitaevskii equation for the condensate wave function represents a nonlinear, partial differential equation and is difficult to solve exactly. Using a computer program [1] that solves the time-independent Gross–Pitaevskii equation in one space dimension in a harmonic trap using the imaginary-time propagation, we are able to obtain its numerical solution for each realization of the disorder potential. Performing disorder ensemble averages we have access to both the condensate density and to the density of disconnected local mini-condensates in the respective minima of the disorder potential [2]. Our study is performed for different values of the disorder strength and the correlation length of the disorder, so that we can study the influence of both of them on the numerical solutions. For small disorder strengths we reproduce the seminal results of Huang and Meng for a Bogoliubov theory of dirty bosons.

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[2] R. Graham and A. Pelster, Int. J. Bif. Chaos **19**, 2745 (2009)

Q 56.51 Thu 16:00 Empore Lichthof

Controlled engineering of extended states in disordered systems — •Alberto Rodriguez[1], Arunava Chakrabarti[2], and Rudolf A. Römer[3] — [1]Physikalisches Institut, Albert-Ludwigs Universität Freiburg,Hermann-Herder Strasse 3, D-79104, Freiburg, Germany — [2]Department of Physics, University of Kalyani, Kalyani, West Bengal-741 235, India — [3]Department of Physics and Centre for Scientific Computing, University of Warwick, Coventry, CV4 7AL, United Kingdom

We describe how to engineer wavefunction delocalization in disordered systems modelled by tight-binding Hamiltonians in $d > 1$ dimensions. We show analytically that a simple product structure for the random onsite potential energies, together with suitably chosen hopping strengths, allows a resonant scattering process leading to ballistic transport along one direction, and a controlled coexistence of extended Bloch states and anisotropically localized states in the spectrum. We demonstrate that these features persist in the thermodynamic limit for a continuous range of the system parameters. Numerical results support these findings and highlight the robustness of the extended regime with respect to deviations from the exact resonance condition for finite systems. The localization and transport properties of the system can be engineered almost at will and independently in each direction. This study gives rise to the possibility of designing disordered potentials that work as switching devices and band-pass filters for quantum waves, such as matter waves in optical lattices. [Phys. Rev. B 86, 085119 (2012)]

Q 56.52 Thu 16:00 Empore Lichthof

Scattering of the spin-orbit coupled ultra-cold atoms — •Gediminas Juzeliunas[1], Julius Ruseckas[1], Rytis Jursenas[1], and Ian Spielman[2] — [1]Institute of Theoretical Physics and Astronomy, Vilnius University, A. Gostatuto 12, LT-01108 Vilnius, Lithuania — [2]Joint Quantum Institute, National Institute of Standards and Technology, and University of Maryland, Gaithersburg, MD 20899, USA

Over the last several years there has been a substantial increase of interest in artificial gauge fields and spin-orbit coupling for electrically neutral atoms [1-3]. The spin-orbit coupling with equal Rashba and Dresselhaus contributions has been recently implemented experimentally [4]. Here we consider manifestations of such a spin-orbit coupling for scattering of ultra-could atoms at the impurity sites [5]. In particular, we show that the spin-orbit coupling can lead to both suppression or enhancement of the atomic backward scattering. Additionally we have analysed the impurity-induced bound states for the spin-orbit coupled atoms.

[1] M. Lewenstein, A. Sanpera, V. Ahufinger, B. Damski, A. S. De and U. Sen, Adv. Phys. 56, 243 (2007). [2] I. Bloch, J. Dalibard and W. Zwerger, Rev. Mod. Phys. 80, 885 (2008). [3] J. Dalibard, F. Gerbier, G. Juzeliunas and P. Öhberg, Rev. Mod. Phys. 83, 1523 (2011). [4] Y.-J. Lin, K. Jimenez-Garcia and I. B. Spielman, Nature (London) 471, 83 (2011). [5] J. Ruseckas, R. Jursenas, G. Juzeliunas and I.B. Spielman, in preparation.

Q 56.53 Thu 16:00 Empore Lichthof

Multiple scattering of interacting bosons in random potentials — Tobias Geiger, •Thomas Wellens, and Andreas Buchleitner — Physikalisches Institut, Albert-Ludwigs-Universität Freiburg, Germnay

We microscopically derive a theory for scattering of N atoms – with all atoms initially prepared in the same single-particle momentum eigenstate – from a three dimensional random disorder potential in the presence of two-body interactions. Starting from an exact diagrammatic expansion of the N-particle transition amplitude, we identify those combinations of diagrams which – in the case of a weak random potential (mean free path much larger than wavelength) – survive the disorder average, and sum up the remaining series of ladder and crossed diagrams non-perturbatively in the strength of the particle-particle interaction. We show that the latter leads to a relaxation of the individual particles' energies towards a Maxwell-Boltzmann distribution as the particles diffuse throughout the random potential [1]. As interferential correction to diffusive transport, we furthermore consider the phenomenon of coherent backscattering and analyze how this coherent effect is modified by interactions.

[1] T. Geiger, T. Wellens, and A. Buchleitner, Phys. Rev. Lett. **109**, 030601 (2012)

Q 56.54 Thu 16:00 Empore Lichthof

Semiclassical theory for laser-driven atoms in optical cavities — •Stefan Schütz[1], Hessam Habibian[1,2], and Giovanna Morigi[1] — [1]Theoretische Physik, Universität des Saarlandes, D-66041 Saarbrücken, Germany — [2]Grup d'Óptica, Universitat Autònoma de Barcelona, E-08193 Bellaterra, Barcelona, Spain

We theoretically study the formation of self-organized structures of atoms, whose dipolar transition is driven by a laser and also couples to the optical mode of a high-finesse cavity. Self-organization in the cavity field emerges due to the mechanical forces of the cavity photons on the atoms, whereby the cavity field is sustained by the photons scattered by the atoms from the laser and hence depends on the atomic position. We consider the semiclassical model in [1], which is used when the laser is well above the self-organization threshold, and identify the limits of validity. We then extend the theoretical description to a Fokker-Planck equation which is valid below threshold, when the intracavity photon number is low. In this regime we analyze the dynamics of cavity cooling, and determine the final temperatures and cooling rates.

[1] P. Domokos et al., J.Phys. B: At. Mol. Opt. Phys. **34** 187-198

(2001)
[2] J.K.Asbóth, P. Domokos, H. Ritsch, and A. Vukics, Phys. Rev. A **72**, 053417 (2005)

Q 56.55 Thu 16:00 Empore Lichthof

ac Stark shift of a cesium atom in a two-color nanofiber-based atom trap — •Fam Le Kien, Philipp Schneeweiss, and Arno Rauschenbeutel — VCQ, TU Wien - Atominstitut, Stadionallee 2, 1020 Wien, Austria

An atom exposed to an intense far-detuned light field experiences shifts of its energy levels. In general, these light shifts (ac Stark shifts) depend not only on the dynamical polarizability of the atomic state but also on the polarization of the light field. Here, we present central results of a systematic derivation of the ac Stark shift induced by a far-off-resonance light field of arbitrary polarization. These results are in particular relevant when theoretically describing the optical trapping of atoms using near-fields or nonparaxial light beams which in general lead to nontrivial polarization patterns.

