A 34: Poster: Ultra-cold atoms, ions and BEC (with Q)

Time: Wednesday 16:30–18:30 Location: Spree-Palais

A 34.1 Wed 16:30 Spree-Palais

Towards Ultracold Chemistry - Scattering of Ba+ and Rb in an optical dipole trap — •Alexander Lambrecht, Thomas Huber, Michael Zugenmaier, Julian Schmidt, Leon Karpa, and Tobias Schaetz — Albert-Ludwigs-Universität Freiburg

Examining collisions of atoms and ions at extremely low velocities permits to gain information about the corresponding scattering potentials and therefore of quantum effects in chemical reactions. In the last years several experimental groups investigated cold collisions between atoms and ions, leading to better understanding of the atom-ion interaction in many different aspects[1-3]. Our approach to reach the regime of ultracold collisions is to precool a barium+ ion, trapped in a conventional Radio-Frequency (RF) trap, by doppler cooling followed by sympathetic cooling via an ambient rubidium MOT. By spatially overlapping the ion and the atom ensemble within a bichromatic optical dipole trap we overcome the limitations set by heating due to the RF micromotion[4]. We describe the experimental apparatus in its recent stage and the first experiments towards the simultaneous optical trapping of ions and atoms. [1]A.T.Grier, M.Cetina, F.Orucevic and V.Vuletic, Phys.Rev.Lett.102,223201(2009) [2]C.Zipkes, S.Palzer, C.Sias and M.Koehl, nature 464, 388 (2010) [3]W.G.Rellergert, S.T.Sullivan, S.Kotochigova, A.Petrov, K.Chen, S.J.Schowalter and E.R.Hudson, Phys.Ref.Lett. 107,243201 (2011) [4]L.H.Nguyen, A.Kalev, M.D.Barret and B.Engelert, Phys.Rev.A 85,052718 (2012)

A 34.2 Wed 16:30 Spree-Palais

Trapping Ions in a triangular microstructured surface trap — •Henning Kalis, Manuel Mielenz, Ulrich Warring, and Tobias Schaetz — Physikalisches Institut, Albert-Ludwigs Universität Freiburg

Many quantum systems, that may offer a variety of exotic behaviour are not fully accessible by classical simulations. One approach to overcome this difficulty could be to implement these quantum systems directly and in a well controllable quantum simulator, as proposed by R. Feynman [1]. Geometrical frustration has turned out to be a mechanism for inducing such exotic quantum disordered phases. As a starting point for quantum simulations of these systems we chose the most basic geometry that exhibits frustration, an equilateral triangle. However high-fidelity quantum control of such systems is obligatory and has been demonstrated in linear Paul-Traps (e.g. the quantum simulation of the 1D transverse-field Ising-Model [2,3]). Though high operational fidelity exceeding 99% is currently still restricted to a very limited number of constituents. A promising bottom-up approach for scaling the trapped ion system in size and dimension is based on radio-frequency surface-electrode traps [4], spanning arrays of individual rf-traps with a spacing of 40 micrometer. These surface-electrode traps may thus extend the control to 2D arrays of individual traps (lattices) enabling, in principle, the simulation of 2D Hamiltonians [5]. We will characterize our trapping setup (in collaboration with NIST, Sandia and R.Schmied) and report on the recent experimental results in our triangular trap.

A 34.3 Wed 16:30 Spree-Palais

Towards resolved sideband cooling in an atom-ion hybrid trap — •Joschka Wolf, Artjom Krükow, Arne Härter, Amir Mohammadi, Tobias Schnetzer, and Johannes Hecker Denschlag — Institut für Quantenmaterie, Universität Ulm, Albert-Einstein Allee 45, 89081 Ulm, Germany

We investigate the properties of a $^{138}Ba^{+}$ ion immersed in a bath of ultracold ^{87} Rb atoms. In the quest for a new level of control of the Ba^{+} ion in our atom-ion apparatus, we want to implement a resolved sideband cooling system. There are some challenges connected to realizing such a system. First a narrow band laser tuned to the $6S_{1/2} \rightarrow 5D_{5/2}$ shelving transition at 1762 nm is needed. To achieve a linewidth much smaller than the typical trapping frequencies of our Paul trap (40 kHz) and a daily frequency drift in the sub kHz regime, we set up a high-Q optical cavity. In order to stabilize the laser to this cavity we need a precise and flexible locking scheme. For this we will use a broadband electro-optical modulator operated in a two-tone configuration [1]. In addition to this shelving laser, we need a second laser resonant to the $5D_{5/2} \rightarrow 6P_{3/2}$ transition in order to deshelve the ion. Employing a sum frequency mixing technique, we will generate the 614 nm light using two high-power lasers at 1064 nm and 1450 nm, respectively. In this poster we show our progress and the capabilities of such a system.

