A 29: Poster: Ultra-cold atoms, ions and BEC (with Q)

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

A 29.1 Wed 16:00 Empore Lichthof

Degenerate mixtures of ultracold ^{40}K-^{6}Li Fermions and Sub-Doppler laser cooling of ^{40}K atoms on the D1 atomic transition — •Franz Sievers[1], Diogo Fernandes[1], Norman Kretzschmar[1], Daniel Suchet[1], Saijun Wu[2], Christophe Salomon[1], and Frederic Chevy[1] — [1]Laboratoire Kastler-Brossel, Ecole Normale Supérieure, Paris, France — [2]Department of Physics, College of Science, Swansea University, Swansea, United Kingdom

We present the design of our apparatus for creating cold mixtures of ^{6}Li and ^{40}K Fermions with which we intend to study condensed matter physics phenomena. Our experimental setup will allow us to simulate several Hamiltonians describing interacting many-body Fermionic systems in one, two and three dimensions. We report on the performances of the magnetic transport and our improved vacuum setup.
Furthermore we report on Sub-Doppler laser cooling of fermionic ^{40}K atoms in three-dimensional gray optical molasses on the D1 atomic transition.

A 29.2 Wed 16:00 Empore Lichthof

Two-channel Bose-Hubbard model of atoms at a Feshbach resonance — •Philipp-Immanuel Schneider and Alejandro Saenz — AG Moderne Optik, Humboldt-Universität zu Berlin, Newtonstr. 15, 12489 Berlin

Based on the analytic model of Feshbach resonances in harmonic traps described in [1] a Bose-Hubbard model is introduced that allows for the accurate description of two atoms in an optical lattice at a Feshbach resonance with only a small number of Bloch bands. The approach circumvents the problem that the eigenenergies in the presence of a delta-like coupling do not converge to the correct energies, if an uncorrelated basis is used.

Furthermore, we describe a possibility to realistically mimic Feshbach resonances within non-perturbative single-channel approaches by using a square-well interaction potential. This allows to compare the predictions of the Bose-Hubbard model to non-perturbative calculations of the stationary eigenenergies and the dynamical behavior of the atoms during an acceleration of the optical lattice.

[1] P.-I. Schneider and A. Saenz, Phys. Rev. A **83**, 030701(R) (2011).

A 29.3 Wed 16:00 Empore Lichthof

Vortex-bright soliton dipoles: bifurcations, symmetry breaking and soliton tunneling in a vortex-induced double well — •Jan Stockhofe[1], Martina Pola[1], Panayotis G. Kevrekidis[3], and Peter Schmelcher[1,2] — [1]Zentrum für Optische Quantentechnologien, Universität Hamburg, Deutschland — [2]The Hamburg Centre for Ultrafast Imaging, Germany — [3]Department of Mathematics and Statistics, University of Massachusetts, USA

The emergence of vortex-bright soliton dipoles in two-component Bose-Einstein condensates through bifurcations from suitable eigenstates of the underlying linear system is examined. These dipoles can have their bright solitary structures be in phase (symmetric) or out of phase (anti-symmetric). The dynamical robustness of each of these two possibilities is considered and the out-of-phase case is found to exhibit an intriguing symmetry-breaking instability that can in turn lead to tunneling of the bright wavefunction between the two vortex "wells". We interpret this phenomenon by virtue of a vortex-induced double well system, whose spontaneous symmetry breaking leads to asymmetric vortex-bright dipoles, in addition to the symmetric and anti-symmetric ones. The theoretical prediction of these states is corroborated by detailed numerical computations.

A 29.4 Wed 16:00 Empore Lichthof

Compressional and surface modes of the trapped dipolar gases — •Alexey Filinov[1,2] and Michael Bonitz[1] — [1]Institut für Theoretische Physik und Astrophysik, D-24098 Kiel, Germany — [2]Joint Institute for High Temperatures RAS, 125412 Moscow, Russia

The low-lying collective excitations -monopole and multipole modes- are analyzed based on the excitation-energy sum rules [1]. This formalism allows to estimate an upper bound for the excitation energies. The involved frequency moments of the strength function are estimated as a trace over the corresponding commutators between an excitation operator and the many-body Hamiltonian in thermodynamic equilibrium. Temperature and dipole interaction strength dependencies of the breathing and quadrupole modes of a 3D trapped dipolar gas are presented. One of our goals is to analyze the frequency shifts of the modes similar to that observed in the experiments with a ^{87}Rb gas at temperatures near T_c [2]. Our analysis is based on finite-temperature quantum MC simulations [3].

