A 41: Poster Session IIIa

Time: Thursday 16:15–18:15 Location: Orangerie

A 41.1 Thu 16:15 Orangerie

Competing magnetic orders in the fermionic $SU(3)$ Hubbard model with non-Abelian gauge-fields — •Mohsen Hafez-Torbati and Walter Hofstetter — Goethe-Universität, 60438 Frankfurt am Main, Germany

Ultracold fermionic alkaline-earth atoms loaded into optical lattices provide a unique possibility to study not only exotic multi-flavour magnetism, valence-bond-solid states, and quantum spin-liquid phases but also the effect of spin-orbit coupling and the topological properties in multi-component fermionic systems. Here we present results on long-range magnetic order in the large-U limit of the $SU(3)$ fermionic Hubbard model under a uniform non-Abelian gauge field obtained by using the real-space implementation of dynamical mean-field theory. We show the competition between different two-sublattice and three-sublattice magnetic orders in the $SU(3)$ Hubbard model and discuss the effect of uniform non-Abelian gauge-fields on the emergence of exotic magnetism.

A 41.2 Thu 16:15 Orangerie

Studying ion-atom scattering in the ultracold regime with Rydberg molecules — •Nicolas Zuber, Thomas Schmid, Christian Veit, Thomas Dieterle, Christian Tomschitz, Robert Löw, and Tilman Pfau — 5. Physikalisches Institut & Center for Integrated Quantum Science and Technology (IQST), Universität Stuttgart, Germany

Using Rydberg molecules to study the ion-atom scattering extends the methods for observing ion-atom collisions to the ultracold quantum regime [1] so far not reached by the hybrid ion-atom-trap experiments. We present details about our new experimental setup with lithium and rubidium, which will allow us to photoassociate Rydberg molecules and start the ultracold ion-atom scattering event with a very fast two-photon ionization process. We aim to image the scattered wave packet with an ion microscope on our delay line detector to extract a scattering length. The ion microscope is composed of three electrostatic ion lenses providing a tuneable magnification. The field of view is 34 micrometer at the maximum magnification of 1000 with 25 micrometer depth of field and a spatial resolution below one micrometer. The temporal resolution of our detector is 100 ps with a single particle rate up to several MHz.

[1] T. Schmid et al.; *arXiv* 1709.10488 (2017).

A 41.3 Thu 16:15 Orangerie

Towards non-destructive, real-time tranport measurements of interacting fermions — •Hideki Konishi, Kevin E. Roux, Barbara Cilenti, and Jean-Philippe Brantut — Institute of Physics, École Polytechnique Fédérale de Lausanne, 1015 Lausanne, Switzerland

In recent years, it has become possible to investigate transport phenomena using cold atoms. Previous researches have realized the Landauer setup [1] and a quantum point contact [2] and observed quantized conductance [3] emerging in mesoscopic systems.

Since the detection method implied so far the destructive observation of atom number densities, measurements relied on comparing different samples. This makes the measurements sensitive to even very weak fluctuations in the atomic sample preparation. In order to achieve more precise measurements, we plan to implement quantum non-demolition measurements of the atomic current featuring cavity quantum electrodynamics for fermionic lithium-6 with a high-finesse optical cavity. We will continuously monitor either the change of atom numbers in one of the terminal resorvoirs or motions of atoms within mesoscopic transport channels [4] by phase sensitive detection of the cavity field. In the poster we will detail the non-destructive probing scheme and present the design of the experimental apparatus and the current status of the experiment.

[1] J.-P. Brantut *et al.*, Science **337**, 1069 (2012). [2] D. Husmann *et al.*, Science **350**, 1498 (2015). [3] S. Krinner *et al.*, Nature **517**, 64 (2015). [4] C. Laflamme *et al.*, Phys. Rev. A **95**, 043843 (2017).

A 41.4 Thu 16:15 Orangerie

Towards a shotnoise limited optogalvanic vapor cell — •Markus Fiedler[1,5], Johannes Schmidt[1,5], Ralf Albrecht[1,5], Patrick Schalberger[2,5], Holger Baur[2,5], Robert Löw[1,5], Harald Kübler[1,5], Denis Djekic[3,5], Jens Anders[4,5], Norbert Frühauf[2,5], and Tilman Pfau[1,5] — [1]5th Institute of Physics — [2]Institute for Large Area Microelectronics — [3]Institute for Microelectronics, University of Ulm — [4]Institute for Theory of Electrotechnology — [5]University of Stuttgart, Center for Integrated Quantum Science and Technology (IQST)

We show how we want to integrate a shotnoise limited ion current detection into an optogalvanic vapor cell. Such a device can be used as a sensitive detector for electric and magnetic fields as well as highly excited atoms and molecules. We excite Alkali Rydberg atoms in an electrically contacted vapor cell [1,2]. These atoms are ionized due to collisions with the background gas. A voltage directs these charges towards the electrodes on the inside of the cell, where they are detected with an amplification circuit. Those circuits need to provide stable, low noise amplification under changing environmental conditions. Circuits based on thin film [3] and CMOS [4] technology are proposed. Furthermore, a random sampling Lock-In method aimed at achieving high bandwidth is discussed.

