A 29: Ultra-cold atoms, ions and BEC (joint session A/Q)

Time: Thursday 16:30–18:30 Location: P

A 29.1 Thu 16:30 P

Quantum degenerate Fermi gas in an orbital optical lattice
— •Yann Kiefer — Luruper Chaussee 149, 22761 Hamburg

Spin-polarized samples and spin mixtures of quantum degenerate fermionic atoms are prepared in selected excited Bloch bands of an optical chequerboard square lattice. For the spin-polarized case, extreme band lifetimes above 10 s are observed, reflecting the suppression of collisions by Pauli*s exclusion principle. For spin mixtures, lifetimes are reduced by an order of magnitude by two-body collisions between different spin components, but still remarkably large values of about one second are found. By analyzing momentum spectra, we can directly observe the orbital character of the optical lattice. The observations demonstrated here form the basis for exploring the physics of Fermi gases with two paired spin components in orbital optical lattices, including the regime of unitarity. Furthermore access to a broad Feshbach resonance enables to study the role of interaction and pairing of ultracold molecular orbital optical lattices.

A 29.2 Thu 16:30 P

non-equilibrium dynamics of a bose-einstein condensate populating higher bands of an optical lattice
— •josé vargas[1,3] and andreas hemmerich[1,2,3] — [1]Institut für Laserphysik, Universität Hamburg, 22761 Hamburg, Germany — [2]Zentrum für Optische Quantentechnologien, Universität Hamburg, 22761 Hamburg, Germany — [3]The Hamburg Center for Ultrafast Imaging, Luruper Chaussee 149, Hamburg 22761, Germany

We present the realization of diverse experiments on non-equilibrium dynamics of a Bose-Einstein condensate populating higher bands of a bipartite square optical lattice. We experimentally investigate single- and many-body phenomena such as Bloch oscillations along different paths over each addressable Brillouin zones, and Josephson oscillations in the second Bloch band of the lattice. In addition, by exciting the atomic sample into different initial quasi-momenta of the lattice, we study instabilities of the system together with the characterization of re-condensation dynamics towards the energy minimum of the Bloch band.

A 29.3 Thu 16:30 P

Optically trapping single ions in a high-focused laser beam
— •Wei Wu[1], Fabian Thielemann[1], Joachim Welz[1], Pascal Weckesser[1,2], Daniel Hönig[1], Amir Mohammadi[1], Thomas Walker[1], and Tobias Schätz[1] — [1]Albert-Ludwigs-Universität Freiburg, Physikalisches Institut, Hermann-Herder-Straße 3, 79104 Freiburg, Germany — [2]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Straße 1, 85748 Garching, Germany

Ions stored in Paul traps are well suited to design few-particle systems with high-fidelity control over electronic and motional degrees of freedom and individual addressability., alongside long-range interactions. It is challenging, however, to extend this control to two- or higher-dimensional systems. This is partly due to the existence of driven motion, which intrinsically leads to decoherence and heating. Ions confined in optical traps, on the other hand, constitute a system which is free of driven motion but still benefits from long-range interaction. For example, ions in optical traps could be used to study and control quantum structural phase transitions from 1D (linear) to 2D (zigzag) crystals. Additionally, optical traps offer scalability, flexibility and nanoscale potential geometries which are not easily accessible with Paul traps. Optical traps for ions also feature state-dependent trapping due to the different potentials seen by the ion when in different electronic states. In this poster, we present a method to deterministically prepare a single ion or string of ions, making use of state dependent potentials in optical traps to eject selected ions from the trap.