[1] J.I. Thorpe, K.Numata, J.Livas, Opt. Expr. **16** 15980(2008)

A 34.4 Wed 16:30 Spree-Palais

statistical evaluation of ultracold molecular fraction rate — •tomotake yamakoshi[1], shinichi watanabe[1], chen zhang[2,3], and chris greene[2,3] — [1]Department of Engineering Science,University of Electro-Communications, Tokyo, Japan — [2]Department of Physics and JILA, University of Colorado, Colorado, USA — [3]Department of Physics, Purdue University, Indiana, USA

In recent years, various ultracold molecule production experiments have been carried out. Molecules are formed via a field ramp through a Fano-Feshbach resonance (FFR). They are subsequently transferred to the rovibrational ground state by STIRAP with very high efficiency. In this scenario, the final molecule conversion rate is restricted by the FFR fractional conversion. We study the FFR molecular fractional conversion rate using a Monte Carlo simulation based on the stochastic phase space sampling (SPSS) model[1]. The key idea of SPSS is that the phase space volume of atomic pairs does not change during an adiabatic magnetic sweep. We have applied this method to Fermi-Fermi, Bose-Bose, and Bose-Fermi cases, and have compared our SPSS result with that of the equilibrium theory[2]. We have identified some differences between results of the two approaches[3], especially in ultracold regions that have not yet been experimentally realized.

References: [1] E. Hodby et al., Phys. Rev. Lett. 94, 120402 (2005) [2] S. Watabe and T. Nikuni, Phys. Rev. A 77, 013616 (2008). [3] T. Yamakoshi, S. Watanabe, C. Zhang, C. H. Greene, Phys. Rev. A 87, 053604 (2013).

A 34.5 Wed 16:30 Spree-Palais

Quantum breathing frequency of trapped dipolar gases — •Tobias Dornheim, Alexey Filinov, and Michael Bonitz — ITAP, Christian-Albrechts-Universität zu Kiel, Leibnizstraße 15, 24098 Kiel

The quantum breathing mode (BM), i.e. the monopole oscillation of trapped quantum particles, serves as an important method for diagnostics of a variety of finite sized systems [1]. We investigate the BM for harmonically confined bosonic atomic gases with dipole interaction and consider one and two dimensional systems for the whole range of coupling strengths and a variety of particle numbers. We begin our analysis with the ab initio calculation of thermodynamic properties like e.g. energies, superfluid fraction and densities of up to $N \sim 10^3$ trapped particles, using a GPU accelerated realization of the Worm Algorithm Path Integral Monte Carlo scheme [2]. A recently published improved sum rule formalism [3] allows us to obtain an accurate upper bound for the breathing mode frequency. Finally we compare our results to available data for trapped fermions [3] and discuss the influence of Bose- and Fermi-statistics.

[1] C.R. McDonald et al., Phys. Rev. Lett., in press
[2] M. Boninsegni et al., Phys. Rev. E **74**, 036701 (2006)
[3] J.W. Abraham et al., ArXiv e-prints **1311.5371**, (2013)

A 34.6 Wed 16:30 Spree-Palais

Quenching effects in one-dimensional few body ensembles — •Simeon Mistakidis[1], Lushuai Cao[1,2], and Peter Schmelcher[1,2] — [1]Zentrum fur Optische Quantentechnologien, Universitat Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany — [2]The Hamburg Centre for Ultrafast Imaging, Universitat Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

Non-equilibrium aspects of few-boson systems in one-dimensional finite lattices are investigated. Starting from the Superfluid regime we drive non-perturbatively the few-body system by sudden interaction quenches. Employing the numerically exact ab-initio Multi-Layer Multi-Configuration time-dependent Hartree method for bosons permits us to realize non-equilibrium simulations. Focussing on the low-lying collective modes of the finite lattice we observe the emergence of tunneling, breathing and dipole processes. In particular the interaction quenches couple the tunneling and dipole modes yielding in this manner resonant phenomena. Finally,complementing the numerical studies an Effective Hamiltonian in terms of the Fock states is derived.

A 34.7 Wed 16:30 Spree-Palais

Classical scattering of charged particles confined on an inhomogeneous helix — •Alexandra Zampetaki[1], Jan Stockhofe[1], Sven Krönke[1], and Peter Schmelcher[1,2] — [1]Zentrum für Optische Quantentechnologien, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany — [2]The Hamburg Centre for Ultrafast Imaging, Luruper Chaussee 149, 22761 Hamburg, Germany

We explore the effects arising due to the coupling of the centre of mass and relative motion of two charged particles confined on an inhomogeneous helix with a locally modified radius. It can be proven that a separation of the centre of mass and the relative motion is provided if and only if the confining manifold represents a homogeneous helix. In this case, bound states of repulsively Coulomb interacting particles occur.