[1] D. Barredo, et al., Phys. Rev. Lett. 110, 123002 (2013)
[2] R. Daschner, et al., Opt. Lett. 37, 2271 (2012)
[3] P. Schalberger, et al., JSID 19, 496-502 (2011)
[4] D. Djekic, et al., ESSCIRC 43, 1386 (2017)

A 41.5 Thu 16:15 Orangerie

Simulations for anisotropic superfluidity in a Dysprosium BEC — •Michael Eisenmann, Matthias Wenzel, Fabian Bötttcher, Jan-Niklas Schmidt, Tim Langen, Igor Ferrier-Barbut, and Tilman Pfau — 5. Physikalisches Institut and Center for Integrated Quantum Science and Technology, Universität Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany

One of the most remarkable effects in quantum mechanics, compared to classical systems, is the possibility of superfluid states, for example in ultra cold atom gases, characterized by the existence of frictionless irrotational flow.

This frictionless behaviour only appears below a certain, so called "critical", flow velocity. Another hallmark of superfluidity is the irrotationality of the flow, leading to the creation of vortices in a rotating superfluid.

Already known for decades in liquid helium, superfluid phenomena, like the critical velocity for vortex creation, have been observed in ultra-dilute superfluids of quantum degenerated gases.

In dipolar interacting systems the superfluidity acquires an anisotropic character, resulting in the systems critical velocity depending highly on the flow direction [1].

We are reporting on numerical simulations, allowing us to investigate the effects of anisotropic interactions on the critical flow velocity, as well as the density profile and the lattice structure of vortices in a Dysprosium Bose-Einstein condensate.

[1] Ticknor, et. al., Physical review letters 106, 065301 (2011)

A 41.6 Thu 16:15 Orangerie

Topological properties of interacting fermions in circularly shaken hexagonal optical lattices — •Tao Qin[1], André Eckardt[2], Alexander Schnell[2], Christof Weitenberg[3,4], Klaus Sengstock[3,4,5], and Walter Hofstetter[1] — [1]Institut für Theoretische Physik, Goethe-Universität Frankfurt, Germany — [2]Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Straße 38, 01187 Dresden, Germany — [3]Institut für Laserphysik, Universität Hamburg, 22761 Hamburg, Germany — [4]The Hamburg Centre for Ultrafast Imaging, 22761 Hamburg, Germany — [5]Zentrum für Optische Quantentechnologien, Universität Hamburg, 22761 Hamburg, Germany

Circularly shaken hexagonal optical lattices are a versatile platform to realize the Haldane model and study related topological properties. Two groups have realized the Haldane model experimentally with slightly different set-ups [1]. Using real-space Floquet dynamical mean field theory (DMFT) we study edge states and Laughlin charge pumping of fermions with the Falicov-Kimball type interaction in a cylinder structure of the hexagonal optical lattice, and their dependence on dissipation induced by an extra bath. We find that dissipation tends to smear out edge states and induce non-integer charge pumping for a system with high frequency circular shaking. Furthermore, we explore the possibility to restore integer charge pumping at low frequency driving or by introducing disorder.

[1] G. Jotzu *et al.*, Nature **515**, 237(2014); N. Fläschner *et al.*, Science **352**, 1091(2016)

A 41.7 Thu 16:15 Orangerie

Selfbound quantum droplets — •Jan-Niklas Schmidt, Matthias Wenzel, Fabian Böttcher, Michael Eisenmann, Tim Langen, 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 arising from anisotropic, long-range interactions. One example we have observed in our experiment with an ultra-cold quantum gas of Dysprosium is the self-organization similar to the Rosensweig instability in classical ferrofluids. This is observed as modulational instability when tuning the scattering length via narrow Feshbach resonances.

Furthermore we found that the product of the instability is an ensemble of self-bound droplets in a liquid state. This state can only be explained by beyond mean-field corrections arising from quantum fluctuations. In cylindrical harmonic traps, the existance of the modulational instability strongly depends on the trap aspect ratio. We obtain a critical point in the phase diagram representing the lowest trap aspect ratio for which this modulational instability is observed. For lower trap aspect ratios an adiabatic crossover between a BEC and a single droplet state takes place. These results are in good agreement with simulations of the extended Gross-Pitaevskii equation.