A 29.4 Thu 16:30 P

Feshbach Resonances in a hybrid Atom-Ion System
— •Joachim Welz[1], Fabian Thielemann[1], Wei Wu[1], Thomas Walker[1], Pascal Weckesser[1,2], Daniel Hönig[1], Amir Mohammadi[1], and Tobias Schätz[1] — [1]Albert-Ludwigs-Universität Freiburg, Physikalisches Institut, Hermann-Herder-Straße 3, 79104 Freiburg, Germany — [2]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Straße 1, 85748 Garching, Germany

We present the observation of Feshbach resonances between neutral atoms and ions [1,2]. These resonances - a quantum phenomenon only observable at ultracold temperatures - allow the interaction rate between particles to be tuned with the perspective to even switch them off. While Feshbach resonances are commonly utilized in neutral atom experiments, reaching the ultracold regime in hybrid rf-optical traps is challenging, as the driven motion of the ion by the rf trap limits the achievable collision energy [3]. By immersing a single Ba ion in an ultracold cloud of Li, we demonstrate the enhancement of both two-body and three-body interactions through changes in the ion's internal and motional energy. This paves the way for all-optical trapping of both species, circumventing the fundamental rf-heating, and for new applications, such as the coherent formation of molecular ions and simulations of quantum chemistry [4].

[1] WECKESSER, Pascal, et al. arXiv:2105.09382, 2021.
[2] SCHMIDT, J., et al. Phys.Rev.Lett. 2020, 124-5.
[3] CETINA, Marko et al. Phys.Rev.Lett. 2012, 109-25.
[4] BISSBORT, Ulf, et al. Phys.Rev.Lett. 2013, 111-8.

A 29.5 Thu 16:30 P

A dipolar quantum gas microscope
— •Paul Uerlings, Kevin Ng, Jens Hertkorn, Jan-Niklas Schmidt, Ralf Klemt, Sean Graham, Tim Langen, and Tilman Pfau — 5. Physikalisches Institut and Center for Integrated Quantum Science and Technology IQST, Universität Stuttgart

We present the progress towards constructing a dipolar quantum gas microscope. This new apparatus combines the long-range interactions found in dipolar quantum gases with the single-site resolution of a quantum gas microscope, allowing for detailed studies of quantum phases in strongly correlated systems. Fermionic atoms trapped in optical lattices can model the behaviour of electrons in complex solid materials. By implementing a quantum gas microscope, microscopic details such as site occupation and site correlations will be observable, providing new insights into elusive quantum phases. We plan to do this using dysprosium atoms trapped in an ultraviolet optical lattice with a lattice spacing of about 180 nm. Combined with the long-range dipole interaction, the short lattice spacing will significantly increase the nearest-neighbour interaction strength to be on the order of 200 Hz (10 nK). This will allow us to study the regime of strongly interacting dipolar Bose- and Fermi-Hubbard physics where even next-nearest-neighbour interactions could be visible.

A 29.6 Thu 16:30 P

Compact device for painting blue-detuned time-averaged optical potentials for space application
— •Kai Frye[1,2], Marius Glaeser[1], Christian Schubert[1,2], Waldemar Herr[1,2], Ernst Rasel[1], and BECCAL Team[1,2,3,4,5,6,7,8,9,10] — [1]Leibniz Universität Hannover — [2]DLR-SI, Hannover — [3]Universität Ulm — [4]FBH Berlin — [5]HU, Berlin — [6]JGU, Mainz — [7]ZARM, Universität Bremen — [8]DLR-QT, Ulm — [9]DLR-SC, Braunschweig — [10]Universität Hamburg

The Bose-Einstein and Cold Atom Laboratory (BECCAL) will be a multi-user and -purpose facility onboard the International Space Station. It will provide ultacold ensembles of Rb and K atoms for experiments on fundamental research and sensor applications. For this, BECCAL will support the confinement of atoms in optical flat-bottom traps of arbitrary shapes.

Here, we present a design of a compact and robust setup for creation of blue-detuned time-averaged optical potentials. We utilize a dual-axis acousto-optical deflector and characterize the setup in terms of efficient use of light power, light extinction in the center of the optical trap and smoothness of the potential.

BECCAL is supported by the German Space Agency DLR with funds provided by the Federal Ministry of Economics and Technology (BMWi) under the grant numbers 50 WP 1431 and 1700. Funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) under Germany*s Excellence Strategy * EXC-2123 QuantumFrontiers * 390837967.

