A 9: Ultra-cold atoms, ions and BEC (with Q)

Time: Monday 16:30–19:00 Location: Empore Lichthof

A 9.1 Mon 16:30 Empore Lichthof

Heating and decoherence effects in a hybird atom-ion system — •Tao Yin, Tao Qin, and Walter Hofstetter — Institut für Theoretische Physik, Johann Wolfgang Goethe-Universität, 60438 Frankfurt/Main, Germany

In this work we study heating and decoherence effects in a hybrid atom-ion system, in which the atom and ion are trapped by a harmonic trap and Paul trap, respectively. We consider the entangled state of one ion strongly coupled to one atom. As a consequence of the time-dependent trapping potential and short-range atom-ion collisions, the ionic micromotion plays an important role in such systems. We investigate the dynamic properties in this system by the Floquet formalism and calculate the effects of heating and decoherence arising from the ionic micromotion. We also study the validity of the secular approximation for different atom-ion mass ratios and trapping geometries. Our results can be used to explain and design experiments on hybrid atom-ion simulators of this type. In addition, we consider adding a second ion to this system, and preliminarily study its possible effects on the atom-ion entangled state due to the long-range coulomb interaction between these two ions.

A 9.2 Mon 16:30 Empore Lichthof

Towards Ultracold Interaction - Optical trapping of Barium Ions and Rubidium Atoms — •Pascal Weckesser, Alexander Lambrecht, Julian Schmidt, Leon Karpa, and Tobias Schaetz — Albert-Ludwigs-Universität Freiburg

In the last years several experimental groups investigated collisions between laser-cooled atoms and ions, leading to a better understanding of the atom-ion interaction in many aspects [1-4]. Due to the RF-confinement of the ions these systems have been dominated by an intrinsic heating effect [5], limiting collision dynamics on the order of a few milli-Kelvin. A purely optical and electrostatic potential for both ions and atoms should overcome this effect [6] allowing to investigate ultracold interactions, such as cluster formation of an ion binding atoms wihtin the common $1/r^4$-potential [7].

Here we present our experimental setup combining simultaneously trapped Ba^+ ions and Rb atoms in a far detunded bichromatic dipole trap. We discuss the properties of this novel trap, methods for extending the ion lifetime as well as prospective experiments within reach with the presented setup.

[1] A.T.Grier et al., Phys.Rev.Lett. 102,223201(2009)
[2] C.Zipkes et al., Nature 464,388(2010)
[3] S.Schmid et al. Phys.Rev.Lett. 105.133202 (2010)
[4] W.G.Rellergert et al., Phys.Rev.Lett. 107,243201 (2011)
[5] M.Cetina et al., Phys.Rev.Lett. 109,253201 (2012)
[6] T.Huber et al., Nat. Comm. 5,5587 (2014)
[7] R.Cote et al. Phys.Rev.Lett. 89.093001 (2002)

A 9.3 Mon 16:30 Empore Lichthof

Orbital magnetism of ultracold fermionic gases in a lattice: Dynamical Mean-Field Approach — •Agnieszka Cichy[1], Anna Golubeva[1], Andrii Sotnikov[2], and Walter Hofstetter[1] — [1]Goethe Universität, Frankfurt a. M., Germany — [2]Kharkiv Institute of Physics and Technology, Kharkiv, Ukraine

The impressive development of experimental techniques in ultracold quantum degenerate gases of alkaline-earth-like atoms in the last years has allowed investigation of strongly correlated systems. Long-lived metastable electronic states in combination with decoupled nuclear spin give the opportunity to study the Hamiltonians beyond the possibilities of current alkali-based experiments. Ytterbium is particularly convenient due to its large number of bosonic and fermionic (e.g. ^{173}Yb) isotopes with a wide range of interaction strengths.

We study finite-temperature properties of the two-band Hubbard model on a simple cubic lattice. Our main goal is to investigate the role of exchange interaction in finite temperature magnetic phases, for the whole range of fillings. We use the Dynamical Mean-Field Theory approach and its extension in real space to obtain finite-temperature phase diagrams including transitions to magnetically-ordered phases. We determine which parameter regimes are most favourable for ferromagnetism, in terms of experimental observation in ultracold atomic gases in a lattice. We also calculate the entropy in the vicinity of magnetically-ordered phases that allows to make important predictions for on-going and future experiments aiming at approaching and studying long-range ordered states in ultracold atomic mixtures.

A 9.4 Mon 16:30 Empore Lichthof

Dynamical Mean-Field Theory of the SU(4)-symmetric Fermi-Hubbard model and its extensions — •Anna Golubeva[1], Agnieszka Cichy[1], Andrii Sotnikov[2], and Walter Hofstetter[1] — [1]Goethe Universität, Frankfurt am Main, Germany — [2]Kharkiv Institute of Physics and Technology, Kharkiv, Ukraine

Alkaline-earth-like atoms have emerged in the field of ultracold quantum gases as a promising alternative to alkali atoms. Their internal structure includes low-lying metastable electronic states offering the possibility to simulate many-body models with orbital phenomena. Furthermore, certain isotopes (specifically ^{87}Sr, ^{173}Yb) exhibit a high SU(N) symmetry of interactions which is a result of the decoupling between the nuclear spin and electronic degrees of freedom. Recent experimental advances in this field [1–3] have triggered theoretical interest.

We investigate the SU(4)-symmetric Fermi-Hubbard model in a simple cubic optical lattice at finite temperatures. By means of Dynamical Mean-Field Theory [4] and its real-space extension we study the magnetic phases and entropy characteristics of the system at half- and quarter-filling. We also analyze the influence of different interspecies interactions on possible magnetic orderings.

[1] Taie et al., Nature Phys. 8, 825–830 (2012)
[2] Taie et al., Phys. Rev. Lett. 105, 190401 (2010)
[3] Fukuhara et al., Phys. Rev. A 79, 021601 (2009)
[4] Georges et al., Rev. Mod. Phys. 68, 13 (1996)

A 9.5 Mon 16:30 Empore Lichthof

Manipulation of a dipolar Bose-Einstein condensate using an electro-optical deflector system — •Matthias Schmitt, Holger Kadau, Matthias Wenzel, Igor Ferrier-Barbut, and Tilman Pfau — 5. Physikalisches Institut and Center for Integrated Quantum Science and Technology, Universität Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany

Strongly dipolar quantum gases enable the observation of many-body phenomena with anisotropic, long-range interactions. Observing these effects can be enhanced by an initial preparation of the atomic density distribution in multi-well [1] or ring-shaped potentials [2] as well as in-situ imaging.

We present the first results on tailored potentials imprinted on a Bose-Einstein condensate of dysprosium atoms. The potentials are created with a 532 nm laser modulated with an electro-optical deflector system and a Pockels cell. The light is focused on the atomic cloud using a diffraction-limited custom objective with high numerical aperture.

[1] D. Peter, K. Pawłowski, T. Pfau and K. Rzażewski, J. Phys. B, 45, 225302 (2012)
[2] M. Abad, M. Guilleumas, R. Mayol, M. Pi and D. M. Jezek, EPL, 94, 10004 (2011)

A 9.6 Mon 16:30 Empore Lichthof

Controlling Rydberg atoms in dense gases — •Karl Magnus Westphal, Kathrin Sophie Kleinbach, Felix Engel, Fabian Böttcher, Michael Schlagmüller, Robert Löw, Tara Cubel Liebisch, Sebastian Hofferberth, and Tilman Pfau — 5. Physikalisches Institut and Center for Integrated Quantum Science and Technology, Universität Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany

When a Rydberg atom is excited in a dense gas, there can be tens of thousands of neutral atoms within the Rydberg electron orbit, resulting in a density-dependent frequency shift, as discovered by Amaldi and Segrè in 1934. However, Rydberg excitations in a BEC lead not only to a density shift, but a line shape that changes with the principal quantum number n. The line broadening depends precisely on the interaction potential energy curves of the Rydberg electron with the neutral atom perturbers. In particular, we show the relevance of the triplet p-wave shape resonance in the e^--Rb($5S$) scattering, which significantly modifies the interaction potential [1]. We discuss a variety of results of experiments with a single charged impurity in quantum gases as well as wavefunction imaging. Spatial control of the excitations allows us to study the density-dependent quantum chemistry between a Rydberg atom and neutral atoms.

