A 26: Poster V

Time: Wednesday 17:00–19:00 Location: Tent C

A 26.1 Wed 17:00 Tent C

Experiments on highly charged ions from S-EBIT II — •Rex Simon[1,2,3], Tino Morgenroth[1,2,3], Sonja Bernitt[1,2,3], Sergiy Trotsenko[2], Reinhold Schuch[1,4], and Thomas Stöhlker[1,2,3] — [1]Helmholtz Institute Jena, 07743 Jena, Germany — [2]GSI Helmholtzzentrum für Schwerionenforschung GmbH, 64291 Darmstadt, Germany — [3]IOQ, Friedrich-Schiller-University Jena, 07743 Jena, Germany — [4]Department of Physics, Stockholm University, 106 91 Stockholm, Sweden

Exploring electron-ion interaction reveals fundamental insights into atomic structures and plasma behaviours. Dielectronic recombination (DR) is one of the crucial processes determining ion charge state balance. This knowledge not only enhances theoretical understanding but is vital for accurate plasma diagnostics[1]. The electron beam ion trap S-EBIT II at the HITRAP ion trapping and cooling facility will serve not only as an exceptional ion source but also operate autonomously, making it a versatile tool for various experiments such as cutting-edge experiments with extracted highly charged ions for measurements of charge-changing processes, notably DR. Integration with the HITRAP beam line, addresses the dynamic requirements of evolving experimental research.

References [1] Beilmann, C. et al. (2013). Multielectronic K-L intershell resonant recombination in Ar, Fe, and Kr ions. Phys. Rev. A, 88(6), 062706.

A 26.2 Wed 17:00 Tent C

Towards a potassium quantum gas miscroscope — •Scott Hubele[1,2], Martin Schlederer[1,2], Alexandra Mozdzen[1,2], Guillaume Salomon[1,2], and Henning Moritz[1,2] — [1]Institute for Quantum Physics, University of Hamburg, Hamburg, Germany — [2]Hamburg Centre for Ultrafast Imaging, University of Hamburg, Hamburg, Germany

Understanding many-body quantum systems, both in and out of equilibrium, is often computationally challenging due to the large Hilbert space of the systems of interest. This makes quantum simulation very attractive, especially when the relevant observables and their correlations can be measured directly. The Bose-Hubbard model for instance, which describes interacting bosons in lattices, can be well simulated using ultracold atoms loaded into optical lattices. High-resolution imaging can then be used to resolve the occupation of each lattice site, in what is known as a quantum gas miscroscope.

Here, we present our progress towards building a quantum gas microscope using ultracold potassium-39, to study the Bose-Hubbard model in 2D. We create an interfering 2D optical lattice by sending a single 1064nm beam twice through the science chamber at orthogonal angles, and retroreflecting it. A shallow angle vertical lattice is used to confine the atoms along the z direction. After some time evolution, a high-NA objective will then used to collect fluorescence from the atoms using Raman sideband imaging. Characterization of our optical lattices is presented as well as progress towards single-site resolved imaging.

A 26.3 Wed 17:00 Tent C

Microwave control of Rydberg pair states — •Shuanghong Tang, Fabio Bensch, Philip Osterholz, Lea-Marina Steinert, Arno Trautmann, and Christian Gross — Eberhard Karls Universität, Tübingen, Germany

Quantum simulator based on Rydberg atoms is a powerful tool to study quantum many-body behaviors. An experimental system with single potassium-39 atoms placed in 2D arrays of optical tweezers with sophisticated resorting algorithm allows us to use microwave to control the interactions of defect-free Rydberg atom array. Here, we present our two-photon excitation scheme and the microwave engineering potential of Rydberg states. With the implementation of the microwave, we are able to couple the different Rydberg states and engineer the potential between them.

A 26.4 Wed 17:00 Tent C

Penetration of s-holes via VU-LVa light — •Annbuhlika kom Fan, Claire Anlage, Andi Macht, and Balude Erbeer — Mahatma University of Fake, Chennai Street 5

In past VU-LVa light as shown great performance of stripping s-holes of various elements from light metals to heavy interacting species. Compared to UV its complicated but more successful in penetrating s-holes as will be presented. Generation, propagation and annhilation of VU-LVa light is discussed in the progress of s-holes penetration is shown via an Iron-Y2-system. Possibillity of use in Gl0-RY hole mechanism is discussed.