[1] E. Lipparini and S. Stringari, Phys. Rep. **175**, 103 (1989); S. Stringari, Phys. Rev. Lett. **77**, 2360 (1996). [2] D.S. Jin and et al., *ibid* **78**, 764 (1997); D.M. Stamper-Kurn and et al., *ibid* **81**, 500 (1998). [3] A. Filinov and et al., *ibid* **105**, 070401 (2010).

A 29.5 Wed 16:00 Empore Lichthof

Collision studies in ultracold calcium atoms — •Purbasha Halder and Andreas Hemmerich — Institut für Laserphysik, Universität Hamburg

We present collision studies of optically trapped calcium atoms in their long-lived triplet states and discuss the feasability of achieving Bose-Einstein condensation in these states by evaporative cooling methods. The metastable states of alkaline earth and rare earth elements have novel elastic and inelastic scattering properties [1], and have important implications for applications like time metrology and lattice-based quantum computing.

The atoms are prepared by an alternative method analogous to the one used to create a ground state BEC [2].

[1] V. Kokoouline, R. Santra, and C. Greene, Phys. Rev. Lett. **90**, 253201 (2003).

[2] P. Halder, C.-Y. Yang and A. Hemmerich, Phys. Rev. A **85**, 031603 (2012).

A 29.6 Wed 16:00 Empore Lichthof

Strontium in an Optical Lattice as a Portable Frequency Reference — •Lyndsie Smith, Ole Kock, Wei He, Huadon Cheng, Steven Johnson, Kai Kai, and Yeshpal Singh — School of Physics and Astronomy, University of Birmingham, Edgbaston Park Road, Birmingham B15 2TT, UK

The higher frequencies (approx. 10^15) of the atomic transitions enable a greater accuracy than the current microwave frequency (approx. 10^10) standard. Optical clocks have now achieved a performance significantly beyond that of the best microwave clocks, at a fractional frequency inaccuracy of 8.6 *10^-18. With the rapidly improving performance of optical clocks, in the future, most applications requiring the highest accuracy will require optical clocks. We are setting up an experiment aimed at a mobile frequency standard based on strontium (Sr) in a blue detuned optical lattice. We have 2D-3D MOT setup where initially cooled atoms in 2D are collected in the 3D MOT. Very recently we have realized our 3D MOT. We have also observed an effect of our 2D MOT on our 3D MOT. However, it should be mentioned that these are preliminary results and a thorough optimization as well as characterization will be done in due course of time. In addition to that we have designed a very compact and robust frequency distribution module for our European collaborative project, Space Optical Clock (SOC-2). An up to date progress on a compact and robust frequency standard experiment will be presented.

A 29.7 Wed 16:00 Empore Lichthof

Imaging vortices in a Bose–Einstein condensate with tracer particles — •Chris Billington[1,2], Philip Starkey[1], Shaun Johnstone[1], Mikhail Egorov[1], and Kristian Helmerson[1] — [1]School of Physics, Monash University, Victoria, Australia — [2]Physikalisches Institut, Universität Tübingen, Tübingen, Germany

Vortex cores in Bose–Einstein condensates are minima in atomic density. As such, an atom experiencing repulsive interactions with a condensate will see vortex cores as potential wells, and may become trapped within them. We are developing an experiment to image vortices *in-situ* using this effect. We will introduce ^{87}Rb atoms to a ^{41}K condensate containing vortices, and image the ^{87}Rb atoms in order to discern the positions of vortex cores.

In order to perform this and other experiments, we have developed a powerful control and analysis system called *labscript.* In labscript, experiments are written as code in a high level language, before being compiled to hardware instructions suitable for programming into devices. Many such experiments can be compiled at once—scanning over one or more input parameters to the experiment—and will be queued up and executed one after the other on the hardware. User-written analysis routines run automatically as new data arrives from the experiment, with plots updating in real time. Analysis results can also determine the input parameters to the next experiment, which we use for closed loop optimization of experiment results using a genetic algorithm.