For an inhomogeneous helix, the coupling of the centre of mass and relative motion induces an energy transfer between the collective and relative motion, leading to dissociation of initially bound states in a scattering process. Due to the time reversal symmetry, a binding of the particles out of the scattering continuum is thus equally possible. We identify the regimes of dissociation for different initial conditions and provide an analysis of the underlying phase space via Poincare surfaces of section.

A 34.8 Wed 16:30 Spree-Palais

phase transition of a bosonic binary mixture in state-dependent hexagonal optical lattices — •Lushuai Cao[1,2], Sven Krönke[1], Jan Stockhofe[1], Peter Schmelcher[1,2], Dirk-Sören Lühmann[3], and Ole Jürgensen[3] — [1]Zentrum für Optische Quantentechnologien, Universität Hamburg, Hamburg, Germany — [2]The Hamburg Centre for Ultrafast Imaging, Hamburg, Germany — [3]Institut für Laser-Physik, Universität Hamburg, Hamburg, Germany

We present numerical investigations on the phase transition of a binary bosonic mixture in the state-dependent hexagonal optical lattices, of which the simulations takes into account many-body effects. It has been experimentally [P. S. Panahi, Nat. Phys. 8, 71 (2012)] shown that a binary bosonic mixture possesses a novel phase of Twisted Superfluid, which is characterized by the symmetry breaking in Time-of-Flight measurements. This phase was initially understood with the mean field approximation, by an interband phase difference, while a more extensive mean-field study [S. Choudhury, Phys. Rev. A 87, 033621 (2013)] indicated that there should be no such interband phase difference in the ground state. This work attempts to understand the novel phase with the more exact simulations, taking into account the many-body effects. The many-body simulations are performed via a numerically exact method ML-MCTDHB [S. Krönke, New J. Phys. 15, 063018 (2013), L. Cao, J. Chem. Phys. 139, 134103 (2013)].

A 34.9 Wed 16:30 Spree-Palais

Effects of anisotropy in simple lattice geometries on many-body properties of ultracold fermions in optical lattices — •Anna Golubeva, Andrii Sotnikov, and Walter Hofstetter — Goethe Universität, Frankfurt am Main, Germany

We study the effects of anisotropic hopping amplitudes on quantum phases of ultracold fermions in optical lattices described by the repulsive Fermi-Hubbard model. In particular, using dynamical mean-field theory (DMFT) we investigate the dimensional crossover between the isotropic square and the isotropic cubic lattice.

We analyze the phase transition from the antiferromagnetic to the paramagnetic state and observe a significant change in the critical temperature: Depending on the interaction strength, the anisotropy can lead to both a suppression or increase. We also investigate the localization properties of the system, such as the compressibility and double occupancy.

Using the local density approximation in combination with DMFT we conclude that density profiles can be used to detect the mentioned anisotropy-driven transitions.

A 34.10 Wed 16:30 Spree-Palais

Exotic Quantum Magnetism with cold atoms — •Marie Piraud, Zi Cai, and Ulrich Schollwoeck — Department für Physik, LMU München, Theresienstrasse 37, 80333 München

Strongly interacting ultra-cold atoms in artificial gauge fields can lead to many interesting effects. In the Mott regime for example, effective spin-Hamiltonians can be derived and various magnetic phases appear. In particular, a Dzyaloshinskii-Moriya (DM) Interaction term – which is relevant in the Condensed Matter context – is typically obtained for fermionic or two-component bosonic gases with spin-orbit coupling. We study the spin-Hamiltonians that are obtained in this context using large-scale DMRG simulations in one and two dimensions. The interplay between the exchange and DM interactions lead to ferromagnetic, antiferromagnetic and spiral ordered phases.

A 34.11 Wed 16:30 Spree-Palais

Development of ultrahigh-finesse crossed cavities for a quantum gas experiment — •Moonjoo Lee, Julian Leonard, Andrea Morales, Thomas Karg, Tilman Esslinger, and Tobias Donner — Institute for Quantum Electronics, ETH Zürich, CH-8093 Zürich, Switzerland

Quantum gases coupled to an optical cavity opened a new field for exploring quantum many-body physics with long-range interactions. An additional cavity will provide various possibilities for both the atomic internal and external degrees of freedom based on the interference of two vacuum fields.

We fabricated two independent ultrahigh finesse cavities whose mode axes cross under an angle of 60 degrees. The supermirrors are modified to put them as close as possible in order to obtain the strongest coupling under the given spatial conditions. The machined mirror surfaces have 600 μm width and each cavity has a length of 1.7 mm with 0.5 million finesse. The resulting cavity parameters for a single rubidium atom are $(g, \kappa, \gamma) / 2\pi = (2, 3, 0.15)$ MHz.

We discuss possible future experiments including the measurement of the eigenspectrum of a Bose-Einstein condensate coupled to the two crossed cavities, cavity-vacuum induced transparency, and slow light which might reveal the granular feature of the cavity photons. When the atoms are illuminated by a classical standing wave field, they can self-organize and scatter light from the pump field into both cavities. The emergent dynamical lattice potential will be hexagonal or triangular shape.