1 M. Schlagmüller et al., **arXiv:1510.07003**, (2015)

A 9.7 Mon 16:30 Empore Lichthof

Towards the production of RbCs ground-state molecules from degenerate gases in an optical lattice — •Beatrix Mayr[1], Lukas Reichsöllner[2], Andreas Schindewolf[1], Silva Mezinska[1], Rudolf Grimm[1,2], and Hanns-Christoph Nägerl[1] — [1]Institut für Experimentalphysik, Universität Innsbruck — [2]Institut für Quantenoptik und Quanteninformation IQOQI, Innsbruck

Ultracold dipolar systems are of high interest for quantum chemistry, precision spectroscopy, quantum many-body physics, and quantum simulation. Our goal is the production of a low entropy sample of dipolar RbCs molecules in the rovibronic and hyperfine ground-state. To be able to mix degenerate samples of Rb and Cs, the inter-species scattering length a_{RbCs} has to be tuned close to zero by means of a magnetic Feshbach resonance. Since Cs three-body losses would cause a breakdown of a Cs BEC in the magnetic-field region, in which RbCs Feshbach resonances are available, we initially prepare a Cs Mott insulator with unity filling spatially separated from the Rb sample. The optical lattice wavelength and depth are chosen in a way that Rb is still superfluid and can be overlapped with Cs after switching the magnetic field to achieve $a_{\mathrm{RbCs}} = 0$. Precise control over the relative position of the two degenerate samples and high magnetic field stability will enable the formation of RbCs Feshbach molecules with a high filling factor of the optical lattice followed by the application of the STIRAP transfer to the absolute molecular ground-state, as demonstrated in Ref. [1].

[1] T. Takekoshi et al., Phys. Rev. Lett. **113**, 205301 (2014)

A 9.8 Mon 16:30 Empore Lichthof

Expansion dynamics of an ultracold gas from realistic trap potentials for atom interferometry — •Srihari Srinivasan and Reinhold Walser — Institut für Angewandte Physik, TU Darmstadt, Hochschulstraße 4a, 64289 Darmstadt

The versatility of Bose-Einstein Condensates (BEC) for use in experiments has enabled an entire genre of topics ranging from quantum optics and condensed matter physics to quantum simulators and sensors. The QUANTUS collaboration [1] aims to use atom interferometry with an ultracold ^{87}Rb gas in the vacuum drop tower at ZARM in Bremen [2]. The experiment module can either be catapulted or dropped inside the vacuum drop tower to perform atom interferometry in microgravity under free fall to test Einstein's Equivalence Principle.

Expansion dynamics of a BEC is well understood analytically [3]. Interferometric fringe contrast of an expanding BEC released from the trap is strongly influenced trap anharmonicity and thermal component of the gas. We aim to simulate the expansion of a BEC and a thermal cloud from a realistic, anisotropic magnetic trap of the QUANTUS II atom chip. This is done as a part of a comprehensive simulation of a realistic atom interferometer to be used for comparison with experimental data.

[1] QUANTUS Collaboration:www.iqo.uni-hannover.de/quantus.html

[2] T. van Zoest et al., Science, **328**, 1540 (2010) and H. Mütinga et al., Phys. Rev. Lett., **110**, 093602 (2013).

[3] Yu Kagan et al., Phys. Rev. A, **54**(3), R1753 (1996) and Y Castin et al., Phys. Rev. Lett., **77**(27), 5315 (1996).

A 9.9 Mon 16:30 Empore Lichthof

Regions of tunneling dynamics for few bosons in an optical lattice subjected to a quench of the imposed harmonic trap — •Georgios Koutentakis[1,2], Simeon Mistakidis[1], and Peter Schmelcher[1,2] — [1]Zentrum für Optische Quantentechnologien, Universität Hamburg, Luruper Chaussee 149, D-22761 Hamburg, Germany — [2]The Hamburg Centre for Ultrafast Imaging, Universität Hamburg, Luruper Chaussee 149, D-22761 Hamburg, Germany

Recent advancements in ultracold atom experiments have introduced an interplay in the trapping length scales of lattice and harmonic confinement. This fact motivates the investigation, whether it is possible to prepare atomic gases at certain quantum states by utilizing a composite atomic trap consisting of a lattice potential that is embedded inside an overlying harmonic trap. In the present work, we examine how frequency modulations of the harmonic trap stimulate the dynamics of an 1D few-boson gas. The gas is initially prepared at a highly confined state, and the subsequent dynamics induced by a quench of the harmonic trap frequency to a lower value is examined. It is shown that a non-interacting gas always diffuses to the outer sites, whereas the response of the interacting system is more involved and is dominated by a resonance, which is induced by the bifurcation of the low-lying eigenstates. Our study reveals that the position of the resonance depends both on the atom number and the interaction coupling, manifesting its many body nature. A corresponding mean field treatment as well as a single-band approximation have been found to be inadequate for the description of the tunneling dynamics in the interacting case.

A 9.10 Mon 16:30 Empore Lichthof

Cradle-like processes and mode-coupling of interaction quenched ultracold bosons in periodically driven lattices — •Simeon Mistakidis[1] and Peter Schmelcher[1,2] — [1]Zentrum fuer Optische Quantentechnologien, Universitaet Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany — [2]The Hamburg Centre for Ultrafast Imaging, Universitaet Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

The out-of-equilibrium dynamics of ultracold bosons in one-dimensional lattices following an interaction quench upon a periodically driven optical latttice is investigated. It is shown that an interaction quench triggers the inter-well tunneling dynamics, while for the intra-well dynamics breathing and cradle-like processes can be generated. In particular, the occurence of a resonance between the cradle and tunneling modes is revealed. On the other hand, the employed periodic driving (vibration) enforces the bosons in the mirror wells to oscillate out-of-phase and to exhibit a dipole mode, while in the central well the cloud experiences a breathing mode. The dynamical behaviour of the system is investigated with respect to the driving frequency revealing a resonant-like behaviour of the intrawell dynamics. To drive the system in a highly non-equilibrium situation an interaction quench upon the driving is performed giving rise to admixing of excitations in the mirror wells, an enhanced breathing in the center and an amplification of the tunneling dynamics. As a result of the quench the system experiences multiple resonances between the inter- and intra-well dynamics at different quench amplitudes.

A 9.11 Mon 16:30 Empore Lichthof

A new apparatus of Bose-Fermi mixture — •Haoze Chen — University of Science and Technology of China Shanghai Branch, Shanghai, China

We will introduce a new apparatus for investigation of lithum6 and potassium41 Bose-Fermi mixture. The whole system contains several novel developed technics. Lithum6 and potassium41 are precooled by a spin-flipped Zeeman slower and 2D plus MOT respectly and captured by 3D-MOT simultaneously. Lithum6 cloud is further cooled by UV-MOT, while potassium41 is further cooled by gray molasses, which enhance the phase-space density from 1e-7 to 1e-4. We then apply D1 optical pumping for both atoms to increase the loading efficiency and purify the spin state. Then both species are loaded in a magnetic trap, and transport from our MOT chamber to science cell, which has a much better vacuum and optical access. We start evaporate cooling of potassium41 in a plugged magnetic trap, while lithum6 is sympathetic cooled by potassium41. After 15s of evaporation, we have generated double degenerate gas with more than 2e5 pure BEC of K41 and 5e5 degenerate fermi gas with 10% Fermi temperature of Li.

A 9.12 Mon 16:30 Empore Lichthof

Energy and mass transfer between zig-zag chains trapped in a double well potential — •Andrea Klumpp[1], Alexandrea Zampetaki[1], and Peter Schmelcher[1,2] — [1]ZOQ Universität Hamburg — [2]ILP Universität Hamburg

Ion traps are versatile tools for experiments in various fields, such as spectroscopy, quantum computing, molecular physics and biophysics [1]. The development of micro-fabricated segmented Paul traps opens up new fields for research relating, among others, to the transport of ions [2], the splitting [3] and also the coupling of ion crystals [4].