A 26.5 Wed 17:00 Tent C

The way towards low-energy, heavy, highly charged ions: the Hitrap deceleration facility — •Nils Stallkamp for the Hitrap-Collaboration — GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt — Institut für Kernphysik, Goethe Universität Frankfurt am Main

The HITRAP facility, located at the GSI Helmholtzzentrum für Schwerionenforschung in Darmstadt, is designed to decelerate and cool heavy, highly charged ions (HCI) created by the GSI accelerator complex and make them accessible at low energies for precision experiments. The system consists of a two-stage deceleration structure, an interdigital H-type linac (IH) and a radio-frequency quadrupole (RFQ), followed by a cryogenic Penning-Malmberg trap for subsequent ion cooling. The deceleration stages reduce the ion energy from 4 MeV/u to 500 keV/u and to 6 keV/u respectively, before forwarding a slow, but hot ion bunch towards the cooling trap. The trap is operated in a so-called nested configuration, in which the electrons, created by an external photo-electron source, are stored simultaneously with the HCI and serve as cold thermal bath.

Recently, the first indications of electron cooling of locally-produced HCI in a Penning trap could be achieved, a major milestone towards heavy HCI at eV and sub-eV energies. We will present the current status of those measurements as well as upcoming steps for further systematic studies of the cooling process.

A 26.6 Wed 17:00 Tent C

ORKA - Design of a cavity enhanced optical dipole trap for the preparation of a Rb87 BEC — •Marius Prinz, Jan Eric Stiehler, Marian Woltmann, and Sven Herrmann — Center of Applied Space Technology and Microgravity (ZARM), University of Bremen, Germany

The LASERs commonly used in optical traps for evaporative cooling to prepare ultra-cold atoms and generate BECs usually come with the downside of a high power budget. A more energy efficient and compact solution for optical dipole traps is to resonantly enhance a low-power trapping laser in a bow tie cavity. In the ORKA project we aim to exploit this to generate a crossed optical dipole trap for preparation of a Rb87 BEC with an input laser power <50 mW. This allows for an experimental setup with a reduced space- and power-budget as compared to commonly used dipole traps, so it can be used for matter-wave-interferometry and microgravity experiments at the Bremen Gravitower Pro. Here we present the properties of our bow tie cavity and the experiment design compatible with the constraints of operation in a drop tower capsule. Our simulations predict an optical dipole trap suitable for BEC preparation with an input power <10 mW using a bow tie cavity with a finesse of >15k for both 780nm and 1064nm. The ability to manipulate the atoms with near resonant light inside the cavity opens up a further avenue for interesting future research. The ORKA project is supported by the German Space Agency DLR with funds provided by the Federal Ministry for Economic Affairs and Climate Action under grant number DLR 50 WM 2267.

A 26.7 Wed 17:00 Tent C

Data analysis solution for axion dark matter research — •Yuzhe Zhang[1], Julian Walter[1], and Declan Smith[2] for the CASPEr-Collaboration — [1]Helmholtz-Institut, GSI Helmholtzzentrum fuer Schwerionenforschung, 55128 Mainz, Germany — [2]Department of Physics, Boston University, Boston, MA 02215, USA

Axions, originally proposed as a solution to the strong-CP problem, have become a dark matter candidate. Theory predicts that the axion field has three kinds of non-gravitational couplings to standard-model particles: the axion-photon, axion-gluon and axion-fermion couplings. These couplings will generate characteristic signals in axion haloscopes. Here, we present the data analysis procedure used in two experiments: Search for Halo Axions with Ferromagnetic Toroids (SHAFT) [1] and Cosmic Axion Spin Precession Experiment (CASPEr) [2]. The analysis not only includes commonly-used signal processing techniques, but also takes advantage of the expected axion lineshape to further increase the signal-to-noise ratio. This work is of potential interest to general axion and other exotic physics research since the data analysis procedure can be tailored to different experiments by specifying the expected signal*s spectral signature.

[1] A. V. Gramolin, D. Aybas, D. Johnson, J. Adam, A. O. Sushkov, Nature Physics 2021, 17, 1 79.

[2] D. Budker, P. W. Graham, M. Ledbetter, S. Rajendran, A. O. Sushkov, Phys. Rev. X 2014, 4.