A 41.8 Thu 16:15 Orangerie

Towards BEC-borne two-species atom interferometry in space — •Maike D. Lachmann[1], Baptist Piest[1], Dennis Becker[1], Wolfgang Ertmer[1], Ernst M. Rasel[1], and QUANTUS Collaboration[1,2,3,4,5,6,7,8,9] — [1]Leibniz-Universität Hannover — [2]HU Berlin — [3]JGU Mainz — [4]ZARM Bremen — [5]DLR-RY — [6]DLR-SC — [7]FBH Berlin — [8]U Ulm — [9]TU Darmstadt

Tests of the universality of free fall using two-species atom interferometers in space are currently of large interest. By increasing the free evolution time in the interferometer due to the microgravity environment the sensitivity can be enhanced significantly. After the successful launch of the MAIUS-1 mission and the first demonstration of Bose-Einstein condensates in space we aim for two-species atom interferometers on the sounding rocket missions MAIUS-2 and -3. The new system contains, in addition to Rb-87, K-41 as second species and will utilize Raman double-diffraction as beam splitters. The poster will show the mission goals, the setup and the current progress on ground.

QUANTUS & MAIUS are supported by the German Space Agency DLR with funds provided by the Federal Ministry of Economics and Technology (BMWi) under grant numbers DLR 50WM 1131-1137.

A 41.9 Thu 16:15 Orangerie

Spectroscopy of Rydberg states in ultra cold ytterbium — •Christian Halter, Apoorva Hedge, Mustafa Jumaah, Christian Sillus, Thomas Burg, and Axel Görlitz — Heinrich-Heine-Universität Düsseldorf

Understanding the special features of Rydberg atoms, e.g. dipole-dipole interaction or van-der-Waals blockade, has become of utmost importance in quantum optics. Particularly ultra cold Rydberg atoms are of great interest for the investigation of long range interactions. Hence, in the present study, ultra cold ytterbium is spectroscopically investigated to gain precise knowledge on the Rydberg states. A special feature of ytterbium is that due to its two valance electrons atoms in Rydberg state can be easily manipulated and imaged using optical fields. For the above-mentioned spectroscopy an induced loss of atoms in a magneto-optical trap (MOT), that is caused by the Rydberg excitation, is used to detect the Rydberg states. Applying this method, we could measure several energy levels of Rydberg states in ultra cold ytterbium.

A 41.10 Thu 16:15 Orangerie

Quantum synchronisation in a bistable system — •Matthew Jessop, Andrew Armour, and Weibin Li — School of Physics and Astronomy, and Centre for the Mathematics and Theoretical Physics of Quantum Non-Equilibrium Systems, University of Nottingham, UK

Classically, two weakly coupled oscillators will lock their relative phase, i.e. the so-called phase synchronisation. In the quantum regime, however, the uncertainty principle requires that a probability distribution description must be instead used. We conduct a theoretical study of quantum synchronisation in a system of two trapped ions in an electric Paul trap. Vibrations (phonons) of each ion are laser cooled to the Lamb-Dicke regime. Using a driving laser, phonons are coupled to electronic states of the ion under a two-phonon resonance condition. When the laser driving strength is weak, phonon excitations are suppressed while a limit cycle is reached at strong driving. We find a bistable regime at the intermediate driving strength where the zero-phonon state and a limit cycle coexist. We explore the emergence of quantum synchronisation when two identical ions are coupled through dipole-dipole interactions. Specifically we focus on the bistable regime where the zero-phonon state and limit cycle synchronise in different ways, leading to distinct phase distributions.

A 41.11 Thu 16:15 Orangerie

Coupled anharmonic oscillators in a two-dimensional ion trap array — •Philip Kiefer, Frederick Hakelberg, Sebastian Schnell, Jan-Philipp Schroeder, Mathias Wittemer, Govinda Clos, Ulrich Warring, and Tobias Schaetz — Physikalisches Institut, Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg

We investigate trapped atomic ions as a platform for quantum simulations [1]. Although one-dimensional systems have delivered groundbreaking results, scaling to larger size and dimension presents a major challenge. We follow a bottom-up approach of single ions in individually controlled trapping sites generated by microfabricated two-dimensional trap arrays. Individually trapped ions represent a system of coupled oscillators, meditated by the Coulomb force, experimentally demonstrated in one-dimensional traps [2].

In our case, we use an equilateral triangular surface trap array, with an ion-ion distance of 40μm, providing individual control of motional mode orientation and frequencies at each site [3]. We show that a large coherent state, generated by a controlled motional excitation, exchanges its population with the other trapping sites. The coupling of the ions can be further controlled by anharmonic contributions of the trapping potential. Moreover we have developed a hybrid magnet setup enabling coherence times of electronic superposition states of greater than six seconds.

[1] New J. Phys. **15**, 085009 (2013)
[2] Nature **471**, 196-203 (2011)
[3] Nat. Com. **7**, 11839 (2016); Phys. Rev. A **94**, 023401 (2016)

A 41.12 Thu 16:15 Orangerie

Measurements of Motional Decoherence in 2D Ion Trap Arrays — •Sebastian Schnell, Frederick Hakelberg, Philip Kiefer, Jan-Philipp Schroeder, Mathias Wittemer, Govinda Clos, Ulrich Warring, and Tobias Schaetz — Atom-, Molekül- und optische Physik, Physikalisches Institut, Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg

Trapped ions present a promising system for quantum simulations [1]. In experiments with trapped ions motional coherence needs to be of an equal or larger time scale than typical experimental durations.