A 29.8 Wed 16:00 Empore Lichthof

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

Ultracold chemistry is a highly interesting research field. 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 large paul trap, with conventional doppler cooling and furthermore with an ambient rubidium MOT. By switching off our RF-potential we overcome the limitations set by heating due to the RF micromotion[4]. We describe the experimental apparatus in its recent stage and the very first experiments done with it.

[1]A.T.Grier, M.Cecina, 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.Rev.Lett. 107 243201 (2011)
[4]L.H.Nguyen, A.Kalev, M.D.Barett and B.Engelert, Phys.Rev.A 85, 052718 (2012)

A 29.9 Wed 16:00 Empore Lichthof

Quantum magnetism of mass-imbalanced fermionic mixtures — •Andrii Sotnikov[1], Daniel Cocks[1], Michiel Snoek[2], and Walter Hofstetter[1] — [1]Goethe Universität, Frankfurt am Main, Germany — [2]Universiteit van Amsterdam, The Netherlands

We study magnetic phases of two-component mixtures of ultracold fermions with repulsive interactions in optical lattices in the presence of hopping and population imbalance by means of dynamical mean-field theory (DMFT). According to our analysis, mass-imbalanced mixtures have important advantages over balanced systems in thermodynamic characteristics that are relevant for obtaining and detecting quantum magnetism in optical lattices.

It is shown that mixtures with both imbalances present can have easy-axis antiferromagnetic, ferrimagnetic, charge-density wave, canted-antiferromagnetic order or be unordered depending on parameters of the system. We study the resulting phase diagram in detail and investigate the stability of the phases to thermal fluctuations. We also perform a quantitative analysis for a gas confined in a harmonic trap, by applying the local density approximation and a real-space generalization of DMFT.

A 29.10 Wed 16:00 Empore Lichthof

Single Ions Trapped in a One-Dimensional Optical lattice — •Thomas Huber, Martin Enderlein, Christian Schneider, Alexander Lambrecht, Michael Zugenmaier, Julian Schmidt, and Tobias Schaetz — Albert-Ludwigs Universität Freiburg

In 2010 we trapped a Mg+ ion in an optical dipole trap [1]. Compared to conventional ion traps optically trapped ions permit novel prospects in several ways: For example to study ultra-cold atom-ion collisions, not suffering from micromotion-induced heating [2] and as potentially scalable systems in optical lattices with long-range interaction for quantum simulations based on ions or ions and atoms.

We report on three-dimensional optical trapping of single ions in a one-dimensional optical lattice formed by two counterpropagating laser beams [3]. We characterize the trapping parameters of the standing-wave using the ion as a sensor stored in a hybrid trap consisting of a radio-frequency (rf), a dc, and the optical potential. When loading ions directly from the rf into the standing-wave trap, we observe a domi-nant heating rate. Monte Carlo simulations confirm rf-induced para-metric excitations within the deep optical lattice as the main source. We demonstrate a way around this effect by an alternative transfer protocol which involves an intermediate step of optical confinement in a single-beam trap avoiding the temporal overlap of the standing-wave and the rf field. We discuss potential applications.

[1]Schneider et al., Nat. Photonics 4(2010)
[2]Cormick et al., New J. Phys. 13 (2011)
[3]M. Enderlein et al., Phys. Rev. Lett. 109 (2012)

A 29.11 Wed 16:00 Empore Lichthof

Laser stabilisation techniques for cooling of Barium ions — •Julian Schmidt, Thomas Huber, Alexander Lambrecht, Michael Zugenmaier, and Tobias Schaetz — Universität Freiburg

In ion trapping experiments, the frequency of the lasers required for cooling, repumping and photoionisation needs to be just as stable as for neutral atom experiments, that is on the order of a fraction of the natural linewidth. However, since the gas is composed of neutral atoms and molecules, one cannot, in general, use established locking techniques on a gas cell filled with the chemical element in question.

For Ba^+, the repumping transition at 650nm is in the vicinity of an Iodine line; however, in typical gas cells, there are no established transitions to lock the Doppler cooling laser at 493nm (which is frequency-doubled from 987nm) or the two-photon photoionisation laser at 413nm. In our experiment, we therefore implement temperature stabilised optical cavities suited to fulfill our requirements at 987nm and 413nm with sub-MHz (sub-Hz stabilisation is not required) linewidth and excellent long-term stability to produce a useful error signal.