When applying this light-shift formalism to cesium atoms in a two-color nanofiber-based optical trap, we find Zeeman-state-dependent optical trapping potentials. The state dependence is a consequence of the effective magnetic field which results from the vector polarizability of the atomic ground state in conjunction with the residual ellipticity of the nanofiber-guided trapping light fields. Using an external (real) magnetic offset field, we observe a spatial displacement of the trapping potential that can be continuously controlled. We propose to exploit this behavior for microwave control and cooling of the atomic motional states. For this purpose, we calculate the Franck-Condon factors between vibrational levels and show that an implementation of these microwave operations appears experimentally feasible.

Q 56.56 Thu 16:00 Empore Lichthof

Towards redistribution laser cooling of molecular gases: Production of candidate molecule SrH by laser ablation. — Philipp Simon, •Lars Weller, Anne Sass, Peter Moroshkin, and Martin Weitz — Institut für Angewandte Physik, Universität Bonn, Bonn, Germany

Laser cooling by collisional redistribution of radiation is a powerful novel technique suitable for cooling of very dense and hot gases. It has been successfully applied for cooling alkali-metal vapours mixed with rare gases at high pressure. Here we report on the progress of our project aiming at the demonstration of the redistribution cooling in a molecular gas. The strontium monohydride molecule SrH possesses a strong near-infrared electronic transition $X\Sigma$ - $A\Pi$ with a highly diagonal Franck-Condon structure that makes it a good candidate for laser cooling. We produce SrH by laser ablation of strontium dihydride in a pressurized rare gas atmosphere. The composition of the ablation plasma plume is analyzed by measuring its emission spectrum. The achieved concentration of SrH molecules and its dynamics following the ablation laser pulse is studied as a function of the buffer gas pressure and the laser intensity.

Q 56.57 Thu 16:00 Empore Lichthof

Transition from ion chain to zigzag configuration in a box like potential — •Andrea Klumpp and Peter Schmelcher — ZOQ University of Hamburg

Self-organizing processes are an interesting subject of physical research. These can be investigate by studing ultracold charged particles in a trap [1]. In numerical calculation of the classical ground state configurations of such trapped particles, the so called Coulomb or Wigner crystals, an harmonic potential $\phi_{eff} = \nu_1 x^2 + \nu_2 y^2 + \nu_3 z^2$ is used as a first approximation for the effective potential of the trap [2]. Thus, for the harmonic potential a number of studies exist for the ground state of the trapped particles and for the phase transition between different formations [3,4]. In order to improve the usually applied approximation we start to model the spatial limits of a trap using a box like potential $\Phi(z) = -\frac{V0}{1+(z/l)^m}$ with the length l of the trap in axial direction and an harmonic potential perpendicular to the axis.

Using this more realistic potential we varied the parameter m governing the box-type behaviour of the potential. We present the results of calculations for the one dimensional Wigner crystal configurations and the transition from ion chain to zigzag formation in the box like potential and compared the results with the purely harmonic confinement [4].

[1] R.Blumel,et all Nature 334,309 (1988)
[2] W.Paul Rev.Mod.Phys. 62,3(1990)
[3] P.Ludwig,S.Kosse, M.Bonitz Phys. Rev.E 71,046403 (2005)
[4] E.Shimshoni, G.Morigi,S. Fishmann PRL 106, 010401 (2011)

Q 56.58 Thu 16:00 Empore Lichthof

A CO_2-laser optical dipole trap for ultracold erbium atoms — •Henning Brammer, Jens Ulitzsch, Matthias Rehberger, and Martin Weitz — Institut für Angewandte Physik, Universität Bonn

The erbium atom has a $4f^{12}6s^2$ $^3H_6$ electronic ground state with a large angular momentum of $L = 5$. So far, most atomic quantum gases have been realized with a sperical symmetric ($L = 0$) S-ground state configuration, for which in far detuned laser fields with detuning above the upper state fine structure splitting the trapping potential is determined by the scalar electronic polarizability. For an erbium quantum gas with its $L > 0$ ground state, the trapping potential also for far detuned dissipation-less trapping laser fields becomes dependent on the internal atomic state (i.e. spin). We report on progress in an ongoing experiment directed at the generation of an atomic erbium Bose-Einstein condensate by evaporative cooling in a quasistatic optical dipole trap generated by the focused beam derived from a CO_2-laser operating near 10.6μm wavelength. The atoms are loaded into the dipole trap from a magneto-optical trap (MOT), which itself is loaded from a Zeeman-slowed atomic beam. For the MOT, the experiment uses a single laser frequency tuned to the red of the $400.91nm$ cooling transition. No repumping radiation is required for the MOT operation, despite the complex energy level structure of the erbium atom.

Q 56.59 Thu 16:00 Empore Lichthof

EIT-control of single-atom motion in an optical cavity — •Tobias Kampschulte[1], Wolfgang Alt[1], Sebastian Manz[1], Miguel Martinez-Dorantes[1], René Reimann[1], Seokchan Yoon[1], Dieter Meschede[1], Marc Bienert[2], and Giovanna Morigi[2] — [1]Institut für Angewandte Physik, Universität Bonn, Wegelerstrasse 8, 53115 Bonn — [2]Theoretische Physik, Universität des Saarlandes, 66123 Saarbrücken

We demonstrate cooling of the motion of a single atom confined by a dipole trap inside a high-finesse optical resonator. Cooling of the vibrational motion results from EIT-like interference in an atomic Λ-type configuration, where one transition is strongly coupled to the cavity mode and the other is driven by an external control laser. Good qualitative agreement with the theoretical predictions is found for the explored parameter ranges. The role of the cavity in the cooling dynamics is confirmed by means of a direct comparison with EIT-cooling performed in the dipole trap in free space. These results set the basis to the realization of an efficient photonic interface based on single atoms.

Q 56.60 Thu 16:00 Empore Lichthof

Sequential loading of a conservative potential — •Ilka Geisel[1], Jan Mahnke[1], Carsten Klempt[1], Wolfgang Ertmer[1], and Kai Cordes[2] — [1]Institut für Quantenoptik, Leibniz Universität Hannover — [2]Institut für Informationsverarbeitung, Leibniz Universität Hannover

We investigate guiding and trapping of rubidium atoms on a mesoscopic chip structure with millimeter-scale wires.

This structure is used to create a quadrupole field for a magneto-optical trap, a magnetic guide and a flexible magnetic trapping potential. In our experiments, the guide allows us to transport cold atoms into a region that provides better vacuum conditions and very effective stray light protection. It is therefore particularly well suited to simultaneously trap and collect atoms.

We show that our control of the local magnetic fields and the effective light shielding enable us to load another MOT without significantly reducing the lifetime of previously trapped atoms. We present first results on sequential loading mechanisms with regard to continuous loading of a conservative potential [1].