A 34.12 Wed 16:30 Spree-Palais

Photoassociation of ultralong-range Rydberg tetramers — •Philipp Ilzhöfer, Anita Gaj, Alexander Krupp, Jonathan Balewski, Robert Löw, Sebastian Hofferberth, and Tilman Pfau — 5. Physikalisches Institut, Universität Stuttgart, Germany

Scattering between a Rydberg electron and ground state atoms can lead to the formation of ultralong-range Rydberg molecules in an ultracold gas. For spherically symmetric Rydberg s-state this was done for principle quantum numbers 35-37 [1]. Here we report on the creation of molecules with higher principle quantum numbers n ranging from 40 to 111 from an ultracold gas of Rb atoms. From the measured binding energies we can precisely determine the electron-atom scattering length. For n=62 and n=71 we observe up to four ground state atoms bound in the Rydberg electron scattering potential. Moreover we can measure Frank Condon factors for the photoassociation of molecular ground and vibrational states. With increasing principle quantum numbers we observe decreasing binding energies, resulting eventually in a broadening and a shift of the spectral lines.

[1] V. Bendkowsky et al., *Nature* **458**, 1005–1008 (2009)

A 34.13 Wed 16:30 Spree-Palais

Curved quantum waveguides: Nonadiabatic couplings and gauge theoretical structure — •Jan Stockhofe[1] and Peter Schmelcher[1,2] — [1]Zentrum für Optische Quantentechnologien, Universität Hamburg, Germany — [2]The Hamburg Centre for Ultrafast Imaging, Universität Hamburg, Germany

We investigate the quantum mechanics of a single particle constrained to move along an arbitrary smooth reference curve by a confinement that is allowed to vary along the waveguide. The Schrödinger equation is evaluated in the adapted coordinate frame and a transverse mode decomposition is performed, taking into account both curvature and torsion effects and the possibility of a cross-section potential that changes along the curve in an arbitrary way. We discuss the adiabatic structure of the problem, and examine nonadiabatic couplings that arise due to the curved geometry, the varying transverse profile and their interplay. The exact multi-mode matrix Hamiltonian is taken as the natural starting point for few-mode approximations. Such approximate equations are provided, and it is worked out how these recover known results for twisting waveguides and can be applied to other types of waveguide designs. The quantum waveguide Hamiltonian is recast into a form that clearly illustrates how it generalizes the Born-Oppenheimer Hamiltonian encountered in molecular physics. In analogy to the latter, we explore the local gauge structure inherent to the quantum waveguide problem and suggest the usefulness of diabatic states, giving an explicit construction of the adiabatic-to-diabatic basis transformation.

A 34.14 Wed 16:30 Spree-Palais

Superfluid atom circuits — •Fred Jendrzejewski, Stephen Eckel, Jeffrey G Lee, Avinash Kumar, Christopher J Lobb, William D Phillips, and Gretchen K Campbell — Joint Quantum Institute, NIST and the University of Maryland

We have created a superfluid atom circuit using a toroidal Bose-Einstein Condensate. Just as a current in a superconducting circuit will flow forever, if a current is created in our superfluid circuit, the flow will not decay as long as the current is below a critical value. A repulsive optical barrier across one side of the torus creates the tunable weak link in the condensate circuit and can be used to control the current around the loop. By rotating the weak link at low rotation rates, we have observed phase slips between well-defined persistent current states. This behavior is analogous to that of a weak link in a superconducting loop. A feature of our system is the ability to dynamically vary the weak link, which in turn varies the critical current, a feature that is difficult to implement in superconducting circuits. For higher rotation rates, we observe a transition to a regime where vortices penetrate the bulk of the condensate. These results demonstrate an important step toward realizing an atomic SQUID analog.

A 34.15 Wed 16:30 Spree-Palais

Measurements of Impurity Coherence in a Fermi Sea by Spin Echo — Marko Cetina[1], •Rianne S. Lous[1,2], Michael Jag[1,2], Florian Schreck[1,3], Rudolf Grimm[1,2], Rasmus S. Christensen[4], and Georg M. Bruun[4] — [1]Insitut für Quantenoptik and Quanteninformation (IQOQI), Österreichische Akademie der Wissenschaften, Innsbruck, Austria — [2]Insitut für Experimental Physik, Universität Innsbruck, Innsbruck, Austria — [3]Institute of Physics, University of Amsterdam, Amsterdam, Netherlands — [4]Department of Physics and Astronomy, University of Aarhus, Aarhus, Denmark

We investigate the decoherence of a fermionic ^{40}K impurity that arises from collisions with a Fermi sea of ^{6}Li using the spin-echo technique. We use a Feshbach resonance to tune the interaction of the impurity with the sea. We measure the decoherence rate of the ^{40}K impurity for various interaction strengths and temperatures. From this, the collision rate of the impurity with the sea can be computed. The results show good agreement with a theory based on the Fermi Liquid picture.