A 29.7 Thu 16:30 P

Trapping Ions And Ion Coulomb Crystals In Optical Lattices
— •Daniel Hoenig[1], Fabian Thielemann[1], Joachim Welz[1], Wei Wu[1], Thomas Walker[1], Leon Karpa[2], Amir Mohammadi[1], and Tobias Schaetz[1] — [1]Albert-Ludwigs-Universität, Freiburg,

Deutschland — [2]Leibniz-Universität, Hannover, Deutschland

Optically trapped ion Coulomb crystals are an interesting platform for quantum simulations due to the long range of the Coulomb interaction as well as the state dependence of the optical potential. Optical lattices expand the possible application of this platform by trapping the ions in seperate potential wells as well as giving optical confinement along the axis of the beam. In the past we reported the succesfull trapping of a single ion in a one dimensional optical lattice as well as of ion coulomb crystals in a single beam optical dipole trap.

In this Poster, we present recent advancements in trapping of Ba138+ ions in an one dimensional optical lattice at a wavelength of 532nm and report the first successfull trapping of small ion coulomb crystals ($N \leq 3$) in a lattice. We compare trapping results between the lattice and a single-beam optical dipole trap and investigate the effect of axial electric fields on the trapping probability of a single ion to demonstrate the axial confinement of the ion by the lattice structure. Additionally we show preliminary results on the measurement of the vibrational modes of a single ion in the optical lattice.

A 29.8 Thu 16:30 P

Vortex motion quantifies strong dissipation in a holographic superfluid — Paul Wittmer[1,2], Christian-Marcel Schmied[2,3], •Martin Zboron[3], Thomas Gasenzer[1,2,3], and Carlo Ewerz[1,2] — [1]Institut für Theoretische Physik, Universität Heidelberg, Philosophenweg 16, 69120 Heidelberg — [2]ExtreMe Matter Institute EMMI, GSI Helmholtzzentrum für Schwerionenforschung, Planckstraße 1, 64291 Darmstadt, Germany — [3]Kirchhoff-Institut für Physik, Universität Heidelberg, Im Neuenheimer Feld 227, 69120 Heidelberg

Gauge-gravity duality establishes a connection between strongly correlated quantum systems and higher-dimensional gravitational theories at weak coupling. In general, finding the quantitative parameters of the quantum system thus described is challenging. We numerically simulate dynamics of generic vortex configurations in the holographic superfluid in two and in three spatial dimensions and match to these the corresponding dynamics resulting from the dissipative Gross-Pitaevskii equation. Excellent agreement between the vortex core profiles and their trajectories in both frameworks is found, both in two and three dimensions. Comparing our results to phenomenological equations for point- and line-like vortices allows us to extract friction parameters of the holographic superfluid. The parameter values suggest the applicability of two-dimensional holographic vortex dynamics to strongly coupled Bose gases or Helium at temperatures in the Kelvin range, effectively enabling experimental tests of holographic far-from-equilibrium dynamics.

A 29.9 Thu 16:30 P

Accordion lattice set-up for trapping Dysprosium ultra-cold gases in two dimensions — •Valentina Salazar Silva, Jianshun Gao, Karthik Chandrashekara, Joschka Schöner, Christian Gölzhäuser, Lennart Hoenen, Shuwei Jin, and Lauriane Chomaz — Physikalisches Institut, Ruprecht-Karls-Universität Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg, Germany

Ultracold quantum gases offer an excellent platform to study few- and many-body quantum phenomena with a remarkable level of control.

At the new group of Quantum Fluids in Heidelberg we are designing a novel experimental set-up focused on highly magnetic dysprosium atoms, with the aim to study the effect of competing long- and short-range interactions at the many-body level and in lower dimensional settings. With our unique combination of 2D and 3D magneto-optical traps, magnetic field coils, and various optical traps, we intend to achieve large quantum degenerate samples and to be able to adjust their confinement geometry and their interaction properties at will.

In order to achieve a 2-dimensional sample in the main experimental chamber, we plan to implement a dynamical optical trap - the accordion lattice. The interference pattern of two laser beams at a shallow angle, theta, creates a spatially periodic potential. Varying theta allows us to adjust both the fringe spacing and the confinement strength in the modulated direction. This scheme makes it possible to achieve a 2D regime with high efficiency and tuneability. At the Erlangen 22 conference, I will present the design and implementation of this accordion lattice.