[1] Continuous loading of a non-dissipative atom trap C. F. Roos et al 2003 Europhys. Lett. 61 187

Q 56.61 Thu 16:00 Empore Lichthof

Surface-electrode microwave structures for electron guiding — •Johannes Hoffrogge[1], Jakob Hammer[1], and Peter Hommelhoff[1,2] — [1]MPI für Quantenoptik, 85748 Garching — [2]Friedrich-Alexander-Universität Erlangen-Nürnberg, 91058 Erlangen

We study the guiding of free electrons in a planar microwave quadrupole guide [1]. The surface-electrode structure is driven at microwave frequencies, which allows tight radial confinement. This results in transverse trap frequencies of up to several hundred MHz and enables the precise control of slow electrons at 1-10 eV by means of purely electric fields. We experimentally and numerically study the dynamics of the electrons and their dependence on the microwave drive parameters. Upon coupling into the guide, the electron trajectories show strong dependence on the microwave phase and fringing electric fields. We therefore present a numerically optimized electrode layout that provides an adiabatic passage of the electron beam into the guide. We also discuss more complex electrode structures like beam splitting elements for guided electrons, as well as designs with electrodes that are larger than the drive wavelength. These require to consider traveling wave effects in the electrode layout [2]. Finally, the combination of an electron guide with a single atom tip electron source should allow the direct preparation of electrons in low-lying quantum states of the transverse harmonic oscillator potential. This would enable new guided matter-wave experiments with electrons.

[1]J. Hoffrogge, *et al. Phys. Rev. Lett.* **106**, 193001 (2011).

[2]J. Hoffrogge, P. Hommelhoff, *New. J. Phys* **13**, 095012 (2011).

Q 56.62 Thu 16:00 Empore Lichthof

Novel paths to phase-space density increase in dipolar atomic gases — Valentin Volchkov, •Jahn Rührig, Matthias Wenzel, Axel Griesmaier, and Tilman Pfau — 5. Physikalisches Institut, Universität Stuttgart, Germany

We present novel paths that we use to increase the phase-space density in a continuously loaded atomic trap. Following the argumentation in [2] we extend our previous work [1] by applying RF radiation during the loading. We discuss how this leads to an increase of the steady state PSD during the continuous process and faster loading. In pulsed operation, we increase the phase-space density by use of the dipolar nature of ^{52}Cr which allows demagnetization cooling [3] and avoids losses connected to evaporative cooling. Starting in an up to now unaccessed temperature regime of $T \approx 100\mu K$ we aim for the production of large dipolar BECs with high repetition rates. The realization of an active magnetic field stabilization on the level of $100\mu G$ per axis enables us to circumvent the previously explored limits set by transversal stray fields with respect to the laser used for optical pumping during the demagnetization.

[1]: M. Falkenau, V. V. Volchkov, J. Rührig, A. Griesmaier and T. Pfau, Phys. Rev. Lett. **106**, 163002 (2011)

[2]: M. Falkenau, V. V. Volchkov, J. Rührig, H. Gorniaczyk, A. Griesmaier, Phys. Rev. A **85**, 023412 (2012)

[3]: M. Fattori, T. Koch, S. Goetz, A. Griesmaier, S. Hensler, J. Stuhler, T. Pfau, Nature Physics **2**, 765 (2006)

Q 56.63 Thu 16:00 Empore Lichthof

Laser cooling of Iron atoms — •Nicolas Huet, Stéphanie Krins, and Thierry Bastin — Institut de Physique Nucléaire, Atomique et de Spectroscopie, Université de Liège, Belgium

We report on the first laser cooling of Iron atoms. Our laser cooling setup makes use of 2 UV laser radiation sent colinearly in a 0.8 m Zeeman slower. One laser is meant for optical pumping of the Iron atoms from the ground state to the lowest energy metastable state. The second laser cools down the atoms using a quasi-perfect closed transition from the optical pumped metastable state. The velocity distribution at the exit of the Zeeman slower is obtained from a probe laser crossing the atom beam at an angle of 50 degrees. The fluorescence light is detected using a photomultiplier tube coupled with a boxcar analyzer. The Iron atom beam is produced with a commercial effusion cell working at around 1950 K. Our laser radiations are stabilized using standard saturated-absorption signals in both an Iron hollow cathode absorption cell and an Iodine cell. We will present our experimental setup, as well as the first evidences of cooled down Iron atoms at the exit of the Zeeman slower.

Q 56.64 Thu 16:00 Empore Lichthof

Phase-Locked Raman Laser Systems Based on Interference Filter ECDLs for Coherent Hyperfine State Manipulation — •Jan Phieler, Michael Bauer, Shrabana Chakrabarti, Philipp Franzreb, Benjamin Gänger, Farina Kindermann, and Artur Widera — Technische Universität Kaiserslautern, FB Physik, Erwin-Schrödinger-Str. 46, 67663 Kaiserslautern, Germany

We report on the construction of phase-locked Raman laser systems for Rb and Cs atoms in a two-species cold atom experiment in order to enable resolved sideband cooling of tightly bound atoms to the quantum mechanical ground state of optical dipole traps as well as controlled preparation of different hyperfine states.

Interference filter stabilized extended cavity diode lasers at wavelengths of 780 and 852 nm form the laser sources of both systems and provide superior stability and narrow linewidth. Driving coherent Raman transitions between the hyperfine substates of the Rb and Cs groundstates requires two phase coherent laser beams. This coherence is achieved by phase-locking the beat-note of the lasers to an external reference oscillator by means of a high speed digital phase frequency discriminator circuit.

We present meaurements on the basic properties of the systems, including passive stability and regulation circuit performance, and report on the current status of integrating them in our experiment.

Q 56.65 Thu 16:00 Empore Lichthof

Optical traps for combining an ultracold Rb gas and single Cs atoms — •Philipp Franzreb, Michael Bauer, Shrabana Chakrabarti, Benjamin Gänger, Farina Kindermann, Jan Phieler, and Artur Widera — Technische Universität Kaiserslautern

Experiments combining single neutral atoms with a many body system require many repetitions of the experimental cycle to obtain significant statistics. Hence it is important to achieve short cycle times with a high production rate of the Bose-Einstein condensate (BEC).

In this poster experimental outline and current status of our optical dipole trap system for a rapid all-optical Rb BEC production and the combination with single Cs atoms is discussed. From a 3D MOT Rb atoms are loaded into a single beam trap, where evaporation is supported due to a crossed beam configuration. Trapping and controlled immersion of single Cs atoms is possible with the aid of an optical lattice formed by an additional anti parallel beam.

Q 56.66 Thu 16:00 Empore Lichthof

Coherence properties of cold cesium atomic spins in a nanofiber-based dipole trap — •Rudolf Mitsch, Daniel Reitz, Clément Sayrin, Philipp Schneeweiss, and Arno Rauschenbeutel — Vienna Center for Quantum Science and Technology, TU Wien, Atominstitut, Stadionallee 2, 1020 Wien, Austria

The possibility to efficiently store quantum information over extended periods of time is a prerequisite for quantum protocols. Here, we present the first experimental characterization of the coherence properties of nanofiber-trapped atoms. In our system, neutral Cs atoms are trapped in a two-color evanescent field surrounding a subwavelength-diameter optical fiber. The atoms are localized in an one-dimensional optical lattice only 200 nm above the dielectric surface [1]. This close proximity and the strong polarization gradients of nanofiber-guided light fields are prone to cause decoherence. In order to investigate these effects, a resonant microwave field is used to drive the $m_F = 0 \rightarrow 0$ clock-transition between the two hyperfine ground states. Ramsey interferometry on this transition yields inhomogeneous dephasing times of about $T_2^* = 500\,\mu s$, whereas spin echo measurements result in homogeneous dephasing times of up to $T_2' = 2\,ms$. These long coherence times are compatible with the implementation of more complex quantum operations, thereby paving the road towards establishing nanofiber-based traps for cold atoms as a building block in a quantum network.

[1] E. Vetsch *et al.*, Phys. Rev. Lett. **104**, 203603 (2010).