We investigate motional coherence times in a conventional Paul trap and a surface-electrode trap using different methods. We present experimental results for variable montional frequencies and excitation amplitudes from single quantum $|\alpha_0|^2 \propto$ 1-10 to $|\alpha_0|^2 \propto 10^3$. We further investigate real time manipulation of control potentials used for tuning of motional mode orientation and frequency [2].

[1] T. Schaetz, New J. Phys. **15**, 085009 (2013)
[2] M. Mielenz *et al.*, Nature Communications **7**, 11839 (2016)

A 41.13 Thu 16:15 Orangerie

Quantum criticality and the Tomonaga-Luttinger liquid in one-dimensional Bose gases — Bing Yang[1,2], Yang-yang Chen[3], Yong-guang Zheng[1,2], •Hui Sun[1,2], Han-ning Dai[1,2], Xi-wen Guan[3], Zhen-sheng Yuan[1,2], and Jian-wei Pan[1,2] — [1]Physikalisches Institut, Ruprecht-Karls-Universität Heidelberg, Im Neuenheimer Feld 226, Heidelberg, Germany — [2]University of Science and Technology of China, Hefei, China — [3]Wuhan Institute of Physics and Mathematics, Chinese Academy of Sciences, Wuhan, China

We experimentally investigate the quantum criticality and Tomonaga-Luttinger liquid (TLL) behavior within one-dimensional (1D) ultracold atomic gases. Based on the measured density profiles at different temperatures, the universal scaling laws of thermodynamic quantities are observed. The quantum critical regime and the relevant crossover temperatures are determined through the double-peak structure of the specific heat. In the TLL regime, we obtain the Luttinger parameter by probing sound propagation. Furthermore,a characteristic power-law behavior emerges in the measured momentum distributions of the 1D ultracold gas, confirming the existence of the TLL.

A 41.14 Thu 16:15 Orangerie

Two- and four-body spin-exchange interactions in optical lattices — •Bing Yang[1,2], Han-Ning Dai[1,2], Andreas Reingruber[1], Hui Sun[1,2], Yu-Ao Chen[2], Zhen-Sheng Yuan[2,1], and Jian-Wei Pan[2,1] — [1]Physikalisches Institut, Ruprecht-Karls-Universität Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg, Germany — [2]Hefei National Laboratory for Physical Sciences at Microscale and Department of Modern Physics, University of Science and Technology of China, Hefei, Anhui 230026, China

Ultracold atoms in optical lattices represent an ideal platform for modeling elementary spin interactions. Here we report on the observations of two- and four-body spin-exchange interactions in an optical superlattice. Using a spin-dependent superlattice, atomic spins can be coherently addressed and manipulated. Bell states are generated via spin superexchange process and their quantum correlations are detected. A minimum toric code Hamiltonian in which the four-body ring-exchange interaction is the dominant term, is implemented by engineering a Hubbard Hamiltonian in disconnected plaquette arrays. Our work represents an essential step towards studying topological matters with many-body systems and the applications in quantum computation and simulation.

A 41.15 Thu 16:15 Orangerie

Fast and high-fidelity motional control of trapped ions — •Jan-Philipp Schröder, Matthias Wittemer, Frederick Hakelberg, Henning Kalis, Manuel Mielenz, Govinda Clos, Ulrich Warring, and Tobias Schaetz — Albert-Ludwigs-Universität Freiburg, Germany

Laser-cooled ions, trapped in radio-frequency potentials, are promising candidates for experimental quantum simulations. In addition to the manipulation of their electronic states (pseudo spin), precise control of the motional states is crucial.
We report on experiments with Mg^+ ions in a linear rf Paul trap and a triangular surface-electrode trap. An arbitrary waveform generator based on a FPGA enables real-time control of the motional degrees of freedom within microseconds. To apply high-frequency waveforms while suppressing electric-field noise, which would lead to motional heating of the ions, we embed switchable low-pass filters. This allows us to create a short time window with higher cut-off frequencies and thereby faster response. Additionally, we compensate the low-pass properties by utilizing an inverse transfer function of the control circuitry's frequency response. These novel implementations may allow precise studies of phenomena like thermalization [1], quantum memory effects [2] and their time scales in isolated and open quantum systems.