For the future, we are investigating several options, e.g. locking the 493nm laser to a transition in the H_2O molecule which is, to our knowledge, not being exploited in other Ba^+-trapping experiments, or to an improved version of our current optical cavity.

A 29.12 Wed 16:00 Empore Lichthof

Structural and dynamical properties of quasi-1D dipolar crystals — •Florian Cartarius[1,2], Anna Minguzzi[1], and Giovanna Morigi[2] — [1]Université de Grenoble 1/CNRS, LPMMC UMR 5493, B.P. 166, 38042 Grenoble, France — [2]Theoretische Physik, Universität des Saarlandes, 66123 Saarbrücken, Germany

We study the ground state of classical dipolar particles in quasi-1D geometries, which can be realized in highly anisotropic traps. Here, the dipolar interaction between the particles can be made repulsive by confining the particles on a plane in presence of an external field perpendicular to it. We study the equilibrium configurations which are obtained for decreasing values of the trap aspect ratio by means of a Basin-Hopping Monte Carlo method and of analytical calculations of the motional spectra, and determine the structural phase diagram.

A 29.13 Wed 16:00 Empore Lichthof

An ultracold ytterbium quantum gas for lattice many-body physics — •C. Hofrichter, P. C. De Groot, F. Scazza, M. Höfer, C. Schweizer, E. Davis, I. Bloch, and S. Fölling — MPI für Quantenoptik, Hans-Kopfermann-Strasse 1, 85748 Garching and Ludwig-Maximilians-Universität, Schellingstrasse 4, 80799 München, Germany

Alkaline-earth-type atoms (AEA) like ytterbium differ in their internal structure from the more widely used alkali atomic species. Their electronic structure is responsible for specific properties that can be exploited in the field of quantum simulation with ultracold atoms in optical lattices.

AEAs possess a metastable excited state useful for implementing state-dependent optical potentials necessary for certain novel types of many-body Hamiltonians. In addition, the high nuclear spin of fermionic isotopes gives rise to an enlarged SU(N) symmetry of the hamiltonian. A significant theoretical effort has been already committed to the understanding of the physics of systems that could be realized with an ytterbium quantum gas trapped in an optical lattice, such as the Kondo lattice model or higher-symmetry Heisenberg models.

We present our setup for the production of an Yb degenerate gas of bosonic or fermionic atoms with control over nuclear and electronic spin state populations in a 3D optical lattice.

A 29.14 Wed 16:00 Empore Lichthof

Detection of Single Flux Quanta with Ultracold Atoms — •Patrizia Weiss, Simon Bernon, Helge Hattermann, Martin Knufinke, Daniel Bothner, 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

We report on the interaction of an atomic cloud with a superconducting ring. When such a structure is cooled through the superconducting transition ($T_c = 9.2\,\mathrm{K}$) in an external field, persistent currents will conserve the magnetic flux inside the ring. The 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 trap atomic clouds of ^{87}Rb in a superconducting magnetic microtrap at 4.2 K and bring the atoms in the vicinity of the ring structure ($R = 10\,\mu$m). The atomic cloud is sensitive to the 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 depth. The results pave the way towards coupling cold atoms to SQUIDS and the generation of periodic magnetic micropotentials based on persistent currents.

A 29.15 Wed 16:00 Empore Lichthof

Operation of a cold atom setup in a delution refrigerator — •Florian Jessen, Martin Knufinke, Petra Vergien, Malte Reinschmidt, Helge Hattermann, Simon Bernon, Simon Bell, Daniel Cano, Dieter Kölle, Reinhold Kleiner, and József Fortágh — Center for Collective Quantum Phenomena, Eberhard Karls Universität Tübingen, Auf der Morgenstelle 14, 72076 Tübingen

We describe the operation and technical details of a cold atom setup in a delution refrigerator. The setup contains a magneto optical trap, which is loaded from a Zeeman slower, magnetic traps and optical dipole traps.

A 29.16 Wed 16:00 Empore Lichthof

Towards probing of fermionic quantum many body systems on the single atom level — •Ahmed Omran[1], Martin Boll[1], Timon Hilker[1], Michael Lohse[1], Thomas Reimann[1,2], Thomas Gantner[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, Fakultät für Physik, Schellingstraße 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.