In our work we investigate the dynamics of two trapped ion crystals in a three dimensional double well potential with a strong confinement perpendicular to the x-z plane as in the case of a planar trap. The initial state of the ions in our setup is given by well separated zig-zag configurations in both wells. The crystals are built of 13 in the first well and 20 in the second. After lowering the barrier between the wells, we observe mass and energy transfer between the crystals as a result of the asymmetry in the initial crystal sizes. In addition, we detect oscillations propagating into the big crystal like a shock wave, while the small ion crystal melts completely.

[1] Major et al., Charged particle traps I+II Springer,(2005 + 2009)
[2] Huber et al., NJP 10, 013004 (2008)
[3] Ruster et al., Phys. Rev. A 90, 033410 (2014)
[4] Klumpp et al., arXiv:1508.07979

A 9.13 Mon 16:30 Empore Lichthof

Magnesium Ion Crystals at SpecTrap — •Manuel Vogel[1], Zoran Andelkovic[1], Gerhard Birkl[2], Tobias Murböck[2], Wilfried Nörtershäuser[3], and Stefan Schmidt[3] — [1]GSI, 64291 Darmstadt — [2]Institut für Angewandte Physik, TU Darmstadt, 64289 Darmstadt — [3]Institut für Kernphysik, TU Darmstadt, 64289 Darmstadt

We have investigated laser-cooled magnesium ions stored in a Penning trap. The ions are produced externally and are dynamically captured in the trap. We have combined buffer-gas cooling and laser cooling, thus reducing the ion temperatures from Mega-Kelvin to milli-Kelvin on the timescale of seconds. At this temperature, the ions adopt crystalline structures. For ion numbers of the order of a few thousand, these so-called 'mesoscopic' ion crystals display shell structures depending on experimental parameters, which we have visualized by use of a CCD camera. We have investigated the fluorescence signal depending on laser parameters and characterized the crystal structures. This is part of the sympathetic cooling of highly-charged ions as a next step in the framework of the SpecTrap experiment at the HITRAP facility at GSI/FAIR.

A 9.14 Mon 16:30 Empore Lichthof

Optimized atomic transport with an atom chip — •Robin Corgier[1,2], Eric Charron[2], Ernst Maria Rasel[1], and Naceur Gaaloul[1] — [1]Leibniz University of Hanover, Germany — [2]Université Paris-Sud, France

Recent proposals for testing performing a quantum test of Einsteins principle of equivalence assume Bose-Einstein condensates (BEC) as sources of atom interferometry sensors. Atom chip devices have allowed to build transportable BEC machines with high repetition rates as demonstrated in the QUANTUS project [J. Rudolph et al. New J. Phys. 17, 079601 (2015)]. The proximity of the atoms to the chip surface is, however, limiting their optical access and the times the atoms spend in the interferometer necessary for precision measurements. In this context, a fast and perturbation-free transport of the atoms is required. Shortcuts to adiabaticity protocols were proposed and allow in principle to implement such sequences with well defined boundary conditions. In this theoretical study, we engineer suitable protocols to move atomic ensembles trapped at the vicinity of an atom chip by tuning the realistic chip currents and external magnetic fields. We find a realistic protocole for moving the atomic trap optimizing the transport time and reducing detrimental effects due to the offset of atoms positions from the trap center. Further developments generelizing our method to anharmonic traps and spatially extended atomic wave packets are also discussed.

A 9.15 Mon 16:30 Empore Lichthof

Species and regime trade-off of atomic sources for extended-time atom interferometry — •Sina Loriani, Dennis Schlippert, Christian Schubert, Ernst Maria Rasel, and Naceur Gaaloul — Leibniz University of Hanover, Germany

Recent proposals for space-borne atomic sensors designed to detect gravitational waves or testing the universality of free fall predict unprecedented sensitivity for long interrogation times. These extremely long drift times of several seconds are possible thanks to the collimation technique of delta-kick cooling (DKC) [Müntinga, et al. Phys. Rev. Lett. **110**, 093602 (2013), T. Kovachy et al., Phys. Rev. Lett. **114**, 143004 (2015)]. These atomic lenses are, however, subject to aberrations depending on the extent of the collimated wave packets and the potentials used. In this theoretical study, we trade-off the performance of the DKC for commonly used alkaline and alkaline-earth-like ensembles of atoms (Rb, Sr, Yb, etc.) in the metrology context. The efficiency of the DKC is evaluated and contrasted for these isotopes in the three possible density regimes (thermal, hydrodynamic and degenerate). The expansion dynamics is followed by solving different scaling law approaches depending on the temperature and density of the considered atomic cloud. The results show a clear advantage when using condensed or hydrodynamic ensembles.

A 9.16 Mon 16:30 Empore Lichthof

Impurity in a Bose-Einstein condensate using quantum Monte Carlo methods — •Luis Ardila[1] and Stefano Giorgini[2] — [1]Max Planck Institute for the Physics of Complex Systems, D-01187 Dresden, Germany — [2]INO-CNR BEC Center and Department of Physics, University of Trento - via Sommarive 14 38123 Povo

We investigate the properties of an impurity immersed in a dilute Bose gas at zero temperature using quantum Monte Carlo methods. The interactions between bosons are modeled by a hard-sphere potential with scattering length a, whereas the interactions between the impurity and the bosons are modeled by a short-range, square-well potential where both the sign and the strength of the scattering length b can be varied by adjusting the well depth. We characterize the attractive and the repulsive polaron branch by calculating the binding energy and the effective mass of the impurity. Furthermore, we investigate the structural properties of the bath, such as the impurity-boson contact parameter and the change of the density profile around the impurity. At the unitary limit of the impurity-boson interaction, we find that the effective mass of the impurity remains smaller than twice its bare mass, while the binding energy scales with $\hbar^2 n^{2/3}/m$, where n is the density of the bath and m is the common mass of the impurity and the bosons in the bath. The implications for the phase diagram of binary Bose-Bose mixtures at low concentrations are also discussed.

A 9.17 Mon 16:30 Empore Lichthof

Interaction-Induced Topological Phases in the Hofstadter-Hubbard Model — •Pramod Kumar, Thomas Mertz, and Walter Hofstetter — Institut für Theoretische Physik, Goethe-Universität, 60438 Frankfurt/Main, Germany

Interaction effects have been the subject of contemporary interest in topological phases of matter. In the presence of interactions, the accurate determination of topological invariant gets cumbersome due to its dependence on multiple integrals containing Green's functions and their derivatives. We employ the recently proposed, "topological Hamiltonian" method (Z. Wang and S.-C. Zhang) to explore interaction-induced topological phases in the time-reversal-invariant Hofstadter-Hubbard model. Within this approach, the zero frequency part of the self-energy is sufficient to determine the correct topological invariant. We combine the topological Hamiltonian approach with the local self-energy approximation within Hartree-Fock and dynamical mean field theory (DMFT), and present the corresponding phase diagram in the presence of many-body interactions. We investigate the presence of quantum spin Hall (QSH) states for different interactions by calculating the $\mathbb{Z}_2$ invariant.

References:

1. Z. Wang and S.-C. Zhang, Phys. Rev. X 2, 031008 (2012).

A 9.18 Mon 16:30 Empore Lichthof

Atom laser based quantum sensors — •Tobias Menold, Carola Rogulj, Malte Reinschmidt, Peter Federsel, Andreas Günther, and József Fortágh — Physikalisches Institut, Universität Tübingen, Germany

Developing new quantum sensors is the biggest challenge in today's quantum technology. Thereby, quantum fluctuations play an important role as they provide direct access to the quantum information of a system. Our goal is to develop a new quantum sensor for these quantum fluctuations. Using a quantum state transfer, they are transferred to an atom laser, whose output is measured with single atom sensitivity.

We demonstrate such a sensor, by transferring the dynamics of an ultra-cold atomic cloud onto an atom laser and reconstructing its dynamics using our time resolved, single atom detection scheme. In a second experiment we transfer classical field noise of a multi-mode microwave field onto the atom laser and analyze its statistics. We find that the atom laser output allows for measuring not only the power spectral density of the noise but also the field correlations.