A 26.8 Wed 17:00 Tent C

Rymax one: A neutral atom quantum processor to solve optimization problems — Tobias Ebert[1], •Jonas Witzenrath[2], Benjamin Abeln[1], Silvia Ferrante[1], Kapil Goswami[1], Jonas Gutsche[2], Hendrik Koser[1], Rick Mukherjee[1], Jens Nettersheim[2], Jose Vargas[1], Niclas Luick[1], Thomas Niederprüm[2], Dieter Jaksch[1], Henning Moritz[1], Herwig Ott[2], Peter Schmelcher[1], Klaus Sengstock[1], and Artur Widera[2] — [1]University of Hamburg, 22761 Hamburg, Germany — [2]RPTU Kaiserslautern-Landau, 67663 Kaiserslautern, Germany

From efficient distribution of workload in industrial manufacturing plants to short vehicle routes for parcel delivery - computationally hard optimization problems are a crucial part of our modern society. While finding solutions using classical solvers requires substantial computational resources, quantum processors promise to yield better solutions in less time.

To explore the potential of quantum computing for real-world applications we are building Rymax One (www.rymax.one), a quantum processor specifically designed to solve hard optimization problems. By using ultracold neutral Ytterbium atoms trapped in arbitrary arrays of optical tweezers, we aim for hardware-efficient encoding of optimization tasks. The level structure of ^{171}Yb provides qubit realizations with long coherence times, Rydberg-mediated interactions and high-fidelity gate operations, allowing us to realize a scalable platform for quantum processing. On that we will explore the performance of novel quantum algorithms to tackle real-world problems.

A 26.9 Wed 17:00 Tent C

Towards Spin-Resolved Single Atom Detection in Disordered Many-Body Rydberg Systems — •Valentina Salazar Silva, Eduard Braun, Sebastian Geier, Gerhard Zürn, and Matthias Weidemüller — Physikalisches Institut, Heidelberg, Deutschland

Rydberg systems remain a key tool in many areas of research due to their unique properties arising from highly excited electronic states. The mapping of many-body spin systems onto tunable Rydberg states has so far allowed for the observation of unique phenomena, such as the stretched relaxation dynamics of disordered spin systems on intermediate timescales, which cannot be accurately described by mean-field theory. These findings could be explained by an emergent integrability, where the dynamics are governed by pairs composed of nearest neighbor spins. Until now, all the diagnostics have been based on measuring average quantities like densities and magnetization. The next step, building upon our latest results, is to study this emergence of integrability at a microscopic level by enabling local access to pair-correlations. The spatial and spin resolution of single atoms can be achieved by adapting a standard fluorescence imaging scheme, as it has been demonstrated for localized Lithium atoms in a two-dimensional plane. In the case of the heavier Rubidium atoms and under similar conditions, we expect a significant performance improvement. Here we discuss the theoretical calculations and first considerations for the designing of an efficient fluorescence imaging setup, taking direct advantage of the Rydberg-manifold, as well as necessary adaptations for the resolving of correlation functions.

A 26.10 Wed 17:00 Tent C

High-performance optical clocks based on ^{171}Yb$^+$ — Martin Steinel, Melina Filzinger, •Saaswath JK, Jian Jiang, Ekkehard Peik, and Nils Huntemann — Physikalisch-Technische Bundesanstalt, Braunschweig, Germany

Optical clocks based on narrow-linewidth electronic transitions of trapped ions are employed in various high-precision experiments probing the limits of our current understanding of physics. The ^{171}Yb$^+$ ion is particularly suited to these measurements, because it provides two transitions with large sensitivity to variations of fundamental constants and low sensitivity to external perturbations. Comparisons of its $^2S_{1/2} - {}^2D_{3/2}$ electric quadrupole (E2) and $^2S_{1/2} - {}^2F_{7/2}$ electric octupole (E3) transition currently provide most stringent limits on potential variations of the fine structure constant and constrain the coupling between normal matter and ultra-light dark matter.

The systematic uncertainty of high-performance ^{171}Yb$^+$ optical clocks operated at room temperature has so far been limited by the uncertainty in the sensitivity of the transitions to thermal radiation $\Delta\alpha$. For the ^{88}Sr$^+$ ion, $\Delta\alpha$ has been measured with significant lower uncertainty. We employ this by using the ^{88}Sr$^+$ as a temperature sensor and determine it's clock transition frequency with record accuracy. In addition, we calibrate the intensity of an infrared laser with a single ^{88}Sr$^+$ ion. Measurements of the induced frequency shift of an ^{171}Yb$^+$ ion at the same position in the beam provides the corresponding $\Delta\alpha$. This way, we largely reduce the uncertainty achievable with ^{171}Yb$^+$ ion clocks.