We are using mixtures of Li-6 and Li-7 atoms to achieve a degenerate bosonic or fermionic many body system trapped in a 3D optical lattice. With a high resolution imaging system, we will be able to resolve single sites in a 2D plane of the lattice and image single atoms. Superimposing an additional small-scale pinning lattice onto the larger-scale physics lattice in order to freeze out the distribution of atoms during imaging, we separate the detector from the physical system under study. This will allow for the investigation of different lattice geometries with single atom sensitivity.

We present the current status of our experimental realization and a method for in-situ thermometry in magnetic traps.

A 29.17 Wed 16:00 Empore Lichthof

Interfacing Cold Atoms and Carbon Nanotubes — •Simon Bell, Peter Federsel, Hannah Schefzyk, Markus Stecker, Andreas Günther, and József Fortágh — Physikalisches Institut, Universität Tübingen, Deutschland

Hybrid systems of ultracold atoms and nano-devices have attracted considerable attention within the last years. In future, such systems might allow the realization of novel nano-devices and nano-sensors with sensitivities only limited by quantum effects. In our system we routinely interface ultracold atoms with single carbon nanotubes. We show how this system might be used to demonstrate a novel quantum galvanometer, and summarize our results on the first cold-atom scanning probe microscope [1, 2].

While efficient single-atom detection will become more and more important for hybrid systems and for quantum atom optics in general, we also show our latest attempts towards in-situ single-atom detection of trapped quantum gases. Currently we are investigating two different schemes, both based on ionization of individual atoms and subsequent ion-detection. The first scheme uses optical ionization and allows highly resolved spatial imaging. The second scheme uses field ionization at the tip of a charged nanotube/nanowire to limit the ionization region to the nm length scale. We will expand on both of these detection schemes and show our first results.

[1] Schneeweiß et al., *Nature Nanotechnology* **7**, 515-519 (2012)
[2] Gierling et al., *Nature Nanotechnology* **6**; 446-451 (2011)

A 29.18 Wed 16:00 Empore Lichthof

Crossover from a crystalline to a cluster phase for a confined finite chain of ions — •Alexandra Zampetaki[1], Fotios Diakonos[2], and Peter Schmelcher[1] — [1]Zentrum für Optische Quantentechnologien, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany — [2]Department of Physics, University of Athens, GR-15874, Athens, Greece

Employing Monte-Carlo simulation techniques we investigate the statistical properties of equally charged particles confined in an one-dimensional box trap. We detect a crossover from a crystalline to a cluster phase with increasing temperature. The corresponding transition temperature depends separately on the number of particles N and the box size L, implying non-extensivity due to the long-range character of the interactions. The probability density of the spacing between the particles exhibits at low temperatures an accumulation of discrete peaks with an overall asymmetric shape. Around the transition temperature it is of a Gaussian form whereas in the high temperature regime it obeys an exponential decay. The high temperature behaviour shows a cluster phase with a mean cluster size that first increases with the temperature but finally saturates.The crossover is clearly identifiable also in the non-linear behaviour of the heat capacity with varying the temperature.

A 29.19 Wed 16:00 Empore Lichthof

Topological Insulators in Optical Lattices: interaction and trapping — •Daniel Cocks[1], Peter Orth[2], Michael Buchhold[1], Stephan Rachel[3], Karyn Le Hur[4], and Walter Hofstetter[1] — [1]Institut für Theoretische Physik, Goethe Universität, Frankfurt — [2]Institut für Theorie der Kondensierten Materie, Karlsruhe Institut für Technologie — [3]Institut für Theoretische Physik, Technische Universität Dreseden — [4]Center for Theoretical Physics, École Polytechnique, Palaiseau

We investigate effects of interaction and trapping in a 2D system to be realised in experiment (Goldman et al. PRL **105**, 255302, 2010) that exhibits topologically insulating phases in an optical square lattice, using both real-space dynamical mean-field theory (R-DMFT) and analytical techniques. This system includes a flux term, which emulates a spin-dependent magnetic field, a Rashba/Dresselhaus-like spin-orbit term, which introduces non-Abelian behavior, and a staggered super-lattice potential, which introduces non-trivial topology at half-filling.

We investigate with R-DMFT the robustness of the topological phases for weak interaction, and transitions to magnetic order at strong interaction. We demonstrate a critical dependence on the number of Dirac points. As well, we derive and analyze the corresponding spin-Hamiltonian and show that the competition of flux and Rashba-like spin-orbit couplings produce non-trivial spiral-like orders. We also consider the effects of trapping on the visibility of edge states, and show that new interesting features arise when smooth trapping is present.