[1] G. Clos et al., Phys. Rev. Lett. **117**, 170401 (2016)
[2] M. Wittemer et al., arXiv:1702.07518 (2017)

A 41.16 Thu 16:15 Orangerie

Rydberg atoms in frustrated optical lattices: numerical study of quantum phases emerging due to the long-range interaction — •Jaromir Panas[1], Andreas Geissler[1], Yongqiang Li[2], Weibin Li[3], and Walter Hofstetter[1] — [1]Goethe-Universität, 60438 Frankfurt am Main, Germany — [2]National University of Defence Technology, 410073 Changsha, P. R. China — [3]University of Nottingham, NG7 2RD Nottingham, United Kingdom

Recent experiments with ultracold Rydberg atoms have shown that the long-range interactions can give rise to spatially ordered structures. It seems that observation of such crystalline phases in a system with Rydberg atoms loaded into optical lattices is also within reach. For such a setup, theoretical studies have predicted a rich phase diagram. In particular, the existence of a series of supersolid and density wave phases with different spatial ordering has been shown for Rydberg atoms in a square lattice. Here we present results of numerical calculations performed for long-range interacting bosons in a triangular lattice. To find the relevant ordering structures, the "frozen"-gas approximation for a deep lattice potential is used. These structures are then investigated using the real-space bosonic dynamical mean-field theory.

A 41.17 Thu 16:15 Orangerie

Dynamical mean-field theory for dissipative ultracold Rydberg gases in optical lattices — •Arya Dhar, Jaormir Panas, Tao Qin, Andreas Geissler, and Walter Hofstetter — Institut für Theoretische Physik, Goethe-Universität, 60438 Frankfurt am Main, Germany

Rydberg-excited ultracold atoms have emerged in recent years as an efficient tool to engineer long-range interactions and simulate a variety of model Hamiltonians [1]. Theoretical studies of Rydberg-excited quantum gases in optical lattices have revealed a number of equilibrium crystalline quantum phases arising due to the competition between the different energy scales [2]. However, observation of these phases in experiments will be affected by dissipative processes such as spontaneous emission and dephasing. Our goal is to develop tools to study steady states and the corresponding non-equilibrium phase diagrams. A promising approach is to combine dynamical mean-field theory (DMFT) with the Lindblad formalism using the auxiliary master equation approach [3]. Here we report on our progress in adapting this method to study dissipative Rydberg-excited quantum gases in optical lattices.

[1] J. Zeiher *et al.*, Nature Physics **12**, 1095 (2016).
[2] A. Geißler *et al.*, PRA **95**, 063608 (2017).
[3] E. Arrigoni *et al.*, PRL **110**, 086403 (2013).

A 41.18 Thu 16:15 Orangerie

Single Rydberg Impurities immersed in a Bose-Einstein condensate — •Thomas Dieterle, Kathrin Kleinbach, Felix Engel, Carolin Dietrich, Robert Löw, Florian Meinert, and Tilman Pfau — 5. Physikalisches Institut, Universität Stuttgart

For a single Rydberg atom excited from a Bose-Einstein condensate typically thousands of ground-state atoms reside within the Rydberg electron orbit. The Rydberg electron interacts with these perturbers simultaneously via electron-neutral quantum scattering. This has pronounced effects on the excitation spectrum of the Rydberg atom, leading to line shifts and broadenings, which in turn provide information on the underlying scattering physics. Very recently, the problem has been interpreted as a novel and exotic type of mesoscopic polaron.

As such, it appears very appealing to not only study the excitation spectrum, but also investigate the effect of the impurity on the quantum phase and density distribution of the condensate. In our experiment, we combine high-resolution optical microscopy with control over giant Rydberg impurities with electron orbits reaching the micrometer scale. We will report on the status of our endeavor to exploit the impurity's backaction on the condensate for implementing microscopy of the Rydberg electron orbit.

A 41.19 Thu 16:15 Orangerie

Matter wave abberations in magnetic chip traps — •Srihari Srinivasan and Reinhold Walser — Institut fuer Angewandte Physik, TU Darmstadt

The first Bose-Einstein Condensate (BEC) and atom interferometry in space was reported in early 2017 by the MAIUS sounding rocket experiment [1,2]. The setup uses an atom chip magnetic trap to obtain a BEC. Magnetic chip traps tend to show anharmonicities as atoms are at a close range to conductors on the chip. These anharmonicities present challenges for the experiment sequence in the form of anisotropic expansion of the BEC which are matter wave analogues of optical aberrations, the resulting inhomogeneities in number density and as anomalous collective modes [3] during time dependent processes.
We characterize the anharmonicity of the chip trap using the excited collective modes. We also study the influence of non-adiabatic dynamics during trap manipulation in the experiment sequence in an effort to help suppress anomalous collective modes. This is done as part of a comprehensive simulation suite for an atom interferometer being developed for comparison with experimental data.

[1] MAIUS Mission: http://www.spiegel.de/wissenschaft/technik/bose-einstein-kondensat-erstmals-im-all-erzeugt-a-1131279.html
[2] A. Cho, Science, **357**(6355), 986 (2017).
[3] C. Huepe et al., PRA **68**, 023609 (2003), S. Ronen et al., PRA **74**, 013623 (2006).