Q 56.67 Thu 16:00 Empore Lichthof

Reflection spectroscopy on laser-cooled atoms trapped around an optical nanofiber — •Bernhard Albrecht, Igor Mazets, Rudolf Mitsch, Daniel Reitz, Clément Sayrin, Philipp Schneeweiss, and Arno Rauschenbeutel — Vienna Center for Quantum Science and Technology, TU Wien, Atominstitut, Stadionallee 2, A-1020 Wien, Austria

Tapered optical fibers with a waist diameter smaller than the optical wavelength have recently been used to trap and optically interface laser-cooled cesium atoms [1,2]. In addition to their potential as a building block in a quantum network, nanofiber-trapped atoms are a promising model system for fundamental investigations on light-matter interaction. Here, we report on our latest experimental results on reflection spectroscopy of cesium atoms trapped in a one-dimensional optical lattice about 200 nm above the nanofiber surface. The atoms are randomly loaded into this lattice while the collisional blockade effect limits the number of atoms per trapping site to one at most. Reflection spectra are taken in regimes dominated by coherent and by incoherent scattering. The data is well described by a model that considers radiation transfer in a non-linear inhomogeneous medium. Our results contribute to the deeper understanding of light propagation through complex atomic media and are an important step towards cavity QED with atomic mirrors [3].

[1] E. Vetsch *et al.*, Phys. Rev. Lett **104**, 203603 (2010).
[2] E. Vetsch *et al.*, IEEE J. Quantum Electron **18**, 1763 (2012).
[3] D. E. Chang *et al.*, New J. Phys. **14**, 063003 (2012).

Q 56.68 Thu 16:00 Empore Lichthof

Heterodyne spectroscopy of single atom motional states inside a high-finesse cavity — •Natalie Thau, Wolfgang Alt, Tobias Kampschulte, Sebastian Manz, René Reimann, Seokchan Yoon, and Dieter Meschede — Institut für Angewandte Physik der Universität Bonn, Wegelerstr. 8, 53115 Bonn

Tight control and knowledge of the motional states of single atoms are a prerequisite for many experiments connected to the field of quantum information. In our system insight to the motional states of single atoms coupled to a high finesse optical resonator is gained by the means of optical heterodyne detection. Measuring the beat signal between a fixed-frequency local oscillator beam and the light interacting with the coupled atoms, we are able to map the atomic motional state to the frequency domain in a non-destructive way. Analysing the spectra we discuss different experimental imperfections and estimate the intra-cavity atomic temperature within the frame of a simple model.

Q 56.69 Thu 16:00 Empore Lichthof

2D Discrete Quantum Simulator — •Stefan Brakhane, Carsten Robens, Andrea Alberti, Wolfgang Alt, and Dieter Meschede — Institut für Angewandte Physik der Universität Bonn,Wegelerstr. 8,53115 Bonn

Coherent control of individual atoms in optical lattices have recently proven to be a key asset in simulating physical phenomena, spanning from quantum transport effects typical of solid state physics to artificial gauge fields.

Our planed apparatus features a 2D optical lattice with polarization controlled state-dependent transport, a high numerical aperture imaging system (NA = 0.92) enabling single site detection and addressing by means of highly-focused steering laser beams, and high magnetic field gradient to act as spin-dependent force.

We report on the current status of the experiment and on the development of a dodecagonal ultra-high vacuum glass cell with minimal bifrefringence allowing for optimal polarization control inside the vacuum.

Q 56.70 Thu 16:00 Empore Lichthof

Optical imaging of thermal and condensed gases — •Cristina Gherasim, Soenke Beck, and Reinhold Walser — Institute for Applied Physics, TU Darmstadt, Germany

Absorption imaging is the standard way of observing trapped atomic gases. From the two dimensional column integrated densities, one obtains optical images on CCD devices after propagation through an optical system, i.e. abberated lenses, $\lambda/4$ plates, vacuum windows, beam splitters etc. In order to assess the fidelity of optically measured particle densities, we analyze the performance of realistic imaging setups for thermal clouds and strongly interacting Bose-Einstein condensates. Using optical design software we model the optical setup of the QUANTUS experiment [1] with geometric ray tracing and wave optics. We compare the 2D density of the atomic cloud with its optical image $n^{2D} = \log(I_o^{vac}/I_o^{BEC})/(2\alpha)$ [2].

[1] T. van Zoest et al, Science, **328**, 1540 (2010).
[2] W. Ketterle, D.S. Durfee and D.M. Stamper-Kurn, Proceedings of the International School of Physics "Enrico Fermi" Course CXL (1999)

Acknowledgments: This project is supported by the Deutsche Luft und Raumfahrt Agentur (DLR Grant: 50 WM 1137).

Q 56.71 Thu 16:00 Empore Lichthof

Precision imaging of interfering matter waves — •Sönke Beck, Cristina Gherasim, and Reinhold Walser — Institut für angewandte Physik, Technische Universität Darmstadt, Hochschulstr. 4A, 64289 Darmstadt, Germany

We investigate the limitations of optical imaging for cold thermal clouds and Bose-Einstein condensates. An optimized imaging system is crucial to perform high precision measurements [1]. Within the paraxial approximation of wave optics, we have calculated the image of an absorptive-dispersive ($\chi = \chi' + i\chi''$) atomic cloud after propagating through an ideal lens system with finite aperture. This shows the limitations of the standard formula for imaging the column integrated density $\tilde{n}$ of dilute clouds, $\tilde{n} = \ln(I_{\mathrm{vac}}/I_{\mathrm{cloud}})/k_0\chi''$ (I_{vac}, I_{cloud} image intensities without and with cloud, k_0 free-space wave number) [2]. The results are particularly relevant for diffraction limited structures of interfering Bose-Einstein condensates in a matter wave interferometer as realized in QUANTUS [3].

References:

[1] T. van Zoest et al., Science **328**, 1540 (2010)
[2] W. Ketterle et al., Proceedings of the International School of Physics “Enrico Fermi” (1999)
[3] J. Rudolf et al., Microgravity Sci. Technol. **23**, 287 (2011)

Q 56.72 Thu 16:00 Empore Lichthof

Non-adiabatic quantum state control in few-well few-atom systems — •Malte C. Tichy, Mads Kock Pedersen, Klaus Mølmer, and Jacob F. Sherson — Lundbeck Foundation Theoretical Center for Quantum System Research, Department of Physics and Astronomy, University of Aarhus, DK-8000 Aarhus C, Denmark

A scheme for arbitrary unitary control of ensembles of interacting bosonic atoms in two-well systems is presented, which uses a discrete sequence of local potential variations as the only control parameter. Exact solutions, readily available for infinite interaction strength, are used as a starting point for numerical optimization yielding high-fidelity procedures to arbitrarily manipulate quantum states. We thereby combine universal but artificially constrained “bang-bang” quantum control with the Euler-decomposition of large unitary matrices to yield a practical powerful scheme. We demonstrate the efficiency of our proposal with non-adiabatic population transfer, N00N-state creation, and transistor-like, conditional evolution of several atoms.