A 29.10 Thu 16:30 P

Towards simulation of lattice gauge theories with ultracold ytterbium atoms in hybrid optical potentials — •Tim Oliver Hoehn[1,2], Etienne Staub[1,2], Guillaume Brochier[1,2], Clara Zoe Bachorz[1,2,3], David Gröters[1,2], Bharath Hebbe Madhusudhana[1,2], Nelson Darkwah Oppong[1,2], and Monika Aidelsburger[1,2] — [1]Ludwig-Maximilians-Universität München — [2]Munich Center for Quantum Science and Technology, München — [3]MPI für Quantenoptik, Garching

Gauge theories play a fundamental role for our understanding of nature, ranging from high-energy to condensed matter physics. Their formulation on a regularized periodic lattice geometry, so-called lattice gauge theories (LGTs), has proven invaluable for theoretical studies. However, as numerical simulations are limited in their capability to simulate, e.g., the real-time dynamics, there have been sustained efforts to develop quantum simulators for LGTs. We report on our recent progress on constructing a novel experimental platform for ytterbium atoms, which employs optical lattices and optical tweezers to engineer and probe LGTs. In contrast to other experimental realizations, this approach allows for a robust and scalable implementation of local gauge invariance. A central component enabling this favorable property are optical tweezer potentials operated at the tune-out wavelengths for the ground and clock state of ytterbium. Notably, optical potentials generated from light at these wavelengths could also find applications for digital quantum computation. We present our efforts towards precisely determining these wavelengths experimentally.

A 29.11 Thu 16:30 P

Investigating ultracold chemical processes with NaK molecules — •Jakob Stalmann, Jula Simone Morich, Kai Konrad Voges, and Silke Ospelkaus — Institute of Quantum Optics, Leibniz University Hannover

Ultracold ground-state molecular quantum gases yield highly complex and mostly unknown scattering behavior, ranging from the formation of long-lived collisional complexes to subsequent chemical reactions, photo-excitation or spontaneous spin relaxation.

Here, we present our approach for the detection of such quantum chemical reaction pathways by state-selective product ionization and VMI mass spectroscopy [1] with ultracold ^{23}Na^{39}K ground-state molecules. The chemically stable, lightweight NaK molecule is ideally suited for such investigations. Alongside deeper studies of ultracold collisions and reaction pathways, this approach will allow us to develop and implement new quantum control techniques for chemical reactions.

[1] Phys. Chem. Chem. Phys., 2020,22, 4861-4874

A 29.12 Thu 16:30 P

A moveable tuneout optical dipole trap for ultracold ^{6}Li in a ^{133}Cs BEC — •Robert Freund, Binh Tran, Eleonora Lippi, Michael Rautenberg, Tobias Krom, Manuel Gerken, Lauriane Chomaz, and Matthias Weidemüller — Physikalisches Institut, Ruprecht Karls University of Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg, Germany

The ultracold Bose-Fermi mixture of ^{133}Cs and ^{6}Li is an interesting system which can be used to study different few- and many-body phenomena. By immersing fermionic ^{6}Li impurities into a ^{133}Cs Bose-Einstein Condensate (BEC) the energy spectrum of quasiparticles namely Bose polaron can be mapped out. The large mass imbalance between Caesium and Lithium atoms is expected to give a signature of 3-body Efimov effect in the polaron spectrum. In order to obtain a clear polaron signal the optimization of the overlap between the two species in space and momentum is crucial. The Lithium is going to be trapped in a tightly confined optical dipole trap with a beam waist of around 10 μm to adapt to the size of the BEC. Moreover the trap is translatable both to compensate for the gravitational sag due to the large mass difference of the species and to store Lithium far away from Caesium during the preparation and cooling procedures. The trap runs at a tune-out wavelength of Caesium to reduce the influence of the trap on the potential landscape of the BEC as much as possible.