A 41.20 Thu 16:15 Orangerie

Floquet state engineering in a periodically driven two-body quantum system — •Joaquín Minguzzi, Rémi Desbuquois, Michael Messer, Frederik Görg, Kilian Sandholzer, Gregor Jotzu, and Tilman Esslinger — Institute for Quantum Electronics, ETH Zurich, 8093 Zurich, Switzerland

Floquet engineering is a promising approach for the realization of novel phases of matter beyond the reach of static Hamiltonians. The challenge lies in finding out suitable protocols to prepare and characterize a particular Floquet state. Here, we use an ultracold fermionic gas in an optical lattice to experimentally explore different Floquet states in an interacting two-body Hubbard Hamiltonian where the site-to-site potential bias is periodically modulated. Whenever the driving frequency is higher than the energy scales of the underlying static Hamiltonian, we adiabatically connect to a Floquet state by simply ramping up the drive. This protocol is not appropriate in the near-resonant regime, where the driving strongly couples different states. Instead, we use a protocol that not only drives the system, but also changes the static Hubbard parameters. While time-averaged observables over one driving cycle are captured by an effective static Hamiltonian, we also detected the presence of micromotion in the resonantly-driven system. Our findings open up the possibility to explore Floquet engineering in a driven many-body quantum system.

A 41.21 Thu 16:15 Orangerie

Hole dynamics and bound states in a spin chain of Rydberg atoms — •Fabian Letscher[1], David Petrosyan[2], and Michael Fleischhauer[1] — [1]Department of Physics and Research Center OPTIMAS, University of Kaiserslautern, D-67663 Kaiserslautern, Germany — [2]Institute of Electronic Structure and Laser, FORTH, GR-71110 Heraklion, Crete, Greece

Spin lattice models play a central role in the studies of quantum magnetism and non-equilibrium dynamics of spin excitations. Here, we investigate the dynamics of 1D spin lattice models realized by coupling atomic ground states to high lying Rydberg states.

First, we discuss a chain of driven dissipative Rydberg superatoms, where each superatom consists of a mesoscopic ensemble of atoms. In the so called facilitation regime (off resonant excitation), a single superatom excitation triggers an excitation cascade of neighboring superatoms. We discuss the relaxation dynamics and show that the steady state resembles a hard rod liquid of holes - a nonexcited superatom surrounded by two excited ones. Second, we discuss the coherent dynamics of two Rydberg excitations immersed in a lattice of ground state atoms dressed to another Rydberg state. We show that the competition between van-der-Waals interaction and resonant dipole exchange interaction leads to the formation of mobile bound states of Rydberg excitations.

A 41.22 Thu 16:15 Orangerie

Self-organization in an opto-magnetically coupled quantum gas — •Nishant Dogra, Manuele Landini, Lorenz Hruby, Katrin Kröger, Tobias Donner, and Tilman Esslinger — Institute for Quantum Electronics, ETH Zurich, 8093 Zurich, Switzerland

We report on the observation of strong opto-magnetical effects on the self-organization of a degenerate atomic system coupled to a single-mode high-finesse optical cavity and subjected to an off-resonant pump field, propagating transversely to the cavity axis. The opto-magnetical effects are a result of multiple atomic transitions which gives rise to non-zero vectorial polarizability and hence spin dependent atom-cavity (vectorial) coupling. The relative strength of the vectorial coupling with respect to the scalar coupling can be tuned by the polarization of the pump field. We observe spin dependent self-organization threshold and phase of the scattered light in the organized phase as a function of pump field polarization. By starting with a mixture of two spin states, we identify two regimes. In the regime of strong scalar coupling, the self-organization process generates density modulations in the system. By increasing the strength of vectorial coupling beyond a critical point, we observe the appearance of a new self-organization pattern consisting of magnetization modulations, a spin texture. We locate the transition point by analysing the phase of the light scattered by the atoms in the organized phase. Our findings pave the way to the exploitation of opto-magnetic effects for generation of long-range magnetic interactions.

A 41.23 Thu 16:15 Orangerie

Mean-field phase diagram of ultracold bosons inside a cavity — •Lukas Himbert, Rebecca Kraus, Shraddha Sharma, Astrid Elisa Niederle, and Giovanna Morigi — Theoretische Physik, Universität des Saarlandes, D-66123 Saarbrücken, Germany

We study a system of ultracold atoms confined by a 2-dimensional optical lattice within a cavity and optomechanically coupled with the cavity mode of the same wavelength as the lattice. The dynamics is described by an extended Bose-Hubbard Hamiltonian with global-range interactions between the atoms. By applying a mean-field approximation, we numerically determine the ground state phase diagram in the grand canonical ensemble. We reproduce the phase diagram presented by Dogra et al. [PRA 94, 023632 (2016)] and identify a Mott insulator, a superfluid, a charge density wave, and a supersolid phase; the latter two exhibit checkerboard order favoured by the global interaction. Moreover, regions separating the superfluid and the supersolid phase exhibit discontinuous jumps of the density as a function of the chemical potential, suggesting a first-order transition. We then consider the inhomogeinity of a harmonic trap and determine its influence on the phase diagram.