Using our sensor, a quantum galvanometer comes into direct reach. It should allow the investigation of quantum transport phenomena in various solid state systems.

A 9.19 Mon 16:30 Empore Lichthof

Towards Dysprosium Quantum Gases — •Florian Mühlbauer, Niels Petersen, and Patrick Windpassinger — QUANTUM, Institut für Physik, Johannes Gutenberg-Universität Mainz, Staudingerweg 7, 55128 Mainz, Germany

Ultra-cold dipolar quantum gases enable the study of many-body physics with long-range, inhomogeneous interaction effects due to the anisotropic character of the dipole-dipole interaction. These systems are expected to show novel exotic quantum phases and phase transitions which can be studied with dysprosium atoms. Dysprosium is a rare-earth element with one of the largest ground-state magnetic moments (10 Bohr magnetons) in the periodic table. Therefore, the dipole-dipole interaction is not a small perturbation but becomes comparable in strength to the s-wave scattering. This influences significantly the physical properties of the trapped atomic sample, such as its shape and stability.

This poster presents the current status of our experimental setup to generate dysprosium quantum gases. We discuss the relevant properties of dysprosium and present our laser system and vacuum design.

A 9.20 Mon 16:30 Empore Lichthof

A quantum gas machine for studies of local losses induced by photoionization — •Tobias Kroker[1], Janine Franz[1], Bernhard Ruff[2,3], Tim Anlauf[1], Juliette Simonet[1], Philipp Wessels[1,3], Markus Drescher[2,3], and Klaus Sengstock[1,3] — [1]Zentrum für Optische Quantentechnologien, Hamburg, Germany — [2]Institut für Experimentalphysik, Hamburg, Germany — [3]The Hamburg Centre for Ultrafast Imaging, Hamburg, Germany

Local photoionization of ultracold atoms shall offer insight into the coherence properties of a Bose-Einstein condensate (BEC). To access the corresponding quantum effects, we are setting up an experiment which allows resolving correlations among electrons photoionized from a BEC by a femtosecond laser pulse.

Here we report on our progress in setting up a quantum gas machine where the ultracold gases are optically transported into the focus region of the femtosecond laser beam. As photoionization induces local losses in the BEC, a theoretical model of the dissipative system is essential including a quantification of the quantum Zeno effect.

A 9.21 Mon 16:30 Empore Lichthof

Dynamics of nonlinear excitations of helically confined charges — •Alexandra Zampetaki[1], Jan Stockhofe[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

The confinement of long-range interacting particles on a curved manifold can modify significantly their effective interactions. In the special case of identical charges trapped on a helical geometry the effective two-body potential acquires an extraordinary oscillatory form [1].

For a closed helical trap the corresponding system of charges was recently found to exhibit an unconventional deformation of the linear spectrum when tuning the helix radius [2]. Here we show that the same geometrical parameter can affect significantly also the dynamical behaviour of an initially broad excitation for long times. In particular, for small values of the radius, the excitation disperses into the whole crystal whereas within a specific narrow regime of larger radii the excitation self-focuses, assuming finally a localized form. Beyond this regime, the excitation defocuses and the dispersion gradually increases again. We analyze this geometrically controlled nonlinear behaviour using an effective discrete nonlinear Schrödinger model, which allows us among others to identify a number of breather-like excitations.

[1] P. Schmelcher, EPL 95 50005 (2011).

[2] A. V. Zampetaki, J. Stockhofe and P. Schmelcher, Phys. Rev. A 91, 023409 (2015).

A 9.22 Mon 16:30 Empore Lichthof

Three-body recombination in a quasi-two-dimensional quantum gas — •Bo Huang[1,2], Alessandro Zenesini[3], and Rudolf Grimm[1,2] — [1]Institut für Experimentalphysik, Universität Innsbruck, 6020 Innsbruck, Austria — [2]Institut für Quantenoptik und Quanteninformation (IQOQI), Österreichische Akademie der Wissenschaften, 6020 Innsbruck, Austria — [3]Institute of Quantum Optics, Leibniz Universität Hannover, 30167 Hannover, Germany

Quantum three-body recombination in three-dimensional systems is influenced by a series of weakly bound trimers known as Efimov states, which are induced by short-range interactions and exhibit a discrete scaling symmetry. On the other hand, two-dimensional systems with contact interactions are characterized by continuous scale invariance and support no Efimov physics. This raises questions about the behaviour of three-body recombination in the transition from three to two dimensions. We use ultracold caesium atoms trapped in anisotropic potentials formed by a pair of counter-propagating laser beams to experimentally investigate three-body recombination in quasi-two-dimensional systems with tunable confinement and tunable interactions. In our recent results, we observed a smooth transition of the three-body recombination rate coefficient from a three-dimensional to a deeply quasi-two-dimensional system. A comparison between the results obtained near two Feshbach resonances indicates a universal behaviour of three-body recombination in the quasi-two-dimensional regime.

A 9.23 Mon 16:30 Empore Lichthof

Local probing of two-dimensinonal superfluid gases in the BEC-BCS crossover — •Klaus Hueck, Keno Riechers, Wolf Weimer, Kai Morgener, Jonas Siegl, Niclas Luick, Thomas Lompe, and Henning Moritz — Institut für Laserphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg

In this poster we present local measurements of the superfluid fraction of a strongly interacting two-dimensional gas of diatomic Li^6 molecules. Using a high resolution imaging system, we perform a local measurement of the phase fluctuations on a single layer 2D gas. From this we extract the algebraic scaling exponent of the first order correlation function $g^{(1)}(r)$. This exponent is directly proportional to the superfluid density.

We furthermore report on our progress towards the creation of homogeneous two-dimensional Fermi gases in the BEC-BCS crossover.

A 9.24 Mon 16:30 Empore Lichthof

Nonequilibrium Green functions approach to expansion dynamics in strongly correlated fermionic lattice systems — •Jan-Philip Joost, Niclas Schlünzen, Sebastian Hermanns, and Michael Bonitz — CAU Kiel, Germany

Experiments with ultracold atoms in optical lattices gained in importance over the last years and are of high current interest, since they allow to directly measure quantum behaviour and serve as a model for solid state systems [1]. The proper description of transport processes in quantum lattices in the regime of strong coupling is a challenging task, which has been limited, so far, to one-dimensional systems. The nonequilibrium Green functions [2] (NEGF) technique, however, is not restricted with respect to dimension or particle number. Combined with the T-matrix approximation [3], in particular, the NEGF method is well-suited to fill the gap for higher dimensions [4]. Here, we show results for strongly interacting fermions in 2D and 3D. The approach gives access to the short-time dynamics, as well as the long-time limit of the expansion. Beside the density and energy evolution, also the momentum distribution, dispersion relation and the site-resolved build-up of correlations are obtained, the latter of which can be verified experimentally using the recently developed fermionic atom microscopes.

[1] U. Schneider *et al.*, Nat. Phys. **8**, 213 (2012)
[2] K. Balzer and M. Bonitz, *NEGF Approach to Inhomogeneous Systems*, Lecture Notes in Physics (Springer, 2013)
[3] M. P. von Friesen *et al.*, Phys. Rev. B **82**, 155108 (2010)
[4] N. Schlünzen *et al.*, arXiv:1508.02947 (2015)

A 9.25 Mon 16:30 Empore Lichthof

Variational calculation of ^{4}He for Droplets — •Christopher Bate, Yaroslav Lutsyshyn, and Dieter Bauer — Universität Rostock Institut für Physik

We aim to study droplets of liquid ^{4}He at very low temperature with the variational ansatz that was recently proposed for the ground state of strongly correlated Bose liquids [1]. This ansatz goes beyond the traditional Jastrow-Feenberg functional form and when optimized, provides an excellent description of the correlations in the system. Even though this wavefunction is constructed of short-range two-body factors and does not contain one-body surface terms, phase separation and free surface emerge at appropriate densities. This allows to study the inhomogeneous phases such as the droplets of superfluid helium, and the formation of the inhomogeneous phase as well. Due to advances in computational techniques and the fact that we can study the system on a variational level, we are able to consider droplets with up to 10^4 particles.