A 29.13 Thu 16:30 P

Towards Quantum Simulation of Light-Matter Interfaces with Strontium Atoms in Optical Lattices — •Valentin Klüsener[1,2], Jan Trautmann[1,2], Dimitry Yankelev[1,2], Annie J. Park[1,2], Immanuel Bloch[1,2,3], and Sebastian Blatt[1,2] — [1]MPQ, Hans-Kopfermann-Str. 1, 85748 Garching, Germany — [2]MCQST, Schellingstr. 4, 80799 München, Germany — [3]LMU, Schellingstr. 4, 80799 München, Germany

In the last two decades, quantum simulators based on ultracold atoms in optical lattices have successfully emulated strongly correlated condensed matter systems. With the recent development of quantum gas microscopes, these quantum simulators can now control such systems with single-site resolution. Within the same time period, atomic clocks have also started to take advantage of optical lattices by trapping alkaline-earth-metal atoms such as Sr, and interrogating them with unprecedented precision and accuracy. Here, we report on progress towards a new quantum simulator that combines quantum gas microscopy with optical lattice clock technology. We have developed in-vacuum buildup cavities with large mode volumes that will be used to overcome the limits to system sizes in quantum gas microscopes. In addition, we present precision spectroscopy of the ultra-narrow magnetic quadrupole transition $^1S_0 - {}^3P_2$ in Sr, which enables spatially selective addressing in an optical lattice. By combining these techniques with state-dependent lattices, we aim to emulate strongly-coupled light-matter-interfaces.

A 29.14 Thu 16:30 P

Magnetic-field-coils and 3D-MOT for novel dysprosium quantum gas experiment — •Joschka Schöner, Lennart Hoenen, Jianshun Gao, Christian Gölzhäuser, Karthik Chandrashekara, Valentina Salazar Silva, Shuwei Jin, and Lauriane Chomaz — Physikalisches Institut, Heidelberg, Germany

Ultra-cold atoms are one of the major platforms to study novel quantum phenomena due to their outstanding level of controllability. Highly magnetic atoms like Dysprosium show a long-range, anisotropic dipolar interaction, comparable in strength to the short-range contact interaction. These interactions can be precisely tuned by controlling the direction and strength of the applied magnetic fields.

At our new Quantum Fluids group in Heidelberg we aim to produce ultracold quantum gases of Dy to study exotic physical phenomena like supersolidity, topological ordering, and out-of-equilibrium physics emerging from competing dipolar and contact interactions and restricting the system to 2D. Our novel experimental platform relies on transferring Dy atoms from a 2D- to a 3D-MOT before loading them into an accordion lattice combined with an in-plane trap of tailorable geometry and a highly controllable magnetic-field environment.

I will report on our 3D-MOT and coil setup. The latter is made of 5 pairs of coils used to generate (1) gradient fields for the MOT, (2) homogeneous magnetic fields at the required strengths and orientations with fast response times. This is central to our quest to realize the promise of the outstanding level of controllability of the ultra-cold atom platform to investigate novel quantum phenomena.

A 29.15 Thu 16:30 P

Dipolar Supersolid States of Matter with Dysprosium — •Kevin Ng[1], Jan-Niklas Schmidt[1], Jens Hertkorn[1], Mingyang Guo[1], Sean Graham[1], Paul Uerlings[1], Ralf Klemt[1], Tim Langen[1], Martin Zwierlein[2], and Tilman Pfau[1] — [1]5. Physikalisches Institut and Center for Integrated Quantum Science and Technology, Universität Stuttgart — [2]MIT-Harvard center for Ulatracold Atoms, Research Laboratory of Electronics, and Department of Physics, MIT

Ultracold dipolar gases are an established platform to realize exotic states of matter due to the anisotropic and long-range dipolar interaction between atoms. Recently, supersolid states of matter which have both a superfluid nature and crystal-like periodic density modulation have been realized with ultracold dysprosium.