Q 56.73 Thu 16:00 Empore Lichthof

Towards coherent interaction between single neutral atoms and a BEC — •Michael Bauer, Shrabana Chakrabarti, Philipp Franzreb, Benjamin Gänger, Farina Kindermann, Nicolas Spethmann, and Artur Widera — Technische Universität Kaiserslautern

Combining a single neutral atom with a quantum many body system, such as a Bose-Einstein condensate (BEC) poses a challenge, not only due to the different temperatures of both systems realized in experiments so far, but also because of the different measurement statistics and typical sequence durations. Studying the interaction of a single atom with a BEC requires many repetitions of the experimental cycle to obtain sufficient statistics. Thus it is essential to achieve short measuring times and therefore a high production rate of the BEC. Here we present a concept and first characterizations for a new setup capable of breeding an all optical BEC in a few seconds and immersing single atoms into the ultracold quantum system.

Our setup will feature mechanisms for independently manipulating and detecting both single atoms and the BEC, thereby providing an unrivaled level of control over impurities in a quantum gas. Possible research directions include the investigation of coherent impurity physics and the creation and characterization of polarons in a BEC. The poster will review the current status of the experiment.

Q 56.74 Thu 16:00 Empore Lichthof

A single atom in a 3D optical lattice strongly coupled to an optical cavity — •Stephan Ritter, Andreas Reiserer, Christian Nölleke, and Gerhard Rempe — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Straße 1, 85748 Garching, Germany

Single atoms in optical cavities have proven ideal for the reversible interconversion and storage of quantum information and therefore make excellent quantum network nodes. Despite these successes, position and momentum of the atom has so far escaped complete control. As a consequence, the atom-cavity coupling strength is neither maximal nor constant. This limits the fidelity and in particular the efficiency of interconversion and other quantum information processing protocols. To solve this problem, we demonstrate deterministic localization of a single atom in a three-dimensional optical lattice with the resonator as one of the lattice axes. By shifting the standing-wave potential formed by one of the lattice beams, we place the atom at the center of the cavity mode. This allows us to reach the strong-coupling regime of cavity QED manifested by a clearly resolved normal-mode splitting even for a moderate cavity finesse. The use of high intensities along all three axes gives adjustable trap frequencies of a few hundred kHz, such that the atom is tightly confined to the Lamb-Dicke regime. This enables Raman sideband cooling to the ground state of the three-dimensional lattice potential.

Q 56.75 Thu 16:00 Empore Lichthof

Counting mesoscopic atom numbers — •Ion Stroescu, Maxime Joos, David B. Hume, Wolfgang Müssel, Helmut Strobel, Jiri Tomkovic, Eike Nicklas, Daniel Linnemann, and Markus K. Oberthaler — Kirchhoff-Institut für Physik, Heidelberg, Germany

Many cold atom experiments rely on precise atom number detection. Especially in the context of quantum atom optics experiments that exhibit effects at the quantum level. Here we investigate the limits of atom number counting via resonant fluorescence imaging for mesoscopic samples of trapped atoms. We characterize the precision of these fluorescence measurements beginning from the single atom level up to more than one hundred. Spatial resolution potentially enables the simultaneous detection of atom numbers in two different magnetic sub-states. This capability enables future experiments with highly entangled states of mesoscopic Bose-Einstein condensates going beyond spin squeezed states.

Q 56.76 Thu 16:00 Empore Lichthof

Towards a miniaturized setup for single photon storage in an ensemble of neutral Rb atoms — •Sutapa Ghosh, Jose C. Gallego, Miguel Martinez-Dorantes, Wolfgang Alt, Marcel Spurny, and Dieter Meschede — Institut für Angewandte Physik, Universität Bonn, Wegelerstraße 8, 53115 Bonn

We present our progress in setting up a miniaturized CQED experiment for single photon storage in an ensemble of neutral Rb atoms. Rb atoms are trapped and cooled using a miniaturized MOT and transfered into a fiber-based optical cavity using our conveyor belt technique, where they are trapped in a 3D optical lattice (comprising a 2D optical lattice and the cavity field). This leads to strong localization of the atoms inside the resonator. The MOT is imaged from two perpendicular sides, giving a quasi-3D impression of the extension and position of the MOT.

Q 56.77 Thu 16:00 Empore Lichthof

A spectral approach to the tunneling decay of two interacting bosons — •Stefan Hunn[1], Klaus Zimmermann[1], Moritz Hiller[2,1], and Andreas Buchleitner[1] — [1]Physikalisches Institut, Albert-Ludwigs-Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg — [2]Institute for Theoretical Physics, Vienna University of Technology, Wiedner Hauptstraße 8-10/136, 1040 Vienna, Austria

We study the microscopic dynamics of two interacting, ultracold bosons in a one- dimensional double-well potential, through the numerically exact diagonalization of the many-body Hamiltonian. With the particles initially prepared in the left well, we increase the width of the right well in subsequent trap realizations and witness how the tunneling oscillations evolve into particle loss. In this closed system, we analyze the spectral signatures of single- and two-particle tunneling for the entire range of repulsive interactions. We conclude that for comparable widths of the two wells, correlated tunneling of a boson pair may be realized for specific system parameters. In contrast, the decay process (corresponding to a broad right well) is dominated by uncorrelated single-particle decay.

Q 56.78 Thu 16:00 Empore Lichthof

Timing control system for cold atom experiments based on a Cortex ARM platform — •Daniel Mayer[1], Felix Schmidt[1], Carsten Lippe[1], Tobias Lausch[1], Nicolas Spethmann[1,2], and Artur Widera[1] — [1]Fachbereich Physik, TU Kaiserslautern, Erwin-Schrödinger-Str. 46, 67663 Kaiserslautern — [2]Department of Physics, University of California Berkley, California, 94720 USA

Precise timing of laser pulses or magnetic fields, for example, are crucial in experiments working with ultracold atoms. We present a timing system featuring a time resolution of .1 microseconds, minimal flank spacing of 1 microsecond, and up to several hundred digital channels, based on standard Cortex ARM processors on a cheap LPC-Expresso platform. The software frontend to create the sequence is programmed in python using QtGui. In order enable maximum automation of the experiment, the software offers a control panel to create basic variables and functions for any repetition of a sequence. Furthermore a small web-server programmed in cpp provides access to the basic functionality of the hardware system. Once created, the sequence is transferred to a master processor, which distributes the signal to eight slave processors, each having 32 digital channels. All processors are locked to a Rb frequency standard, which provides exact relative timing between them and allows for a scalable number of slaves. Additionally the hardware offers a manual mode in order obtain quasi-real-time control over any connected device.

The poster will present details of the hardware design as well as the basic software used to control the timing system.

Q 56.79 Thu 16:00 Empore Lichthof

Cryogenic fiber amplifier for optical trapping of neutral mercury — •Holger John, Patrick Villwock, and Thomas Walther — Technische Universität Darmstadt, Institut für Angewandte Physik, Laser- und Quantenoptik, Schlossgartenstraße 7, 64289 Darmstadt

Laser-cooled mercury constitutes an interesting starting point for various experiments in particular in light of the existence of bosonic and fermionic isotopes in relatively high natural abundance. On the one hand the fermionic isotopes could be used to develop a new time-standard based on a lattice optical clock employing the $^1S_0$ - $^3P_0$ transition at 265.6 nm. Another interesting venue is the formation of ultra cold Hg-dimers employing photo-association and achieving vibrational cooling by employing a special pumping scheme.

The requirements for trapping neutral mercury are given by the cooling transition with a linewidth of 1.27 MHz at a wavelength of 253.7 nm. Our approach is to twice frequency double a Yb:disc laser with the fundamental wavelength of 1014.8 nm. In the recent past we have successfully trapped the bosonic ^{202}Hg as well as the fermionic ^{199}Hg isotopes and have performed first temperature measurement.