[1] Y. Lutsyshyn, "A coordinated wavefunction for the ground state of liquid helium-4", arXiv 1506.03752 (2015), to be published.

A 9.26 Mon 16:30 Empore Lichthof

Interactions of Single Cesium Atoms with an Ultracold Rubidium Bath — •Daniel Mayer[1,2], Manuel Stein[1], Michael Hohmann[1], Farina Kindermann[1], Tobias Lausch[1], Felix Schmidt[1,2], and Artur Widera[1,2] — [1]Department of Physics and Research Center OPTIMAS, University of Kaiserslautern, Ger-

many — [2]Graduate School Materials Science in Mainz, Kaiserslautern, Germany

Our project aims on combining single, tightly controlled particles with a quantum many-body system by immersing single neutral Cesium (^{133}Cs) atoms into a Rubidium (^{87}Rb) Bose-Einstein condensate.

We store both species in a common, red detuned dipole trap which gives rise to dynamical interspecies interaction. To capture the dynamics of the Cs distribution interacting with a cold, thermal Rb cloud, a species selective, 1D optical lattice is used for position resolved fluorescence imaging of the single Cs atoms. The temperature for Rb and Cs atoms can be measured by release-recapture thermometry providing an additional, independent view on the interaction process.

We will give the current status on interaction dynamics between single impurities in an ultracold Rb gas.

A 9.27 Mon 16:30 Empore Lichthof

Lifetime Measurements of Topological Defects in Coulomb Crystals — •Miriam Bujak[1], Jonathan Brox[1], Philip Kiefer[1], Isabelle Schmager[1], Haggai Landa[2], and Tobias Schaetz[1] — [1]Atom-, Molekül- und optische Physik, Physikalisches Institut, Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg — [2]LPTMS, Université Paris Sud, Orsay, France

We study structural defects (kinks) of Mg-Ions in Coulomb crystals. Simulations reveal a strong anharmonicity of the kink's internal mode of vibration, further enhanced by the controlled extension into three dimensions. As a consequence, the discrete kink experiences a self-induced globally confining potential, capable of trapping it at the centre of the crystal.

The formation of kink configurations in dependence of the trapping parameters is investigated and the lifetime of these defects is explored.

[1] M. Mielenz et al., Phys. Rev. Lett. **110**, 133004 (2013)

A 9.28 Mon 16:30 Empore Lichthof

Spectroscopy of Discrete Solitons in Coulomb Crystals — •Jonathan Brox[1], Miriam Bujak[1], Philip Kiefer[1], Isabelle Schmager[1], Haggai Landa[2], and Tobias Schaetz[1] — [1]Atom-, Molekül- und optische Physik, Physikalisches Institut, Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg — [2]LPTMS, Université Paris Sud, Orsay, France

We study structural defects (kinks) which are formed during the transition from a laser cooled cloud of Mg-Ions to a Coulomb crystal [1]. The occurrence of these structures is investigated in dependence of crystal size and axial as well as radial confinement.

Ion crystals with such structural defects feature localized vibrational modes in the spectrum of phonons [2]. We present first results on the spectroscopy of vibrational modes of the Coulomb crystal.

[1] M. Mielenz et al., Phys. Rev. Lett. **110**, 133004 (2013)
[2] H. Landa et al., New J. Phys. **15**, 093003 (2013)

A 9.29 Mon 16:30 Empore Lichthof

Characterizing and Controlling the Structure of Topological Defects in Coulomb Crystals — •Isabelle Schmager[1], Jonathan Brox[1], Miriam Bujak[1], Philip Kiefer[1], Haggai Landa[2], and Tobias Schaetz[1] — [1]Atom-, Molekül- und optische Physik, Physikalisches Institut, Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg — [2]LPTMS, Université Paris Sud, Orsay, France

We study structural defects (kinks) in Coulomb crystals of Mg-Ions in dependency on the ratio of radial to axial confinement and cooling conditions [1].

The formation of kink configurations and the transformation of kinks to different structures are investigated. We compare the properties of extended (2D) and blurred (3D) kinks for crystals consisting of 30 ions [2]. Furthermore, different creation and control processes are studied in detail.

[1] M. Mielenz et al., Phys. Rev. Lett. **110**, 133004 (2013)
[2] H. Landa et al., New J. Phys. **15**, 093003 (2013)

A 9.30 Mon 16:30 Empore Lichthof

Motional Mode Analysis of Trapped Ions — •Frederick Hakelberg, Henning Kalis, Matthias Wittemer, Manuel Mielenz, Ulrich Warring, and Tobias Schaetz — Physikalisches Institut, Albert-Ludwigs-Universität Freiburg

Trapped ions present a promising system for quantum simulations [1]. However scaling to large systems present a major challenge. Surface-electrode traps with individually controllable potential wells offer a promising approach by allowing the design of arbitrary patterns of trapped ions [2]. The Coulomb coupling of ions in two distinct traps (separated by $\approx 40\,\mu m$) has been shown [3]. In our experiment we trap $^{25}Mg^+$ ions in a triangular surface-trap array with individual trap sites. The trap features 30 control electrodes which allow us to apply potentials for stray field compensation, and the control of motional-mode frequencies and mode orientations. We present two methods for measuring mode orientations and frequencies. The first is based on motional-sensitive two-photon stimulated-Raman transitions. The second makes use of oscillating control potentials generated by the control electrodes. We compare results with detailed models of both methods.

[1] Ch. Schneider *et al.*, Rep. Prog. Phys. **75**, 024401 (2012)
[2] T. Schaetz *et al.*, New J. Phys. **15**, 085009 (2013)
[3] K. R. Brown *et al.*, Nature **471**, 7337 (2013)

A 9.31 Mon 16:30 Empore Lichthof

SOC2: Neutral-atom Space Optical Clock — •Sruthi Viswam[1], Lyndsie Smith[1], Wei He[1], Dariusz Swierad[1], Joshua Hughes[1], Yeshpal Singh[1], Kai Bongs[1], Stefano Origlia[2], Soroosh Alighanbari[2], Stefan Schiller[2], Soren Dorscher[3], Stefan Vogt[3], Christian Lisdat[3], and Uwe Sterr[3] — [1]University of Birmingham, United Kingdom — [2]Heinrich-Heine Universität Düsseldorf, Germany — [3]Physikalisch-Technische Bundesanstalt, Germany

Several different atoms and ions are used to build ultra-stable clocks which might find application in time referencing, gravity measurement, data encryption, navigation etc. although it seems that it is strontium that is going to replace the current definition of time. Many groups around the world have already proven reliability and robustness of the strontium optical lattice clock and the next step is to make it more transportable and mobile. In this poster we report our progress and results from the robust transportable Space Optical Clock. So far, the robust preparation of cold Sr-88 atoms in a first stage magneto-optical trap (MOT) with 8E+6 and second-stage red broadband MOT with a transfer efficiency of 40 percent , single frequency MOT with 80 percent transfer efficiency and lattice with 1E+5 atoms is achieved. The compact atomic package is transported from the University of Birmingham, United Kingdom to Physikalisch-Technische Bundesanstalt , Germany.Next step is to lock the clock laser to the atomic transition. Lasers that are frequency stabilized by locking to the resonant mode of ultra low expansion cavities have been used for the cooling purpose.

A 9.32 Mon 16:30 Empore Lichthof

Experiments and theory of NaK molecules — •Kai K. Voges, Matthias W. Gempel, Torben A. Schulze, Torsten Hartmann, Alessandro Zenesini, and Silke Ospelkaus — Institut für Quantenoptik, Universität Hannover

Dipolar collisions between ultracold molecules are characterized by the amazing combination of long-range interaction and strong anisotropy. These properties and their tunability are powerful tools for the investigation of various phenomena, from the many-body dynamics of degenerate gases to the fundamental understanding of collisional physics and chemical processes.