With a self-organized array of dipolar quantum droplets in one dimension, we demonstrate supersolidity of the droplet array from the coherent nature of these droplets and have observed the low energy goldstone mode that exists as a consequence of the systems superfluidity. We map out the elementary excitations of droplet arrays in one and two dimensions and study in-situ the density fluctuations at the superfluid-supersolid phase transition. A peak in the extracted static structure factor identifies the transition region and allows us to connect the crystallization mechanism of the droplet array to the emergence of low-lying angular roton modes. Furthermore, we theoretically predict supersolid phases beyond droplets in two dimensions at higher densities, where density saturation favours honeycomb and stripe phases.

A 29.16 Thu 16:30 P

Towards dark energy search using atom interferometry in microgravity — •Magdalena Misslisch[1], Holger Ahlers[2], Maike Lachmann[1], and Ernst Rasel[1] — [1]Institute of Quantum Optics, Hanover, Germany — [2]Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR) Institut für Satellitengeodäsie und Inertialsensorik, Hanover, Germany

Dark energy is estimated to represent around 70 % of the universe energy budget, yet its nature remains unknown. A possible solution for this problem is the proposed scalar chameleon field whose effects are hidden from usual high density probe particles due to a screening effect.

The project DESIRE (Dark energy search by atom interferometry in the Einstein-Elevator) aims to detect chameleon dark energy by atom interferometry in microgravity. In this experiment multi-loop interferometry with Rb-87 Bose-Einstein condensates will be performed to search for phase contributions induced by chameleon scalar fields shaped by a changing mass density in their vicinity [1]. Atoms traverse a periodic test mass designed in cooperation with the JPL while accumulating the signal within a multi-loop interferometer over several seconds. To reach these long interaction times the experiment will be performed in microgravity in the Einstein-Elevator, an active drop tower in Hanover.

[1] Sheng-wey Chiow und Nan Yu. "Multiloop atom interferometer measurements of chameleon dark energy in microgravity" doi: 10.1103/PhysRevD.97.044043, 2018

A 29.17 Thu 16:30 P

Excitation Spectra of Homogeneous Ultracold Fermi Gases — •René Henke, Hauke Biss, Niclas Luick, Jonas Faltinath, Lennart Sobirey, Thomas Lompe, Markus Bohlen, and Henning Moritz — Institute of Laserphysics, University of Hamburg, Luruper Chaussee 149, Gebäude 69, 22761 Hamburg, Germany

Understanding the origins of unconventional superconductivity has been a major focus of condensed matter physics for many decades. While many questions remain unanswered, experiments have found that the systems with the highest critical temperatures tend to be layered materials where superconductivity occurs in two-dimensional (2D) structures. However, to what extent the remarkable stability of these strongly correlated 2D superfluids is related to their reduced dimensionality is still an open question. In our experiment, we use dilute gases of ultracold fermionic atoms as a model system to directly observe the influence of dimensionality on strongly interacting fermionic superfluids. This poster presents our most recent work, where we measured the superfluid gap of a strongly correlated quasi-2D Fermi gas over a wide range of interaction strengths and compares the results to recent measurements in 3D Fermi gases as well as theoretical predictions.

A 29.18 Thu 16:30 P

RF and MW coils for experimental quantum simulators — •Hüseyin Yildiz, Tobias Hammel, Maximilian Kaiser, Keerthan Subramanian, Matthias Weidemüller, and Selim Jochim — Physikalisches Institut, Universität Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg (Germany)

To manipulate the spin degree of ultracold atoms we apply radio frequency (RF) and microwave (MW) magnetic fields. In current experiments it is challenging to realize magnetic field amplitudes that realize sufficiently large Rabi frequencies. It is therefore a major challenge to optimize magnetic field coil designs.

We present optimized and frequency-variable RF and MW coils for the excitation of different states in the Paschen-Back regime of ultracold Lithium-6 atoms and molecules. Fast and controlled changes in resonance frequency of RF and MW coils enable more flexible sequences and shorter sequence times.