A 41.24 Thu 16:15 Orangerie

Upgrade of the Giessen MaMFIT — Marc Keil[1], Stefan Schippers[1], •Alfred Müller[2], and Alexander Borovik Jr[1] — [1]I. Physikalisches Institut, Justus-Liebig-Universität Gießen — [2]Institut für Atom- und Molekülphysik, Justus-Liebig-Universität Gießen

A Main Magnetic Focus Ion Trap (MaMFIT), a compact tool for spectroscopy of highly-charged ions [1], has been recently installed in Giessen and has already been employed for investigation of dielectronic recombination in highly-charged iridium ions [2]. The original construction, however, permitted experimental access almost exclusively to the ions of the sputtered cathode material, which, presently, is iridium. The main reason for this restriction is the process of evaporative cooling [3]. We report on an upgrade of the MaMFIT in Giessen. A gas inlet system enabling fine-dosed supply of gaseous elements has been designed, built and installed. In addition, a system facilitating periodic dumping of the ion trap has been set up. These measures have greatly enhanced the versatility of the MaMFIT. Now, a much wider spectrum of elements can be accessed. Results of the reference measurements using highly-charged argon ions will be presented. [1] V. P. Ovsyannikov, (2014) arXiv 1403.2168. [2] A. Borovik, Jr et al., to be published. [3] M. B. Schneider, AIP Conf. Proc. 188 (1989) 158

A 41.25 Thu 16:15 Orangerie

Optical dipole trapping in a drop tower experiment — •Marian Woltmann[1], Christian Vogt[1], Sven Herrmann[1], Claus Lämmerzahl[1], and The PRIMUS-Team[1,2] — [1]Center of Applied Space Technology and Microgravity (ZARM), University of Bremen — [2]Institut für Quantenoptik, LU Hannover

The PRIMUS-project develops an optical dipole trap for the use in a dual species (Rb and K) atom interferometer under microgravity conditions. For this purpose a trapping laser with peak power of 10 W at a wavelength of 1960 nm is used in an experimental setup for the Bremen drop tower. Combining an optical dipole trap with a microgravity environment offers significant advantages over current approaches. A dipole trap is capable of trapping all mF-states and features a superior harmonicity of the trapping potential. The latter is especially important for an effective delta-kick collimation, needed for the preparation of BEC-clouds with particularly low effective temperatures. As the trap is solely based on optical interaction, Feshbach resonances will become feasible in microgravity. Within the PRIMUS-project the first ever optical dipole trap in microgravity was realised. In this manner our project also serves as a pathfinder experiment for further dipole trap based cold atom experiments in different microgravity environments. With our poster we will give an overview of the experiment and report on latest experimental results. The PRIMUS-project is supported by the German Space Agency DLR with funds provided by the Federal Ministry for Economic Affairs and Energy (BMWi) under grant number DLR 50 WM 1642.

A 41.26 Thu 16:15 Orangerie

Optical bistability in thermal Rydberg vapor — •Patrick Kaspar, Daniel Weller, Nico Sieber, Robert Löw, and Harald Kübler — 5. Physikalisches Institut, Universität Stuttgart, Deutschland

Vapor cells filled with thermal atomic gas are one promising building block for future applications in quantum communication and sensing [1]. It is therefore crucial to gain a fundamental understanding of all the physical effects happening inside such a cell when addressing the atoms with laser beams. One particularly interesting effect happens when exciting an atomic ensemble to Rydberg states: at large Rabi frequencies compared to the weak probe regime, the system undergoes a hysteresis in the absorption spectrum of an EIT-like excitation scheme [2]. Recently we have shown that dipolar interactions between Rydberg atoms can be ruled out as the origin of this bistability, and have placed Coulomb interactions in the focus of our research: due to the large polarizability of Rydberg states, ionized atoms nearby cause the required energy shift leading to the observed nonlinearity [3]. Here we present our measurement techniques to fully understand the mechanisms involved: a two-species EIT-spectroscopy in rubidium allows us to determine the electric fields present in the vapour cell during Rydberg excitation, and fluorescence detection enables us to study the significantly altered spectrum due to the presence of charged particles.