In the experiment we are currently setting up, all these phenomena and many others will be investigated by involving ultracold ground-state NaK molecules. Our set-up has wide optical access, careful design of the electric field and large tunability of the experimental parameters for a wide control of the molecular properties. Here we present the current status of the experiment and an analysis of possible coherent two-photon transfer paths from weakly-bound Feshbach molecules to rovibronic ground state molecules.

A 9.33 Mon 16:30 Empore Lichthof

Dissipative preparation of antiferromagnetic order in the Fermi-Hubbard model — Jan Kaczmarczyk[1], Hendrik Weimer[2], and •Mikhail Lemeshko[1] — [1]IST Austria, Klosterneuburg, Austria — [2]Leibniz Universität Hannover, Germany

The realization of strongly correlated quantum phases such as the antiferromagnetic phase is one of the longstanding goals of quantum simulations with ultracold fermions in optical lattices. We show that a combination of two Raman-assisted hopping schemes gives rise to dissipative dynamics that exhibits a large amount of antiferromagnetic order in the steady state. We analyze the interplay between the familiar Fermi-Hubbard Hamiltonian and these additional dissipative terms using wave-function Monte-Carlo methods and a novel variational principle for dissipative quantum many-body dynamics [1]. We observe antiferromagnetic correlations appearing within experimentally accessible times on the order of 0.5 s, as well as a substantial reduction in entropy per particle compared to the current experimental setups without additional dissipation. Our considerations are based on the atomic level structure of fermionic 40K and can be implemented into existing experimental setups.

[1] H. Weimer, Phys. Rev. Lett. 114, 040402 (2015).

A 9.34 Mon 16:30 Empore Lichthof

An analytic model of quantum thermalization — •Gregory Szep[1], Mikhail Katsnelson[2], and Mikhail Lemeshko[1] — [1]Institute of Science and Technology Austria, Am Campus 1, Klosterneuburg 3400, Austria — [2]Radboud University of Nijmegen, Heijendaalseweg 135, 6525AJ Nijmegen, The Netherlands

The thermalisation of a subsystem, contained in a closed dynamical system - in both classical and quantum regimes - is an intuitive phenomenon by which the energy levels of the subsystem irreversibly approach the maximum entropy canonical distribution. Numerical evidence, based on single trajectories of both integrable and non-integrable systems, has been presented [1,2], while no analytic results exist that do not invoke the eigenstate thermalisation hypothesis or artificial thermostats. Here a method is proposed, that treats the eigenstates spanned by the equivalent closed subsystem as the basis set from which measurements are obtained. By considering how do the hybridised subsystem-system states, project onto the closed subsystem eigenstates, an attempt is made to derive a canonical distribution for the subsystem.

[1] F. Jin, et. al., New. J. Phys. 15, 033009 (2013) [2] S. Yuan, H. De Raedt, and M. I. Katsnelson, J. Phys. Soc. Jpn. 78, 094003 (2009).

A 9.35 Mon 16:30 Empore Lichthof

Geometrical pumping with a Bose-Einstein condensate — •Maximilian Schemmer[1], Lu Hsin-I[2], Lauren Aycock[2], Dina Genkina[2], Seiji Sugawa[2], and Ian Spielman[2] — [1]Institut d' Optique Graduate School, Palaiseau, France — [2]Joint Quantum Institute, National Institute of Standards and Technology, and University of Maryland, Gaithersburg, Maryland, USA

We realized a quantum "charge" pump for a Bose-Einstein condensate (BEC) in a novel bipartite magnetic lattice, whose bands are characterized by non-trivial topological invariants: the Zak phases. For each band, the Zak phase is determined by that band's integrated Berry curvature, a geometric quantity defined at each crystal momentum. We probed this Berry curvature in a charge pump experiment, by periodically and adiabatically driving the system. Unlike topological charge pumps in filled bands that yield quantized pumping, our BEC occupied just a single crystal momentum state allowing us to access its band's local geometry. Like topological charge pumps, for each pump cycle we observed an overall displacement (here, not quantized) and a temporal modulation of the atomic wavepacket's position in each unit cell, i.e., the polarization. Our magnetic lattice enabled us to observe this modulation by measuring the BEC's magnetization. While our periodic drive shifted the lattice potential by one unit cell per cycle, the displacement of the BEC, solely determined by the underlying Berry curvature, was always less than the lattice's displacement.

A 9.36 Mon 16:30 Empore Lichthof

Development of a deterministic ion source — •Jens Benary, Andreas Müllers, Cihan Sahin, and Herwig Ott — Technische Universität Kaiserslautern

We present a deterministic ion source based on an ultracold atom cloud. ^{87}Rb atoms are confined in a magneto-optical trap (MOT) and subsequently photo-ionized. The fast electrons are detected with a channel electron multiplier (CEM) and act as a trigger for the ions.

In addition to photoionization, we are implementing a three photon excitation to Rydberg states. Using the mechanism of Rydberg blockade, the source could be adapted to control the number of emitted ions down to a single particle.

Currently, the ions are detected with a second CEM. However, future applications may include ion interferometry or semiconductor doping. These will benefit from the high repetition rate and low energy spread of this type of source.

The three photon excitation via the intermediate $5P_{3/2}$ and $5D_{5/2}$ states gives access to nP or nF Rydberg states. This can be realized in a simple manner using IR diode lasers with wavelengths between 776 nm and 1260 nm. In addition, the $5D_{5/2}$ state has a decay channel to $6P_{3/2}$, which can be excited to nS or nD Rydberg states with an additional laser at 1016 nm.

We discuss the status of the experiment and present results obtained so far.

A 9.37 Mon 16:30 Empore Lichthof

Sympathetic cooling of OH- ions using Rb atoms in a MOT — •Ji Luo[1], Bastian Höltkemeier[1], Henry Lopez[1], Pascal Weckesser[1], Andre de Olivera[1,2], Eric Endres[3], Roland Wester[3], and Matthias Weidemüller[1] — [1]Physikalisches Institut, Universität Heidelberg, INF 226, 69120 Heidelberg — [2]Departamento de Física, Universidade do Estado de Santa Catarina-Joinville, SC, Brazil — [3]Institut f. Ionenphysik und angewandte Physik, Universität Innsbruck, Technikerstraße 25/3, 6020 Innsbruck

We report on the current status of our experiment employing a hybrid atom-ion trap for investigating the interaction between OH* anions and rubidium atoms. The experimental setup consists of an octupole rf ion trap with thin wires providing sufficient optical access to combine the ion trap with a dark-spontaneous-force optical trap for the atoms. The motional and internal temperature of the anions will be probed by photodetachment spectroscopy.

A 9.38 Mon 16:30 Empore Lichthof

Mode frequency stability of individually trapped ions in a two-dimensional array — •Yannick Minet, Manuel Mielenz, Henning Kalis, Frederick Hakelberg, Matthias Wittemer, Ulrich Warring, and Tobias Schaetz — Physikalisches Institut, Albert-Ludwigs-Universität, Hermann-Herder-Straße 3, 79104 Freiburg, Germany

A promising way to realise quantum simulations is based on trapped ions. Advanced micro-fabrication techniques and geometrical optimisation allows the construction of two-dimensional surface-electrode trap arrays [1] that may be used as large-scale simulators [2]. Prerequisites for such implementations are high-fidelity control of all motional degrees of freedom and a high-level of mode stability.

We present measurements of the stability of mode frequencies of a single $^{25}Mg^{+}$ ion trapped in one out of three sites, which are arranged in an equilateral triangle and separated by 40 μm. Our results are discussed in the context of future experiments, where we aim to establish inter-ion Coulomb couplings between all three trap sites.

[1] Ch. Schneider et al., Rep. Prog. Phys. **75**, 024401 (2012)
[2] T. Schaetz et al., New J. Phys. **15**, 085009 (2013)

A 9.39 Mon 16:30 Empore Lichthof

Fast and high-fidelity motional control of trapped ions — •Matthias Wittemer, Govinda Clos, Frederick Hakelberg, Henning Kalis, Manuel Mielenz, Ulrich Warring, and Tobias Schaetz — Physikalisches Institut, Albert-Ludwigs-Universität, Hermann-Herder-Straße 3, 79104 Freiburg, Germany

Laser-cooled ions, trapped in radio-frequency potentials, are promising candidates for experimental quantum simulations [1]. In addition to the precise manipulation of the electronic states (pseudo spin), control of the motional states of the trapped ions is crucial for adequate quantum simulations.