A 29.20 Wed 16:00 Empore Lichthof

Millisecond Dynamics of Ultracold Rydberg Gases — •Tobias Weber, Thomas Niederprüm, Torsten Manthey, Giovanni Barontini, Vera Guarrera, and Herwig Ott — TU Kaiserslautern

We observe ultracold atoms continuously coupled to Rydberg states on a timescale exceeding the vastly investigated so called frozen Rydberg regime. A scanning electron microscope technique is exploited to prepare distributions of mesoscopic ensembles with dipole-dipole interactions induced by resonant and off-resonant excitation. Characterisations of correlations between Rydberg atoms and of ionization processes are derived from the analysis of the ion signal.

A 29.21 Wed 16:00 Empore Lichthof

Investigation of two ultra-cold dipolar particles in a trap — •Bruno Schulz, Philipp-Immanuel Schneider, Simon Sala, and Alejandro Saenz — Institut für Physik, Humboldt Universität zu Berlin, Germany

Ultra-cold dipolar gases have lead to novel phenomena in the regime of degenerate many-body quantum systems. The interaction strength of such systems can easily be varied by external homogeneous electric or magnetic fields depending on the type of dipoles. Therefore, a high degree of control can be achieved on the quantum states of such systems. Those dipolar quantum gases are interesting candidates for applications like quantum computation due to their strong dipole-dipole interaction that often acts on a longer distance than the standard atom-atom interaction. Despite the large interest in ultra-cold dipolar quantum gases, a fully theoretical description of two dipolar particles interacting via a short-range contact interaction and the dipole-dipole interaction in a trap is not known. Therefore, our group developed an approach to solve the time-independent Schrödinger equation with a realistic full Born-Oppenheimer interatomic interaction potential and the long-range anisotropic dipole-dipole interaction in three dimensions in a finite optical lattice. The understanding of the pair interaction of two particles interacting via dipole-dipole interaction could help to understand general properties of such systems and to obtain improved parameters for Ising-type models. As a first step towards the understanding we present and discuss the energy spectra and pair densities of two ultra-cold dipolar particles in a harmonic trap.

A 29.22 Wed 16:00 Empore Lichthof

Towards Ultracold Mixtures on an Atom Chip — •Jonathan Nute, Matthew Jones, Asaf Paris Mandoki, Sonali Warriar, Peter Krüger, and Lucia Hackermüller — University of Nottingham, UK

Ultracold mixtures hold the promise of understanding new phases of matter and collisions at very low energies. 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. We plan to introduce a micro-chip, which in conjunction with optical dipole trapping, will make it possible to trap these mixtures in low dimensions and tune their scattering lengths via Feshbach resonances. In this way it will also be possible to realise experiments with additional magnetic potentials, position dependent interactions or impurity dynamics. Here we present the current status of our experiment. We detail the cooling schemes for the two atom species and include the recent development of implementing an optical dipole trap. We discuss plans for introducing a glass cell to our caesium setup in preparation for our contribution to the Quantum Integrated Light and Matter Interface (QuILMI) European collaboration.

A 29.23 Wed 16:00 Empore Lichthof

An Ultracold Fermi Gas in an Optical Lattice — •Puneet Murthy, Mathias Neidig, Martin Ries, Andre Wenz, Thomas Lompe, and Selim Jochim — Physikalisches Institut, Universität Heidelberg, Heidelberg

Ultracold Fermi gases confined in optical lattices hold great promise in understanding interesting many-body phenomenon. Recent studies have demonstrated single site resolution in a system of bosonic quantum gases. Our objective is to employ similar techniques in the study of an ultracold quantum degenerate Fermi gas of ^{6}Li atoms. This poster presents our recent experimental progress towards attaining such a system.

At present we are able to transfer a quantum degenerate two component gas of ^{6}Li atoms from an optical dipole trap into a stack of several 'pancake'-shaped potentials, which are formed by the interference pattern of two off-resonant laser beams. We use a radio-frequency tomographic method to probe the occupation of individual pancakes and find that we can load atoms into less than five pancakes. In the next step, we aim to transfer the atoms into a single pancake potential. By having additional lattice beams creating standing waves in the perpendicular direction, we will be able to produce a two-dimensional optical lattice containing an ultracold degenerate Fermi gas, and perform in-situ studies on it.