[1] Nature Physics 8, 819–824 (2012), arXiv:1709.00262(2017)
[2] Phys. Rev. Lett. 111 113901 (2013)
[3] Phys. Rev. A 94, 063820 (2016)

A 41.27 Thu 16:15 Orangerie

Quantum Simulation of Energy Transport with Rydberg Atoms — •Sayali Shevate[1], Tobias Wintermantel[1,2], Yibo Wang[1], and Shannon Whitlock[1,2] — [1]Institut de physique et de chimie des Matériaux de Strasbourg (IPCMS), University of Strasbourg, France 67200 — [2]Physikalisches Institut, Universität Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg

The transport of charge, energy and information is fundamental to the behavior of electronic materials, complex molecules (e.g. light harvesting complexes like Fenna-Matthews-Olson (FMO)) and information networks. Yet, it is still largely unknown which underlying properties of the system lead to the most efficient or robust transport, especially in the presence of quantum effects. Ultracold atoms excited to Rydberg states possessing strong dipolar interactions provide a unique platform for studying fundamental energy transport processes in a fully controllable environment. We propose a novel experimental system for exciting Rydberg atoms in tailored geometries capable of simulating energy transport with almost full control over spatially and temporally correlated disorder. This will provide a route to address how excitations migrate through quantum many-body system possessing non-trivial correlations and how spatially and temporally correlated noise can enhance the robustness and efficiency of energy transport in synthetic quantum systems.

A 41.28 Thu 16:15 Orangerie

Phasetransition of a Bose-Einstein condensate in an optical ring resonator with internal coupling — •Simon C. Schuster, Philip E. Wolf, Sebastian Slama, and Claus Zimmermann — Physikalisches Institut, University Tübingen

We investigate the dynamics of an atomic Bose Einstein condensate interacting with the light modes of a high-finesse ring resonator. Two counterpropagating longitudinal modes of the resonator are coupled by the atoms due to coherent light scattering. Previous work ([1],[2]) explored Collective Atomic Recoil lasing (CARL) and its threshold for various pump-resonator detuning. With our newly developed subrecoil resolving ring resonator we investigate the transition between the CARL-regime and a new steady state regime. This new regime emerges in the presence of additional coupling between the two counterpropagating modes. We present experimental evidence of the steady-state and determine the phase boundary for various internal coupling rates.

[1] D. Schmidt et al., Phys. Rev. Lett. 112, 115302 (2014)
[2] H. Tomczyk et al., Phys. Rev. A 91, 063837 (2015)

A 41.29 Thu 16:15 Orangerie

Autonomous thermal machine for amplification and control of energetic coherence — •Gonzalo Manzano[1,2], Ralph Silva[3], and Juan M. R. Parrondo[1] — [1]Departamento de Física Atómica, Molecular y Nuclear and GISC, Universidad Complutense Madrid, 28040 Madrid, Spain — [2]Instituto de Física Interdisciplinar y Sistemas Complejos IFISC (CSIC-UIB), Campus Universitat Illes Balears, E-07122 Palma de Mallorca, Spain — [3]Group of Applied Physics, University of Geneva, 1211 Geneva 4, Switzerland

We present a model for an autonomous quantum thermal machine comprised by two qubits that is capable of amplifying the coherence in a non-degenerate system by using only thermal resources. This novel method of coherent control allows for the interconversion between energy, both work and heat, and coherence. This model opens up new possibilities in the generation and manipulation of coherence by autonomous thermal machines.

A 41.30 Thu 16:15 Orangerie

Decoherence of Rydberg molecules — •Andrew Hunter, Alex Eisfeld, and Jan-Micheal Rost — Max Planck Institute for the Physics of Complex Systems

A Rydberg atom in the presence of a neutral perturber is investigated using scattering theory. Due to a negative s-wave scattering length at low energies these perturbers can form a bound state with the Rydberg atom, known as a trilobite molecule [1]. These molecules interact strongly with their environment due to their large polarisability or dipole moment [2]. In particular, we study such systems coupled to external environments and the decoherence that results. The prospect of interfacing these molecules with mesoscopic systems such as a moving mirror is then explored.

[1] C. H. Greene, A. S. Dickinson, and H. R. Sadeghpour, Phys. Rev. Lett. 85, 2458 (2000).
[2] P. J. J. Luukko and J. M. Rost, Phys. Rev. Lett. 119, 203001 (2017).

A 41.31 Thu 16:15 Orangerie

Quantum many-body physics under the microscope — •Simon Hollerith[1], Antonio Rubio Abadal[1], Johannes Zeiher[1], Jun Rui[1], Christian Gross[1], and Immanuel Bloch[1,2] — [1]Max-Planck-Institut für Quantenoptik, 85748 Garching, Germany — [2]Ludwig-Maximilians-Universität München, 80539 München, Germany

In our experiment we use a high-resolution objective in order to image and adress ultracold rubidium atoms trapped in a single layer of a three dimensional optical lattice with single-site resolution. Studying the relaxation dynamics of non-equilibrium states under the influence of site-dependent disorder created by our adressing light, we address questions around many-body-localization in two dimensions. Tuning our adressing beam to the magic wavelength where only one of the two spin states interacts with the light field, we study how the localized spins get affected by a thermal bath. In a second project, we use off-resonant coupling to Rydberg states - so called Rydberg dressing - in order to engineer long-range interacting ground state atoms. Using Ramsey sequences, we verify the realization of long-range interacting spin models by measuring spin-spin correlations as well as the total magnetization of our system for variable interaction times.