We report on experiments with Mg+ ions in a (conventional) linear Paul trap and a surface-electrode trap with three distinct trapping sites, arranged in an equilateral triangle. The implementation of an arbitrary waveform generator [2] into the experimental setups enables real-time control of the motional degrees of freedom within a few microseconds. This may allow precise studies of tunable spin-spin interactions [3] and phenomena like thermalization [4] or squeezed-state emergence [5] in isolated quantum systems.

[1] T. Schaetz *et al.*, New J. Phys. **15**, 085009 (2013)
[2] R. Bowler *et al.*, Rev. Sci. Instrum. **84**, 033108 (2013)
[3] A.C. Wilson *et al.*, Nature **512**, 57-60 (2014)
[4] G. Clos *et al.*, arXiv:1509.07712 (2015)
[5] R. Schützhold *et al.*, Phys. Rev. Lett. **99**, 201301 (2007)

A 9.40 Mon 16:30 Empore Lichthof

Fermi-Fermi Mixtures of Dysprosium and Potassium — Cornee Ravensbergen[2], Slava Tzanova[1], Vincent Corre[2], •Marian Kreyer[1], Alexander Werlberger[1], and Rudolf Grimm[1,2] — [1]Intitut für Experimentalphysik, Universität Innsbruck, Austria — [2]Institut für Quantenoptik und Quanteninformation IQOQI, Innsbruck, Austria

Ultracold Fermi-Fermi mixtures with tunable interactions represent an intriguing test bed for exploring the physics of strongly interacting many-body quantum systems and few-body quantum states. Two-species Fermi gases extend the variety of phenomena thanks to mass imbalance. Mixtures of a fermionic isotope of dysprosium (^{161}Dy or ^{163}Dy) and the fermionic ^{40}K provide a mass ratio of about four, which is big enough to experience strong asymmetries while avoiding losses from Efimov states. Furthermore, the large magnetic moment of dysprosium offers an additional feature to study anisotropic effects. In our experimental setup, we have implemented a Zeeman slower for dysprosium and a 2D magneto-optical trap (2D-MOT) for potassium to load a two-species MOT in the main vacuum chamber. It is planned to load both clouds into a dipole trap for evaporative cooling to achieve degeneracy of both species.

A 9.41 Mon 16:30 Empore Lichthof

Dimensional Phase Transitions of Bosons in Optical Lattices with Tunable Hopping — •Bernhard Irsigler[1], Denis Morath[2], Dominik Strassel[2], Sebastian Eggert[2], and Axel Pelster[2] — [1]Physics Department, Freie Universität Berlin, Germany — [2]Physics Department and Research Center OPTIMAS, Technische Universität Kaiserslautern, Germany

Here we investigate in detail how the dimensionality affects the critical temperature of Bose-Einstein condensation. Motivated by the recent experiment [1] we consider bosons in an optical lattice, where the hopping along the three spatial dimensions is assumed to be tunable. With this we model all possible continuous transitions between the dimensions $D = 1, 2, 3$ and determine the respective critical temperatures in the vicinity of pure integer dimensions, which turn out to agree with the Mermin-Wagner theorem. In the homogeneous case the critical temperature vanishes in $D = 1, 2$ and therefore also in the dimensional transition $1 \to 2$. However in $D = 3$ the critical temperature is finite and vanishes for $3 \to 2$ logarithmically and for $3 \to 1$ like a power law. For the harmonically trapped case in any dimension $D = 1, 2, 3$ the critical temperature remains finite.

[1] A. Vogler, R. Labouvie, G. Barontini, S. Eggert, V. Guarrera, and H. Ott, Phys. Rev. Lett. **113**, 215301 (2014).

A 9.42 Mon 16:30 Empore Lichthof

Variational calculation of ^{4}He droplets — •Christopher Bate, Yaroslav Lutsyshyn, and Dieter Bauer — Institut für Physik, Universität Rostock, 18051 Rostock

We aim to study droplets of liquid ^{4}He at very low temperature with the variational ansatz that was recently proposed for the ground state of strongly correlated Bose liquids [1]. This ansatz goes beyond the traditional Jastrow-Feenberg functional form and, when optimized, provides an excellent description of the correlations in the system. Even though this wavefunction is constructed of short-range two-body factors and does not contain one-body surface terms, phase separation emerges and a free surface is formed at appropriate densities. This allows to study the inhomogeneous phases such as the droplets of superfluid helium, and the formation of the inhomogeneous phase as well. Due to advances in computational techniques and the fact that we can study the system on a variational level, we are able to consider droplets with up to 10^4 particles.

[1] Y. Lutsyshyn, "A coordinated wavefunction for the ground state of liquid helium-4", arXiv 1506.03752 (2015), to be published.

A 9.43 Mon 16:30 Empore Lichthof

Investigating and Minimizing Surface Effects in Cold Atom magnetic Field Microscopy — •Xiaoke Li[1], Amruta Gadge[1], Tim James[1], Bo Lu[2], Christopher Mellor[1], Nephtali Garrido-Gonzalez[1], Christian Koller[3], Fedja Orucevic[1], and Peter Krüger[1] — [1]School of Physics and Astronomy, University of Nottingham, Nottingham NG7 2RD, UK — [2]Department of Physics, The Chinese University of Hong Kong, Shatin, N.T., Hong Kong — [3]Mirco and Nano systems FH,Wiener Neustadt, Austria

Using cold atom as magnetic field sensor is one of the promising directions towards quantum technology. The advantage is that it can measure the magnetic field (and electric field) with both high spatial resolution and good field sensitivity, compared with magnetic force microscopy and SQUIDs. The limitation of achieved resolution is met while minimizing the distance between atoms and surface, which leads to loss of atoms due to Casimir force and Johnson noise. To reduce the surface effects and achieve submicron trapping, we investigate different surfaces such as silicon nitride membranes. The positioning of atoms over different samples is carried out by an on-chip magnetic transport system, which is generated by a 10-layer printed circuit board containing wires with 10μm to 20mm widths. Before loading the ^{87}Rb atoms into the magnetic trap, we use a novel dual color magneto-optical trap to improve the atom number. We will present the results of simulation and current progress of experiment.

A 9.44 Mon 16:30 Empore Lichthof

High resolution ion imaging of cold atoms — •Markus Stecker, Hannah Schefzyk, Malte Reinschmidt, Andreas Günther, and József Fortágh — Physikalisches Institut, Universität Tübingen, Germany

Spatially resolved optical detection methods of cold atomic clouds are in general diffraction limited. In our novel approach we ionize atoms out of the cloud and image them via an ion optics with variable magnification up to 1000 and a spatial resolution above the optical diffraction limit. This allows the observation of trapped quantum gases with single atom sensitivity and high temporal and spatial resolution. In such a system, local statistic like temporal and spatial correlations can be studied, and global cloud properties or dynamical processes can be investigated.

We present the ion optics setup and the corresponding simulations, which show the theoretical limits of the system in terms of magnification and resolution. We also show the experimental implementation to an ultra-cold atom setup. The current ionization scheme uses a 480nm laser to ionize atoms out of a magneto-optical trap. In order to characterize the imaging quality, we imprint test structures with the ionization laser onto the MOT and analyze the generated ion patterns. Furthermore, we present the first steps to use this system for excitation and spatially resolved detection of Rydberg atoms.

A 9.45 Mon 16:30 Empore Lichthof

Towards the micromotion energy limit in a hybrid atom-ion experiment — •Joschka Wolf, Artjom Krükow, Amir Mohammadi, Amir Mahdian, and Johannes Hecker Denschlag — Universität Ulm, Institut für Quantenmaterie, Albert-Einstein-Allee 45, D-89069 Ulm, Deutschland

In our hybrid atom-ion experiment, we investigate the interaction of a laser-cooled trapped ^{138}Ba ion with an ultracold cloud of ^{87}Rb atoms [1].