A 34.16 Wed 16:30 Spree-Palais

Towards Creation and Detection of Momentum Entangled Atom Pairs — •Michael Keller[1,2], Mateusz Kotyrba[2], Maximilian Ebner[2], Mario Rusev[2], Johannes Kofler[3], and Anton Zeilinger[1,2] — [1]Institue for Quantum Optics and Quantum Information (IQOQI), Vienna, Austria — [2]University of Vienna, Vienna, Austria — [3]Max-Planck Institute for Quantum Optics, Garching, Germany

We present our work towards the creation and detection of momentum entangled states of metastable helium (He*) atoms.

Starting from a Bose-Einstein condensate (BEC) of metastable helium, stimulated Raman transitions transfer momentum onto the atoms. Subsequent collisions between two counterpropagating matter waves lead to atom pairs that are entangled in their momentum degree of freedom. This state represents a three-dimensional version of the one discussed in the Einstein-Podolsky-Rosen gedankenexperiment.

By using a position resolved micro-channel plate (MCP) detector the high internal energy of the He* atoms of almost 20 eV per atom allows for efficient detection of individual atoms with a high spatial and temporal resolution.

We show that a double double-slit as well as a ghost interference scheme can be used to show the entanglement and that those schemes are feasible with experimental restrictions in our setup. We discuss the main challenges in the experimental realization and present the present status of the experiment.

A 34.17 Wed 16:30 Spree-Palais

The Dynamics of Few-body Dipolar Bosons in the One-dimensional Optical Lattices — •Xiangguo Yin, Lushuai Cao, and Peter Schmelcher — Zentrum für Optische Quantentechnologien, Luruper Chaussee 149, D-22761 Hamburg, Germany

Based on the Multilayer Multi-Configuration Time Dependent Hatree method for bosons, We investigate the dynamics of one-dimensional few-body system composed of bosons with strong dipolar interaction in optical lattices. For the ground state of N bosons in 2N-1 wells, each boson occupies single well without particles in the nearest well, which is like crystal state in solid physics and named crystal-like state. For the ground state of N bosons in 3N-1 wells, each boson occupies two adjacent wells and there is one unoccupied well between each bosons, which is like supersolid state and named supersolid-like state. These two kinds of ground states are set as the initial state and two kinds of local driven potential are taken on one well of optical lattices, including asymmetric tilt potential and symmetric step potential. The vibration, driven by tilt potential, would be transfered from one side to the other side of optical lattices for crystal-like state. While for supersolid-like state, both of driven potential can cause the tunneling of the first particle in two adjacent wells with different amplitude and frequency and the correction induced tunneling of the other particles. However, the frequency of latter tunneling is independent on the shape and amplitude of driven potential.

A 34.18 Wed 16:30 Spree-Palais

Dimensional BCS-BEC Crossover — •Igor Boettcher[1], Jan Martin Pawlowski[1,2], and Christof Wetterich[1] — [1]Institute for Theoretical Physics, Heidelberg University, Germany — [2]ExtreMe Matter Institute EMMI, GSI Helmholtzzentrum fuer Schwerionenforschung mbH, Darmstadt, Germany

We investigate how the reduction of spatial dimension influences superfludity of two-component fermion in the BCS-BEC crossover by means of the Functional Renormalization Group. Our approach allows to study the system over the whole parameter space of interaction strength, density, temperature, spin-imbalance, and dimension. The high precision and tunability of recent experiments allows for a solid benchmarking of our description. We present results on the equation of state and the phase diagram as a function of dimension, and compare with recent measurements.

A 34.19 Wed 16:30 Spree-Palais

Trapped-atom interferometry with losses — •Valentin Ivannikov — Swinburne University of Technology, Centre for Atom Optics and Ultrafast Spectroscopy, Australia — Physikalisches Institut, Universität Heidelberg, Germany

An ensemble density matrix model that includes one- and two-body losses is derived for a trapped-atom clock. A trapped-atom clock is mainly affected by one- and two-body losses, generally giving non-exponential decays of populations; nevertheless, three-body recombination is also quantitatively analyzed to demonstrate the boundaries of its practical relevance. The importance of one-body losses is highlighted without which population trapping behaviour would be observed. The model is written with decay constants expressed through experimental parameters. It can complement, e.g., the ISRE (identical spin rotation effect) model to improve its predictions: ISRE dramatically increases the ensemble coherence time, hence it enables one to observe the influence of two-body losses on the interferometry contrast envelope. The presented model is useful for Ramsey interferometry and is ready for immediate experimental verification in existing systems.

In addition, several Ramsey-type interferometry models are presented which include one-body and few-body losses. A way to include ensemble-phase noise to the many-body model due to the rotational property of the Ramsey detection pulse is suggested to avoid the computational complexity of the Markovian simulation.