Our goal is to increase the reproducibility of our setup by substituting the thin-disc laser with a Yb doped fiber amplified ECDL. We will report on the status of the experiments.

Q 56.80 Thu 16:00 Empore Lichthof

Disordered gases of two level Rydberg atoms — •Martin Gärttner[1,2], Thomas Gasenzer[2], and Jörg Evers[1] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg — [2]Institut für Theoretische Physik, Universität Heidelberg, Philosophenweg 16, 69120 Heidelberg

Exciting atoms to high lying Rydberg states leads to extreme properties, most important of which are their long life-times and the long range interactions among them. For ensembles of Rydberg atoms various appications in quantum optics, quantum information and solid state physics have been proposed and implemted. We study the coherent dynamics of a finite laser-driven cloud of ultra-cold Rydberg atoms by calculating the time evolution from the full many body Hamiltonian. Using the frozen gas approximation and treating the atoms as effective two level systems, we identify effects of finite size and finite density leading to modifications of the predicted parameter scaling of the excited fraction. Also, we analyze the influence of resonant excitation channels in the case of two-photon detuned excitation lasers. We thereby study the buildup of strong correlations and crystal-like structures and discuss potential applications of these features.

Q 56.81 Thu 16:00 Empore Lichthof

Modelling many-body Rydberg interactions — •David Schönleber, Martin Gärttner, and Jörg Evers — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

In the field of Rydberg physics, basically two approaches to modelling many-body interactions exist, namely the approach to solve the many-body Schrödinger equation and the approach to solve effective models such as rate equations. While the first approach includes exact correlation effects which the latter neglects, it does not include reservoir effects such as damping. We develop methods to augment the exact many-body Hamiltonian approach with the ability to model reservoir effects e.g. by implementing quantum jumps via Monte Carlo techniques [1], aiming to enlarge the field of validity of the Schrödinger equation approach. Consequently, the scope of the methods developed is studied with respect to the conventional models.

[1] K. Mølmer *et al*, J. Opt. Soc. Am. B 10, 524-538 (1993)

Q 56.82 Thu 16:00 Empore Lichthof

Conical Intersections and exitation transport 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 show that Rydberg systems also allow reflection of the excitation transport by fixing the positions of the last atoms in the aggregate.

Further we extend the setup to a 2D arrangement to get access to Conical intersections. We use this feature to create entanglement of atomic motion.

References

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[2] C. Ates, A. Eisfeld, J-M. Rost, *New. J. Phys.* **10**, 045030 (2008).
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[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).

Q 56.83 Thu 16:00 Empore Lichthof

Towards Imaging Single Rydberg Atoms via Electromagnetically Induced Transparency — •Stephan Helmrich, Georg Günter, Hanna Schempp, Christoph S. Hofmann, Vladislav Gavryusev, Martin Robert-de-Saint-Vincent, Shannon Whitlock, and Matthias Weidemüller — Physikalisches Institut, Universität Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg

Electromagnetically induced transparency of Rydberg atoms presents the unique possibility to image individual Rydberg atoms immersed in a dense atomic gas and to study their spatial correlations. In our recent proposal [1] the level shifts induced by the Rydberg atoms to the surrounding gas are utilized to provide sensitive, single-shot absorption images of individual Rydberg atoms.

To experimentally realize this idea we require quasi-1D or 2D trapping geometries and a high resolution imaging system capable of resolving single Rydberg blockade spheres. Therefore we designed and implemented a diffraction limited imaging system taking maximum advantage of the present experimental setup. Additionally we optimized critical experimental parameters including atomic density and exposure time to achieve the highest possible signal-to-noise ratio and spatial resolution. We will present our experimental progress towards imaging single Rydberg atoms.

[1] G. Günter et al., Phys. Rev. Lett. 108, 013002 (2012)

Q 56.84 Thu 16:00 Empore Lichthof

Study of Rydberg-surface interactions in thermal atomic vapor — •Ralf Ritter, Daniel Barredo, Robert Löw, and Tilman Pfau — 5. Physikalisches Institut, Universität Stuttgart, 70569 Stuttgart, Germany

The coherent control of strong interactions between Rydberg atoms hold great promise for the manipulation of quantum information. In ultracold experiments several results have already been achieved to proof the basic concepts for this intention. However, thermal atomic vapor cells offer an attractive alternative in terms of scalability for practical devices [1]. For the successful applicability of this approach, decoherence effects with nearby walls need to be investigated and minimized.

In our work, we study the Rydberg atom-surface interaction in a UHV environment as a function of surface composition, corrugation, and temperature for different Rydberg states, atomic species and buffer gases. We will present the versatile setup we utilize for this project and discuss the current status of the experiment.

[1] H. Kübler et al., Nature Photon. 4, 112-116 (2010)

Q 56.85 Thu 16:00 Empore Lichthof

Electric field optimization of a Rydberg atom experiment — •Maximilian Argus, Hanna Schempp, Georg Günter, Shannon Whitlock, and Matthias Weidelmueller — Physikalisches Institut Universitaet Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg Germany

Modern experiments with ultracold Rydberg atoms with application to many body physics and quantum information science, demand a high level of experimental sophistication. In particular, Rydberg atoms are highly polarizable, therefore special care must be taken to control external electric fields. In our experiment this is possible using a structure hosting >10 individually controllable electrodes. However, finding the optimal control voltages can be a challenging task, further complicated by incomplete knowledge of the underlying charge distributions, including possible patch fields.

To overcome this challenge we have applied evolutionary algorithms, a group of powerful search heuristics, to optimize the overall performance of our experiment. Focussing on two problems: cancellation of electric fields and and optimum guiding of field ionized Rydberg atoms to a MCP detector, we asses the performance of several algorithms with competing requirements of noise robustness and fast convergence. Future applications to controlling quantum state evolution and engineering strongly correlated many body systems of interacting Rydberg atoms will be considered.

Q 56.86 Thu 16:00 Empore Lichthof

Strongly interacting single photons in an ultra-cold Ryberg gas — •Hannes Gorniaczyk, Christoph Tresp, and Sebastian Hofferberth — 5. Physikalisches Institut, Universität Stuttgart, Deutschland

Strong photon-photon coupling can be achieved in highly nonlinear media such as Rydberg atoms under the condition of electromagnetically induced transparency. Such a system enables the implementation of fundamental building blocks for photonic quantum information processing. More fundamentally, the underlying interacting Ryberg polaritons form a novel strongly correlated many-body system with widely tunable parameters.

We are currently constructing an experimental setup for Rydberg excitation in an optically dense medium of ultra-cold ^{87}Rb atoms in a crossed optical dipole trap. With excitation lasers focussed smaller than the Rydberg blockade radius a one-dimensional system of Rydberg-polaritons can be realized. This system is suited to create non-classical light, in particular to create and absorb single photons in a deterministic way.