A 29.19 Thu 16:30 P

A new apparatus for trapping single strontium atoms in arrays of optical microtraps — Tobias Kree, •Felix Rönchen, Jonas Schmitz, and Michael Köhl — Physikalisches Institut Bonn

We present the design and implementation of the vacuum system featuring a custom designed titanium vacuum chamber with optical access along six different axes. The apparatus offers space to incorporate two high-NA objectives (NA > 0.65) to manipulate and read out atoms cooled to the motional ground state. One of the two objectives is characterized and currently being installed. In addition we describe the sequence of cooling steps we implemented to rapidly cool thermal Strontium atoms to microkelvin temperatures. To produce optical dipole traps we set up and characterized a liquid-crystal based spatial light modulator. We are able to produce highly uniform one-, two- and three-dimensional geometries of hundreds of optical foci. The system will be integrated into the main experiment in the upcoming months. In the future the experiment will be used as a quantum simulator profiting from the powerful combination of high imaging efficiency and arbitrary arrangements of single atoms.

A 29.20 Thu 16:30 P

Quantum simulation of many-body non-equilibrium dynamics in tilted 1D fermi-hubbard model. — •Bharath Hebbe Madhusudhana[1,2], Sebastian Scherg[1,2], Thomas Kohlert[1,2], Immanuel Bloch[1,2], and Monika Aidelsburger[1] — [1]Ludwig-Maximilians-Universitat Munchen, Germany — [2]Max-Planck-Institut fur Quantenoptik, Garching, Germany

Thermalization of isolated quantum many-body systems is deeply related to redistribution of quantum information in the system. Therefore, a question of fundamental importance is when do quantum many-body systems fail to thermalize, i.e., feature non-ergodicity. A useful test-bed for the study of non-ergodicity is the tilted Fermi-Hubbard model. Here we experimentally study non-ergodic behavior in this model by tracking the evolution of an initial charge-density wave over a wide range of parameters, where we find a remarkably long-lived initial-state memory [1]. In the limit of large tilts, we identify the microscopic processes which the observed dynamics arise from. These processes constitute an effective Hamiltonian and we experimentally show its validity [2]. We show that in these simulations, our experiment surpasses the present-day computational limitation with $L_{exp} = 290$ lattice sites and evolution times up to 700 tunneling times. We use our experiment to benchmark a new efficient numerical technique to solve for the dynamics of many-body systems [3].

[1.] Sebastian Scherg et al. Nature Communications 12 (1), 1-8 [2.] Thomas Kohlert et al. arXiv:2106.15586 [3.] Bharath Hebbe Madhusudhana et. al. PRX Quantum 2, 040325.

A 29.21 Thu 16:30 P

Tunable Beyond-Ising Interactions in Tweezer Arrays by Rydberg Dressing — Lea Steinert, •Philip Osterholz, Arno Trautmann, and Christian Gross — Physikalisches Institut, Eberhard Karls Universität Tübingen, 72076 Tübingen, Germany

We report on a new experimental platform leveraging the long coherence times of a spin-1/2 encoded in the potassium-39 ground-state manifold and the tunability and versatility of interactions between atoms excited to Rydberg-states. We utilize an SLM to prepare an arrangement of optical tweezers, each occupied by a single atom. By off-resonantly coupling to the Rydberg manifold via a single photon transition, we are able to map tuneable angular- and distance-dependent XYZ-type interactions onto the spin-1/2 system. This approach paves the way not only to novel types of quantum magnets but together with the fast cycling time of ~1s it holds the promise to enable the measurement of new entanglement witnessing observables.

A 29.22 Thu 16:30 P

Multiloop functional renormalization group study of the Fermi polaron problem — •Marcel Gievers — Max Planck Institute for Quantum Optics, Garching, Germany

Imbalanced mixtures of strongly correlated fermions have been investigated both theoretically and experimentally for several decades. A single impurity immersed in a Fermi gas is subject to a transition from a bound molecule of two different fermion species to a so-called Fermi polaron where the impurity forms a quasiparticle with the surrounding fermions. We study the Fermi polaron problem theoretically in three dimensions in an experimentally more realistic setup where there is a finite density of the impurity particles. For this, we apply multi-loop functional renormalization group (mfRG) which is an extension of the conventional functional renormalization group equivalent to the diagrammatic parquet formalism. With this elaborate numerical method, we aim to provide more reliable theoretical predictions such as the lifetime of the polaron.