A 26.11 Wed 17:00 Tent C

Quantum Monte Carlo simulations of hardcorde bosons with repulsive dipolar density-density interactions on two-dimensional lattices — •Robin Rüdiger Krill[1,2], Jan Alexander Koziol[2], Calvin Krämer[2], Anja Langheld[2], Giovanna Morigi[1], and Kai Phillip Schmidt[2] — [1]Theoretical Physics, Universität des Saarlandes, 66123 Saarbrücken, Germany — [2]Department of Physics, Friedrich-Alexander-Universität Erlangen-Nürnberg, Staudtstraße 7, Germany

We apply stochastic series expansion quantum Monte Carlo simulations to determine ground-state properties of frustrated long-range hardcore Bose-Hubbard lattice models in two dimensions. Recent investigations of such systems with mean-field approaches indicate rich quantum phase diagrams including a devil's staircase of solid phases and a plethora of exotic lattice supersolids [1,2]. The quantum Monte-Carlo approach allows us to extend this mean-field study by fully incorporating quantum fluctuations, and thus to analyse the interplay among frustration, long-range interactions, and quantum fluctuations.

[1] J.A Koziol, A.Duft, G.Morigi, K.P. Schmidt, SciPost Phys. 14, 136 (2023)

[2] J.A Koziol, G.Morigi, K.P. Schmidt, arXiv:2311.10632 (2023)

A 26.12 Wed 17:00 Tent C

Signatures of IR-laser dressing in coherent diffractive imaging — •Tom von Scheven, Björn Kruse, Bjarne Mergl, Christian Peltz, and Thomas Fennel — Institute of Physics, University of Rostock, Albert-Einstein-Str. 23-24, D-18059 Rostock, Germany

Single-shot coherent diffractive imaging (CDI) enables the capture of a full diffraction image of a nanostructure using a single flash of XUV or X-ray light. The resulting scattering image encodes both the geometry and the optical properties of the target. So far, this method has mainly been employed for ultrafast structural characterization [1]. However, CDI can also be utilized to resolve ultrafast optical property changes caused by e.g. transient excitation from nonlinear scattering [2], or by illumination with a second ultra-short laser pulse.

Here, we explore the expected signatures for the latter case theoretically, where simultaneous exposure to a strong IR field can induce transient optical properties. To this end, the effective optical properties emerging from the laser dressing must be determined and used to describe the resulting scattering process, which we model using the well-known Mie-solution. We extract the effective optical properties from the dipole response of a local quantum description based on an atom-like solution of the time-dependent Schrödinger equation. The identification of the states and processes responsible for these properties and the corresponding features in the diffraction image is performed by a systematic comparison with results for a few-level system.

[1] I. Barke *et al.*, Nat. Commun. **6**, 6187 (2015)

[2] B. Kruse *et al.*, J. Phys.: Photonics **2**, 024007 (2020)

A 26.13 Wed 17:00 Tent C

Exploration of Supersolidity in Spin-Orbit Coupled Bose-Einstein Condensates — •Sarah Hirthe, Vasiliy Makhalov, Rémy Vatré, Craig Chisholm, Ramón Ramos, and Leticia Tarruell — ICFO - The Institute of Photonic Sciences, Castelldefels, Spain

A Supersolid is an exotic phase of matter that combines seemingly opposing characteristics of solids and superfluids. It displays spontaneous translational symmetry breaking manifesting in crystalline order, while also possessing superfluid properties like frictionless flow. Although originally predicted over fifty years ago in the context of solid Helium, supersolidity was first observed only few years ago using ultracold atoms. In these systems, various approaches like cavitymediated interactions, dipolar interactions, or optically induced spin-orbit coupling can cause the spontaneous breaking of translational symmetry. Here, we characterize supersolidity in a spin-orbit coupled Bose-Einstein condensate of potassium. This dressed system displays an engineered single-particle dispersion relation with two minima at distinct momenta. Matter-wave interference between the condensates in the two minima gives rise to a density modulation, thus realizing the so-called supersolid stripe phase. We are able to observe this spontaneous stripe pattern in-situ, by employing a matter-wave lensing technique to magnify the density. Furthermore, we characterize the collective modes of our system. In particular, we observe a softening of the spin dipole mode for increasing coupling strength.