Induced by micromotion, in this system there are three main sources of atom-ion collision energy. The excess micromotion caused by static electrical fields, the phase micromotion resulting from a phase delay between the radio frequency blades and a collision induced micromotion energy.

In this poster we show our recent progress in the minimization of phase micromotion and excess micromotion. We are then essentially left with collision induced micromotion and plan to measure this quantity for the first time in the near future.

[1] A. Krükow et al., arXiv:1510.04938 (2015)

A 9.46 Mon 16:30 Empore Lichthof

Towards high resolution imaging in a strongly imbalanced Bose Fermi mixture — •Alexander Mil, Fabian Olivares, Arno Trautmann, Marcell Gall, and Fred Jendrzejewski — Kirchhoff-Institut für Physik, Heidelberg, Deutschland

Strongly imbalanced Bose-Fermi mixtures are an ideal tool for the study of impurity problems, which are of great interest in modern condensed matter physics e.g. the polaron or the Kondo problem. A generic property of such systems is the screening cloud surrounding the impurity. While these screening clouds are central to the properties of most systems with impurities, they still remain hard to detect and to control. The current state of our experiment is well suited to tackle this problem. Using a mixture of bosonic sodium and fermionic lithium, with one of the species tightly trapped, leads to well localized impurities. Recent experiments on this system led to the observation of the phonon-induced lamb shift, which is characteristic for the presence of the screening cloud. Next goal is the direct observation of the screening cloud in real space.

We present our progress towards high resolution imaging in a sodium lithium mixture for direct observation of the screening cloud. Key feature here is a new imaging lens design enabling diffraction limited resolution for both species at a numerical aperture of 0.4. Moreover we elaborate on the imaging algorithm and the experimental setup allowing for high detection efficiencies.

A 9.47 Mon 16:30 Empore Lichthof

Towards ultracold mixtures of lithium and caesium — •Elisa Da Ros, Pierre Jouve, Jonathan Nute, Jizhou Wu, Nathan

Cooper, and Lucia Hackermüller — University of Nottingham, United Kingdom

Ultracold mixtures hold the promise of understanding new phases of matter and collisions at very low energies. We showcase here our experiment capable of producing ultracold clouds of both bosonic caesium-133 and fermionic lithium-6 using a crossed-beam optical dipole trap.

We present the results of in situ optical density measurements of molecular lithium-6 Bose-Einstein condensates, aiming to compare different theoretical models. We also explain the design, construction and characterization of a dual species effusive oven for fast loading of magneto-optical traps integral to our experiments involving ultracold mixtures of both species. Finally, we exhibit our progress towards a quantum integrated light and matter interface (QuILMI) using waveguide chips in collaboration with the University of Jena, University of Vienna and the Max Planck Institute for the Physics of Complex Systems.

A 9.48 Mon 16:30 Empore Lichthof

A Thouless quantum pump with ultracold bosonic atoms in an optical superlattice — •Christian Schweizer[1,2], Michael Lohse[1,2], Oded Zilberberg[3], Monika Aidelsburger[1,2], and Immanuel Bloch[1,2] — [1]Fakultät für Physik, LMU München, Germany — [2]Max-Planck-Institut für Quantenoptik, Garching, Germany — [3]Institut für Theoretische Physik, ETH Zürich, Switzerland

Topological charge pumping enables the transport of charge through an adiabatic cyclic evolution of the underlying Hamiltonian. In contrast to classical transport, the transported charge is quantized and purely determined by the topology of the pump cycle, making it robust to perturbations. Here, we report on the realization of such a pump with ultracold bosonic atoms forming a Mott insulator in a dynamically controlled optical superlattice. By taking in situ images of the cloud,we observe a quantized deflection per pump cycle. We reveal the pump's genuine quantum nature by showing that, in contrast to groundstate particles, a counterintuitive reversed deflection occurs for particles in the first excited band. Furthermore, we directly demonstrate that the system undergoes a controlled topological transition in higher bands when tuning the superlattice parameters. These results open a route to the implementation of more complex pumping schemes, including spin degrees of freedom and higher dimensions.

A 9.49 Mon 16:30 Empore Lichthof

Coulomb explosion imaging of $^6Li_2$ Feshbach molecules in a reaction microscope — •Niels Kurz, Alexander Dorn, and Thomas Pfeifer — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

A reaction microscope enables the imaging of the spatial structure of complex molecules by instant ionization of all constituent particles using e.g. fs laser pulses, a technique coined "Coulomb Explosion Imaging". The use of ultracold targets in a reaction microscope has been successfully applied to investigate multi-photon ionization of ^{7}Li in 800 nm fs pulses or in intense VUV light at the FLASH facility in Hamburg [M. Schuricke, K. Bartschat, A. N. Grum-Grzhimailo, G. Zhu, J. Steinmann, R. Mooshammer, 2009].

Unprecedented is the combination of this technique with an ultracold target of weakly bound di-atomic molecules formed from fermionic atoms (^{6}Li in our case) by the use of Feshbach resonances. In the universal regime the spatial extension of Feshbach molecules can be tuned over a wide range, by using only one experimental parameter, to create molecules with a spatial extent of up to 10.000 Bohr radii.

We present a project aimed at creating firstly a BEC of di-atomic ^{6}Li molecules and secondly few-fermion systems as targets in a reaction microscope by the use of the so-called spilling technique [F. Serwane, S. Jochim, 2011]. This will result in the first measurement of interatomic distance in $^6Li_2$ Feshbach molecules with tunable interatomic distance.

A 9.50 Mon 16:30 Empore Lichthof

Full tomographic reconstruction of a two-mode squeezed state — •Jan Peise[1], Ilka Kruse[1], Karsten Lange[1], Bernd Lücke[1], Luca Pezzè[2], Jan Arlt[3], Wolfgang Ertmer[1], Klemens Hammerer[4], Luis Santos[4], Augusto Smerzi[2], and Carsten Klempt[1] — [1]Institut für Quantenoptik, Leibniz Universität Hannover, Germany — [2]INO-CNR and LENS, Firenze, Italy — [3]Institut for Fysik og Astronomi, Aarhus Universitet, Denmark — [4]Institut für Theoretische Physik, Leibniz Universität Hannover, Germany

Homodyne detection serves as a standard tool in quantum optics for a wide range of applications including full state reconstruction by tomography. Homodyne detection is not limited to quantum optics with photons but can be similarly employed as a detection tool in atomic systems. Up to now, it was utilized to demonstrate nonseparability or the many-particle realization of interaction-free measurements.

Here we present the full state reconstruction of a two-mode squeezed state which was created by spin dyanmics in a Bose-Einstein condensate. By unbalanced homodyning of the created state, we obtain an unbiased, complete density matrix via a Maximum-Likelihood reconstruction. The reconstructed state shows the characteristics expected from the spin-dynamics process. The created state is characterized by a dominant population of twin Fock states compared to other states with the same overall particle number. It resembles an ideal two-mode squeezed state with a fidelity of 78.4%. The created two-mode squeezed state has a large variety of application in the fields of quantum information and metrology.

A 9.51 Mon 16:30 Empore Lichthof

Motion of a rotating impurity in a Bose-Einstein condensate — •Bikashkali Midya[1], Richard Schmidt[2], and Mikhail Lemeshko[1] — [1]Institute of Science and Technology (IST) Austria, Am Campus 1, 3400 Klosterneuburg, Austria — [2]ITAMP, Harvard-Smithsonian Center for Astrophysics, Cambridge, USA

In this work, we consider the translational motion of a rotating quantum impurity coupled to a Bose-Einstein condensate with boson-boson contact interaction, and boson-impurity anisotropic interaction. The microscopic Hamiltonian to describe such system is derived by first eliminating the dynamical variable of impurity by Lee-Low-Pines transformation, and then approximating the boson system by Bogoliubov method. The effect of the linear momentum of the impurity on the quasiparticle "angulon", a quantum rotor dressed by quantum field [1], spectrum is investigated by the variational technique.

[1] Richard Schimdt and Mikhail Lemeshko, "Rotation of quantum impurities in the presence of a many-body environment", Phys. Rev. Lett. 114, 203001 (2015).