Q 56.87 Thu 16:00 Empore Lichthof

Fractional quantum Hall physics for Rydberg-dressed atoms in artificial magnetic fields — Fabian Grusdt[1,2] and •Michael Fleischhauer[1] — [1]Department of Physics and research center OPTIMAS, University of Kaiserslautern, Germany — [2]Graduate School Materials Science in Mainz, Staudinger Weg 9, 55128 Mainz, Germany

We study ultracold Rydberg-dressed Bose gases in the lowest Landau level (LLL) generated by artificial gauge fields. The characteristics of the Rydberg interaction gives rise to interesting many-body ground states different from standard LLL fractional quantum Hall physics. The non-local but rapidly decreasing interaction potential favors crystalline ground states for very dilute systems. While a simple Wigner crystal becomes energetically favorable compared to the Laughlin liquid for filling fractions $\nu < 1/12$, a correlated crystal of composite particles emerges already for $\nu \leq 1/6$. The presence of a new length scale, the Rydberg blockade radius a_B, gives rise to a bubble crystal phase when the average particle distance becomes less than a_B and $\nu \lesssim 1/4$. For larger fillings indications for strongly correlated, non-Abelian cluster liquids are found.

Q 56.88 Thu 16:00 Empore Lichthof

Rydberg Polaritons — •Johannes Otterbach[1,2], Matthias Moos[2], Dominik Muth[2], and Michael Fleischhauer[2] — [1]Physics Department, Harvard University, Cambridge, MA 02138, USA — [2]Fachbereich Physik and Forschungszentrum OPTIMAS, Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany

The near resonant interaction of light fields with three-level atoms involving a Rydberg state under conditions of electromagnetically induced transparency (EIT) can be described in terms of strongly interacting quasi-particles, termed Rydberg polaritons. An effective many-body model for dark and bright Rydberg polaritons is introduced and compared to recent experiments. The low energy physics of a 1D gas of dark Rydberg polaritons is discussed in terms of a Luttinger liquid model and numerical DMRG simulations. The generation of non-classical photon states with e.g. sub-poissonian number statistics and long-range crystalline order is discussed.

Q 56.89 Thu 16:00 Empore Lichthof

Quantum-classical lifetimes of Rydberg molecules — •Andrej Junginger, Jörg Main, and Günter Wunner — 1. Institut für Theoretische Physik, Universität Stuttgart, Germany

A remarkable property of Rydberg atoms is the possibility to create molecules formed by a scattering process of a highly excited Rydberg electron and an atom in the ground state. Besides the good agreement between theory [1] and the experiment [2] concerning the vibrational states of the molecule, the experimental observations yield the astonishing feature that the lifetime of the molecule is clearly reduced as compared to the bare Rydberg atom [3]. With focus on this yet unexplained observation, we investigate the vibrational ground state of the molecule in a quantum-classical framework. We show that the Rydberg wave function is continuously detuned by the presence of the moving ground state atom and that the timescale on which the detuning significantly exceeds the natural linewidth is in good agreement with the observed reduced lifetimes of the Rydberg molecule.

[1] C. H. Greene et al , Phys. Rev. Lett. 85, 2458 (2000).
[2] V. Bendkowsky et al, Nature 458, 1005, (2009).
[3] B. Butscher et al , J. Phys. B 44, 184004 (2011).

Q 56.90 Thu 16:00 Empore Lichthof

Towards ultracold polar NaK molecules — •Matthias W. Gempel, Torben A. Schulze, Torsten Hartmann, Maurice Petzold, Janis Wöhler, and Silke Ospelkaus — Institut für Quantenoptik, Universität Hannover

Quantum degenerate gases of polar molecules are promising candidates for the realization of strongly correlated quantum many body systems. Particularly promising in this respect is a quantum gas of NaK molecules.

In its groundstate NaK has large electric dipole moment of -2.579 Debye [J. Chem. Phys. 129, 064309 (2008)]. Furthermore, chemical reactions of the form $\mathrm{NaK} + \mathrm{NaK} \rightarrow \mathrm{Na_2} + \mathrm{K_2}$ are expected to be endothermic and therefore suppressed at ultra low temperatures [PRA 81, 060703(R) (2010)]. As a consequence quantum gases of NaK molecules are expected to be stable at ultracold temperatures.

On this poster, we will present our progress towards a quantum degenerate gas of NaK molecules. In particular, we will present the design and the current status of our experimental apparatus.

Q 56.91 Thu 16:00 Empore Lichthof

Collisions of ultracold fermionic molecules: Averaged rates and state-changing collisions — •A. Pikovski[1], M. Klawunn[2], A. Recati[2], and L. Santos[1] — [1]Institut für theoretische Physik, Leibniz Universität Hannover, Germany — [2]INO-CNR BEC Center and Dipartimento di Fisica, Università di Trento, Italy

At very low temperatures, effects of quantum statistics play an important role in interparticle collisions. We study ensemble-averaged collision rates for a two-component gas of fermions, with possibly different masses, particle densities, and temperatures, for general two-body collisions. The results give an understanding of how the experimentally measured rates depend on the system parameters. [arXiv:1211.6613]

A concrete example of ultracold collisions are state-changing collisions in ultracold polar molecules in a bilayer geometry. If the molecules in each layer are initially prepared in a different rotational state, we show that the inter-layer dipole-dipole interaction induces a swap of the rotational state of molecules in different layers in two-body collisions. Remarkably, for optically trapped highly reactive molecules like KRb, such state swaps lead to losses by chemical reactions, and hence the state-changing collisions can be observed by monitoring the molecule number. [Phys. Rev. A 84, 061605(R) (2011)]

Q 56.92 Thu 16:00 Empore Lichthof

Two-Photon-Spectroscopy of YbRb - Towards paramagnetic molecules — •Cristian Bruni, Frank Münchow, Maximilian Madalinski, and Axel Görlitz — Institut für Experimentalphysik, HHU Düsseldorf, 40225 Düsseldorf

Ultracold heteronuclear molecules offer fascinating perspectives ranging from ultracold chemistry to novel interactions in quantum gases. Here we report on the spectroscopic investigation of vibrational levels in the electronic ground state of YbRb which is an important step towards the realization of YbRb ground state molecules [1]. Using two-photon photoassociation spectroscopy in laser-cooled mixtures of ^{87}Rb and various Yb isotopes we are able to determine the binding energies of weakly-bound vibrational levels and the positions of possible magnetic Feshbach resonances. Recent theoretical work suggest that also in mixtures of alkali and spin-singlet atoms magnetic Feshbach resonances could be experimentally accessible [2]. From additional investigations by means of Autler-Townes spectroscopy we obtain information on the transition rates between vibrational levels of different electronic molecular states.

[1] F. Münchow, C. Bruni, M. Madalinski, and A. Görlitz. Two-photon photoassociation spectroscopy of heteronuclear YbRb. PCCP,13(42):18734 - 18737, (2011).
[2] Piotr S. Zuchowski, J. Aldegunde, and Jeremy M. Hutson. Ultracold RbSr molecules can be formed by magnetoassociation. Phys.Rev. Lett., 105(15):153201, (2010).

Q 56.93 Thu 16:00 Empore Lichthof

Magnetic field dependence of collisions in ultracold YbRb mixtures — •Fabian Wolf, Cristian Bruni, Ali Al-Masoudi, Arnd Obert, Kira Borkowski, and Axel Görlitz — Institut für Experimentalphysik, HHU Düsseldorf, 40225 Düsseldorf

Due to its paramagnetic ground state YbRb is an interesting candidate for the realization of dipolar molecules with additional degrees of freedom. Exploration of magnetically tunable collision properties may eventually offer the possibility to associate ultracold atoms to molecules via Feshbach association. Recent theoretical work suggest that in mixtures of alkali and spin-singlet atoms a coupling between the entrance channel and the bound state channels exists [2]. This coupling leads to the existence of narrow Feshbach resonances. Via two-photon photoassociation spectroscopy the binding energies of weakly bound vibrational levels in YbRb were determined [1] and the positions of possible magnetic Feshbach resonances were predicted. Here we report on the current status of the experiment where we measure the atom loss in an optically trapped YbRb mixture under the influence of a tunable magnetic field.