A 34.20 Wed 16:30 Spree-Palais

Crystallization in dissipative Rydberg lattices — •Wildan Abdussalam[1], Michael Hoenig[2], George Bannasch[1], Michael Fleischhauer[2], and Thomas Pohl[1] — [1]Max Planck Institute for the Physics of Complex Systems, D-01187 Dresden, Germany — [2]Fachbereich Physik und Forschungszentrum OPTIMAS, Technische Universiteit Kaiserslautern, 67663 Kaiserslautern, Germany

We study two-dimensional lattices of Rydberg atoms with strong van der Waals interactions for configurations in which the competition between coherent laser driving and dissipative processes lead to an inversion of electronic populations. Using Monte Carlo simulations we determine the many-body steady states of this system and identify conditions for the emergence of crystalline phases. Despite the rapid drop of the van der Waals potential the long-range tail of the interaction is shown to qualitatively affect the system behaviour, making simplified nearest-neighbor models inapplicable. Comparisons to previous mean field predictions moreover highlight the importance of classical correlations. Finally, we will discuss different experimental routes to observe the predicted phase transition towards crystalline order.

A 34.21 Wed 16:30 Spree-Palais

Coherently coupled two-component ultracold bosons — •Ulrike Bornheimer, Ivana Vidanovic, and Walter Hofstetter — Goethe Universität, Institut für Theoretische Physik, Max-von-Laue Straße 1, 60438 Frankfurt am Main

We investigate an ultracold, two-component bosonic gas in a cubic optical lattice. In addition to density-density interactions, the atoms are subject to coherent light matter interactions that couple different internal hyperfine states. In the strongly interacting Mott regime, the resulting Bose-Hubbard Model can be mapped onto an effective spin Hamiltonian. We examine the influence of the coherent coupling on the system and its' quantum phases by using Gutzwiller Mean Field as well as Bosonic Dynamical Mean Field Theory.

A 34.22 Wed 16:30 Spree-Palais

Towards atom chips with submicron atom-surface separation — •Amruta Gadge[1], Robert Hollenstein[1,2], Francesco Intravaia[1,3,4], Jessica Maclean[1], Samanta Piano[1], Mark Fromhold[1], Christian Koller[1], and Peter Kruger[1] — [1]Midlands Ultracold Atom Research Centre, School of Physics and Astronomy, University of Nottingham, Nottingham NG7 2RD, UK — [2]Vienna Center for Quantum Science and Technology, TU Wien, Atomistitut, Stadionallee 2 1020 Wien — [3]Institut fuer Physik, Humboldt-Universitaet zu Berlin, Newtonstr. 15, 12489 Berlin, Germany — [4]Max-Born-Institut, 12489 Berlin, Germany

Current atom chip technology enables trapping of atoms at distances of 10-100 microns from the surface. The limitation on the trapping distance arises from distance-dependent effects like surface forces, Johnson noise or fields generated from the adsorbates. Ultra-close trapping of atoms would improve the resolution of cold-atom based surface probes when they are used to map out current distributions and electric and magnetic fields. We are constructing an experimental system to trap atoms very close to the surface, considering relevant effects that can impede trapping at submicron distances. The basis of these experiments is an atom chip incorporating a thin film. We will position an ultracold cloud of Rb87 atoms, above a graphene sheet supported by a TEM grid, which will allow us to control and shift the cloud precisely to specific grid locations. We will compare the losses from the trap when the cloud is above the metal part and the hollow region of the grid. We will show theoretical calculations and experimental progress.

A 34.23 Wed 16:30 Spree-Palais

Artificial gauge fields in a driven optical lattice — •Malte Weinberg[1], Christoph Ölschläger[1], Julian Struck[1], Juliette Simonet[1], Patrick Windpassinger[2], and Klaus Sengstock[1] — [1]Institut für Laserphysik, Universität Hamburg, Germany — [2]Institut für Physik, Johannes Gutenberg-Universität, Mainz, Germany

Atomic quantum gases are neutral, and therefore, not affected by external electromagnetic fields in the way electrons are. This constitutes a central issue towards the quantum simulation of solid state models involving an external magnetic field, e.g. the Quantum Spin Hall Effect. Therefore the experimental realization of artificial gauge fields in ultracold atomic systems shall put through quantum simulators of new kinds of exotic quantum matter.

In this perspective, driven optical lattices constitute a versatile tool, which allows controlling both phase and amplitude of the complex tunneling parameters and, thus, generating artificial gauge potentials [1]. By expanding this concept to a triangular lattice structure, it is possible to realize gauge invariant and fully tunable artificial magnetic fluxes that exhibit a staggered ordering [2].