A 29.24 Wed 16:00 Empore Lichthof

Low-noise absorption detection for sub-shot-noise atom interferometry — •Bernd Lücke, Jan Peise, Wolfgang Ertmer, and Carsten Klempt — Institut für Quantenoptik, Leibniz Universität Hannover, Germany

Atom interferometers are extremely precise measurement tools in a wide field of metrological applications. An interferometer maps the quantity of interest on the number of atoms in its output ports. Therefore a low noise detection of the atoms is crucial. Moreover new entangled states of matter will push the precision of atom interferometers to new limits and thus require even more precise atom detection. In our experiment we create entangled twin Fock states for interferometry beyond the shot noise limit. The measurement of the interferometric sensitivity of this state sets high requirements on our absorption detection. We show how we were able to increase its precision and discuss the effect of photon shot noise as a fundamental limitation for absorption detection.

A 29.25 Wed 16:00 Empore Lichthof

Evidence for a quantum-to-classical transition in a system of two coupled quantum rotors — •Bryce Gadway[1,2], Jeremy Reeves[1], Ludwig Krinner[1], and Dominik Schneble[1] — [1]Dept. of Physics and Astronomy, Stony Brook University, Stony Brook, NY, USA — [2]present address: JILA, University of Colorado, Boulder, CO, USA

We experimentally realize a pair of two coupled quantum kicked rotors, by subjecting a coherent atomic matter wave to two periodically pulsed, incommensurate optical lattices. Momentum transport in this system is found to be radically different from the well-known behavior of a single kicked rotor, with a breakdown of dynamical localization and the emergence of classical diffusion. Our observations confirm a long-standing prediction for many-dimensional quantum-chaotic systems, and shed new light on how classical behavior can emerge in isolated, periodically driven quantum systems.

A 29.26 Wed 16:00 Empore Lichthof

Progress at the Munich ultracold polar molecules project — •Nikolaus Buchheim, Zhenkai Lu, Diana Amaro, Tobias Schneider, Immanuel Bloch, and Christoph Gohle — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Strasse 1, 85748 Garching

Ultra cold quantum gases with large dipolar interaction or large polarizability that are recently becoming available promise exciting new possibilities. Self assembled lattices of polarized particles supporting phonon modes will provide opportunities to simulate an even broader range of solid state physics phenomena [1]. New classes of many body phases (like super solids and stripe phases) are on the horizon and ferroelectric phases of highly polarizable systems are expected.

Among other systems like Rydberg atoms or Atoms with exceptionally large magnetic dipole moments, simple polar molecules are a viable alternative due to their good balance between dipole length and scattering length as well as their potential long levity. We present the latest news on our experiment to create ultracold NaK molecules. In this system the instability due to inelastic two body collisions known from pioneering experiments [2] does not exist and chances are good to reach far into the interesting parameter space.

[1] Pupillo, G., Micheli, A., Büchler, H. P., & Zoller, P. (2008). Condensed Matter Physics with Cold Polar Molecules. arxiv:0805.1896.

[2] Ni, K.-K., Ospelkaus, S., et al. A high phase-space-density gas of polar molecules. Science, 322, 231-5 (2008).

A 29.27 Wed 16:00 Empore Lichthof

Stable Heteronuclear Few-Atom Bound States in Mixed Dimensions — •Tao Yin[1,2], Peng Zhang[2], and Wei Zhang[2] — [1]Institut für Theoretische physik, Goethe-Universität, 60438 Frankfurt/Main, Germany — [2]Department of Physics, Renmin University of China, Beijing 100872, People's Republic of China

We study few-body problems in mixed dimensions with two or three heavy atoms trapped individually in parallel one-dimensional tubes or two-dimensional disks, and a single light atom travels freely in three dimensions. By using the Born-Oppenheimer approximation, we find three- and four-body bound states for a broad parameter region. Specifically, the existence of trimer and tetramer states persist to negative scattering lengths regime, where no two-body bound state is present. As pointed out by Nishida in an earlier work [Phys. Rev. A **82**, 011605(R) (2010)], these few-body bound states are stable against three-body recombination due to geometric separation. In addition, we find that the binding energy of the ground trimer and tetramer state reaches its maximum value when the scattering lengths are comparable to the separation between the low-dimensional traps.