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[2] Piotr S. Zuchowski, J. Aldegunde, and Jeremy M. Hutson. Ultracold RbSr molecules can be formed by magnetoassociation. Phys. Rev. Lett., 105(15):153201, (2010).

Q 56.94 Thu 16:00 Empore Lichthof

Zur Gültigkeit der adiabatischen Näherung im getriebenen Zwei-Niveau-System — •Ralf Saplata und Carsten Henkel — Universität Potsdam

Wir untersuchen ein getriebenes Zwei-Niveau-System (Rabi-Modell), für das der Einfluss der RWA auf die Berry-Phase kontrovers diskutiert wurde [1]. Obwohl die entsprechenden Kriterien [2] formal erfüllt sind, ist es nicht klar, ob die adiabatische Näherung angewendet werden darf [3]. Zur Interpretation der Berry-Phase untersuchen wir die Entwicklung des Zustands auf der Bloch-Kugel. Alternativ wird die Zeitentwicklung an Hand von numerischen Lösungen einer Differentialgleichung vom Hill-Mathieu-Typ diskutiert, wobei wir Floquet-Matrizen verwenden, um kurze und lange Zeitskalen zu überbrücken.

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[2] A.Messiah,Quantum Mechanics,Vol.2,North-
Holland Pub. Co. Amsterdam (1962)
[3] K.P.Marzlin and B.C.Sanders, Phys.Rev.Lett.93, 160408(2004)

Q 56.95 Thu 16:00 Empore Lichthof

On the Electrons in the Quantum Free-Electron Laser — •Rainer Endrich[1], Enno Giese[1], Peter Kling[1], Matthias Knobl[1], Paul Preiss[1,2], Wolfgang P. Schleich[1], Roland Sauerbrey[2], and Muhammad S. Zubairy[3] — [1]Institut für Quantenphysik and Center for Integrated Quantum Science and Technology (IQ$^{\mathrm{ST}}$), Universität Ulm, Albert-Einstein-Allee 11, D-89081, Germany — [2]Helmholtz-Zentrum Dresden-Rossendorf eV, D-01328 Dresden, Germany — [3]Institute for Quantum Science and Engineering, Department of Physics and Astronomy, Texas A&M University, College Station, Texas 77843, USA

Free-Electron Lasers (FEL) provide coherent and widely tunable radiation of high brilliance. Most theoretical descriptions are based on classical physics in agreement with experimental results. However, an FEL working the quantum regime is within reach at the Research Center Dresden-Rossendorf. Substantial theoretical progress has been made to understand quantum effects which are usually suppressed in the classical regime and therefore ignored. This includes two-level behavior, recoil effects, phase diffusion and much more. Based on our earlier work, we take a closer look at the density matrix of the joint system of laser field and electron beam. By this way we analyze the center-of-mass motion of the electrons and show how bunching emerges in the low-gain regime as well as the hole-burning effect.

Q 56.96 Thu 16:00 Empore Lichthof

Towards an interaction-free measurement with electrons — •Sebastian Thomas[1], Jakob Hammer[1], Johannes Hoffrogge[1], and Peter Hommelhoff[1,2] — [1]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching, Gemany — [2]Universität Erlangen-Nürnberg, Erwin-Rommel-Str. 1, 91058 Erlangen, Germany

Exploiting wave-particle duality, it is possible to determine the position of an object without affecting it in any way. This phenomenon is called an “interaction-free measurement” [1]. It can be realized with a single-photon source coupled into a Mach-Zehnder interferometer, where the presence of an object in one of the paths becomes noticeable as it prevents interference at the interferometer exit.

Recently, an interaction-free measurement setup has been proposed with electrons instead of photons [2]. This way, a new type of electron microscope might be constructed, in which samples receive a greatly reduced radiation dose. We discuss general features of interaction-free measurements as well as different approaches towards the realization of such a measurement with electrons. In particular, we investigate the effect of semi-transparent samples, and we consider the application of a linear microwave guide of low-energy electrons [3] for interaction-free measurements.

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[2] W. Putnam, M. Yanik, Phys. Rev. A 80, 040902 (2009)

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Q 56.97 Thu 16:00 Empore Lichthof

Relativistic aspects of the free-electron laser in the quantum limit — •Peter Kling[2], Roland Sauerbrey[1], Muhammad S. Zubairy[3], Rainer Endrich[2], Enno Giese[2], Matthias Knobl[2], Paul Preiss[1,2], and Wolfgang P. Schleich[2] — [1]Helmholtz-Zentrum Dresden-Rossendorf e V, D-01328 Dresden, Germany — [2]Institut für Quantenphysik and Center for Integrated Science and Technology, Universität Ulm, Albert-Einstein-Allee 11, D-89081 Ulm, Germany — [3]Institute for Quantum Science and Engineering, Department of Physics and Astronomy, Texas A&M University, College Station, Texas 77843, USA

Free-electron laser (FEL) devices are radiation sources with a wide tunability ranging from far-infrared up to X-rays. All existing FELs can be described by classical electrodynamics. However, due to experimental progress in the last years a new regime, the so-called quantum regime seems to be in reach.

Here recoil effects become important and a Jaynes-Cummings-like behavior between the radiation and the center-of-mass motion arises. Within our approach we investigate its emergence as well as its properties. In contrast to earlier approaches based on quantum mechanics in a co-moving reference frame we stay in the laboratory frame and use quantum electrodynamics.

Q 56.98 Thu 16:00 Empore Lichthof

Quantum tunnelling from a metastable potential: the driven Morse potential — •Harald Losert, Karl Vogel, and Wolfgang P. Schleich — Institut für Quantenphysik, Universität Ulm, D-89069 Ulm, Germany

We study the behaviour of a particle in a Morse potential under the influence of an external force. We have chosen the Morse potential as an example for an anharmonic potential since the eigenvalues, eigenfunctions and dipole matrix elements can be calculated analytically. Based on these results we solve the time-dependent Schrödinger equation for the driven system numerically.

In the first step we use a time-dependent external force to induce transitions from the ground state to an excited state, for example to an energy eigenstate. In the second step we apply a constant external force to enable quantum tunneling through an energy barrier whose height can be tuned by changing the external force. We investigate quantum tunnelling for various excited states, in particular energy eigenstates.

Q 56.99 Thu 16:00 Empore Lichthof

Comparison of phase space dynamics of Kopenhagen and Causal interpretations of Quantum Mechanics — •Christoph Tempel and Wolfgang P. Schleich — Institut f\"ur Quantenphysik, Universit\"at Ulm, D-89069 Ulm

Recent publications pursue the attempt to reconstruct Bohm trajectories experimentally utilizing the technique of weak measurements. We study the phase space dynamics of a specific double slit setup in terms of the Bohm de-Broglie formulation of quantum mechanics.

We want to compare the results of those Bohmian phase space dynamics to the usual quantum mechanical phase space formulation with the Wigner function as a quasi probability density.