[1] J. Struck et al., Phys. Rev. Lett. 108, 225304 (2012)
[2] J. Struck et al., Nat. Phys. 9, 738-743 (2013)

A 34.24 Wed 16:30 Spree-Palais

Progress on the Fermi Quantum Microscope — •Timon Hilker[1], Martin Boll[1], Ahmed Omran[1], Thomas Reimann[1], Konrad Viebahn[1], Alexander Keesling[1], Immanuel Bloch[1,2], and Christian Gross[1] — [1]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str.1, 85748 Garching — [2]Ludwig-Maximilians-Universität München, Schellingstr. 4, 80799 München

Ultracold atoms in optical lattices have proven to be a powerful tool for investigating quantum many body systems. Recent experiments have demonstrated the power of single-site resolved detection in optical lattices for the study of strongly correlated bosonic many body systems.

In our experiment we plan to apply similar techniques to fermionic systems. Here, we present our progress towards a fermionic many body system trapped in a 3D optical lattice. Li-6 atoms are cooled to degeneracy using a UV-MOT and a fast optical evaporation. We plan to achieve the imaging of single atoms resolved on individual sites of a 2D plane of the lattice by superimposing an additional small-scale pinning lattice onto the larger-scale physics lattice. This freezes out the distribution of atoms during imaging with a high resolution imaging system, which allows to separate the detector from the physical system under study. Different lattice geometries can thus be studied with single atom sensitivity. In this way we plan to probe the quantum phases of the Fermi-Hubbard Hamiltonian by local measurements, and investigate the underlying phenomena associated with condensed matter systems, e.g. quantum magnetism.

A 34.25 Wed 16:30 Spree-Palais

Stochastic theory of thermal matter fields — •Holger Hauptmann[1], Sigmund Heller[1], Holger Kantz[2], and Walter T. Strunz[1] — [1]Technische Universität Dresden — [2]Max-Planck-Institut für Physik komplexer Systeme

We study quasi one-dimensional ultracold Bose gases with repulsive self interaction. A nonlinear stochastic matter-field equation of generalized Gross-Pitaevskii type will be presented to describe Bose gases in the canonical ensemble (fixed particle number). This might be a more realistic experimental scenario than the grand-canonical approach. Applications of this equation to simulate recent experiments from the Schmiedmayer group [1] will be shown, especially the emergence of correlations in quantum many-body systems. Moreover, results for equilibrium coherence properties of one-dimensional Bose gases will be presented.

[1] Langen et al. Nature Physics 9, 640-643 (2013)

A 34.26 Wed 16:30 Spree-Palais

Nonequilibrium BCS Dynamics of Ultracold Fermi Gases — •Peter Kettmann[1], Simon Hannibal[1], Mihail Croitoru[2], Alexei Vagov[3], Vollrath Martin Axt[3], and Tilmann Kuhn[1] — [1]Institute of Solid State Theory, University of Münster — [2]Condensed Matter Theory, University of Antwerp — [3]Theoretical Physics III, University of Bayreuth

Ultracold Fermi gases are a convenient testbed for complex interacting Fermi systems like, e.g., superconductors. They are on the one hand easily accessible in experiment. On the other hand their interparticle interaction strength can be tuned to pass from a BCS to a BEC state. In this way, many-body effects in strongly correlated Fermi systems like high-Tc superconductors can be tested in a controlled way.

We investigate the BCS phase of an ultracold Fermi gas. In particular we calculate the nonequilibrium dynamics of a confined ^{6}Li gas after a sudden excitation, which can be achieved, e.g., by an abrupt change of an external magnetic field or the system confinement. We show that the dynamics of the BCS gap is given by a collective damped oscillation breaking down after a certain time. Afterwards a rather chaotic oscillation appears. We explain this behavior by expressing the quasiparticle equations of motion in terms of a set of coupled oscillators.

Studying systems with different parameters we see that the dynamics show a more or less pronounced initial part of the oscillation depending on the confinement. This is related to size-dependend superfluid resonances predicted by recent theoretical studies [1] and thus to the BCS-BEC crossover. [1] A. A. Shanenko et al., PRA 86, 033612 (2012)

A 34.27 Wed 16:30 Spree-Palais

Narrow-line laser cooling of dysprosium into an optical dipole trap — •Matthias Schmitt, Thomas Maier, Holger Kadau, Axel Griesmaier, and Tilman Pfau — 5. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany

We present our techniques to laser cool dysprosium on a narrow-line transition to achieve suitable conditions to directly load atoms into an optical dipole trap. Dysprosium is the element with the highest magnetic moment and offers a non-spherical symmetric groundstate $^5I_8$. This complex electronic structure leads to several possible cooling and optical pumping transitions. We use a broad cooling transition at 421 nm for Zeeman slowing and capture these atoms in a narrow-line magneto-optical trap using a transition at 626 nm. A transversal cooling stage before the Zeeman slower increases the capture rate by a factor of 4 and atom number by a factor of 3. By using a spectral broadener to increase the capture velocity, we can trap up to $1.2 \cdot 10^8$ atoms and double the capture rate.

To directly load into an optical dipole trap, we compress the magneto optical trap and achieve temperatures of $\sim 10\,\mu$K. We transfer 10 million atoms and subsequently optically transport the cold atom cloud to a glass cell, which offers high optical access. Ongoing work is to increase the phase space density until quantum degeneracy in a crossed optical dipole trap. Future techniques are to implement a high resolution imaging and the possibility to write nearly arbitrary time-averaged potentials with an electro-optical deflector system.

A 34.28 Wed 16:30 Spree-Palais

Single flux quanta observed with ultracold atomic clouds — •Patrizia Weiss, Helge Hattermann, Simon Bernon, Martin Knufinke, Daniel Bothner, Matthias Rudolph, Lörinc Sárkány, Florian Jessen, Petra Vergien, Simon Bell, Reinhold Kleiner, Dieter Koelle, and József Fortágh — Physikalisches Institut and CQ Center for Collective Quantum Phenomena and their Applications, Eberhard-Karls-Universität Tübingen, Auf der Morgenstelle 14, D-72076 Tübingen, Germany

When superconducting closed loops like a ring are cooled through the superconducting transition ($T_c = 9.2\,$K) in an external field, persistent currents will conserve the magnetic flux inside the ring. This trapped flux is quantized and will be an integer multiple of the magnetic flux quantum $\Phi_0 = 2.067 \times 10^{-15}\,\mathrm{Tm}^2$.

We report on the interaction of an atomic cloud with a superconducting ring. We trap atomic clouds of ^{87}Rb in a superconducting magnetic microtrap at 4.2 K and bring the atoms into the vicinity of the ring structure ($R = 10\,\mu$m). The atomic cloud is sensitive to the additional potential generated by the persistent currents in the ring. Changes of single flux quanta Φ_0 can be observed in the atomic density distribution, as well as in the trap shape. The results pave the way towards coupling cold atoms to SQUIDS and the generation of periodic magnetic micropotentials based on persistent currents.

As a further step towards coupling, we will discuss the preparation of cold atomic clouds in a dilution refrigerator [1].

[1] F. Jessen *et. al.*, arXiv:1309.2548

A 34.29 Wed 16:30 Spree-Palais

Towards frustrated systems in a tunable Kagome lattice — •Vincent M. Klinkhamer[1,2], Thomas Barter[2], Claire K. Thomas[2], and Dan M. Stamper-Kurn[2] — [1]Universität Heidelberg, Germany — [2]University of California, Berkeley, USA

We present a revised optical lattice setup and a magnetic field compensation that will improve experimental control of our Kagome lattice experiment. The experiment consists of a ^{87}Rb BEC which is loaded into a tunable optical superlattice. We have studied the geometry-induced phase transition between the superfluid and Mott-insulating phases by continuously varying the lattice from a triangular to a Kagome geometry. Our next goal is to access the third, flat band of the Kagome lattice and study the effects of orbital and spin frustration.

A 34.30 Wed 16:30 Spree-Palais

Towards degenerate Li-Cs mixtures — Sonali Warriar, Asaf Paris Mandoki, Matthew Jones, •Jonathan Nute, Raghavan Kollengode, and Lucia Hackermueller — School of Physics and Astronomy, University of Nottingham, University Park, NG7 2RD, Nottingham, UK

Ultracold mixtures hold the promise of understanding new phases of matter and collisions at very low energies or modelling condensed matter systems. We are setting up an experiment for Bose-Fermi mixtures of lithium and caesium, which are especially well suited to study impurities, transport, solitons or mixtures in optical lattices. These species are appealing because they offer favourable interaction properties and can be manipulated independently of each other due to their different resonance frequencies. Here we present the current status of our experiment. We detail the cooling schemes for the two atomic species and include the development and optimal loading of an optical dipole trap.

A 34.31 Wed 16:30 Spree-Palais

Development of a high power semiconductor based laser source at 493nm for optical trapping of Ba+ ions. — •Tobias Schnetzer, Artjom Krükow, Arne Härter, Amir Mohammadi, Joschka Wolf, and Johannes Hecker Denschlag — Institute for Quantummater, Ulm, Germany

One of the most commonly used tools to trap ions to date are Paul traps. Due to their operating principle trapped particles will undergo a driven micromotion which cannot be cooled. Using optical dipole forces to create a confining potential this micromotion can be circumvented therefore reducing the lower limit of attainable kinetic energies of the trapped ion. In our atom-ion hybrid apparatus we require a common optical trap to confine a single Ba+ together with an ultracold Rb atom cloud at the same time. In this poster we present a home-built semiconductor based laser providing a narrowband multi watt output of near resonant light for the Ba+ ion at 493nm. We discuss our approach to realize a common atom-ion trap where this laser source is key and show our progress.