A 15: Poster I

Time: Tuesday 17:00–19:00 Location: Tent A

A 15.1 Tue 17:00 Tent A

Relaxation in dipolar spin ladders — •Gustavo Dominguez[1], Luis Santos[1], Thomas Bilitewski[2], David Wellnitz[3], and Ana Maria Rey[3] — [1]Leibniz University, Hannover, Germany — [2]Oklahoma State University, Oklahoma, USA — [3]University of Colorado, Boulder, USA

Ultracold dipolar particles pinned in optical lattices or tweezers provide an excellent platform for studying out-of-equilibrium quantum magnetism with dipole-mediated couplings. Starting with an initial state in which spins of opposite orientations are prepared in each of the legs of a ladder lattice, we show that spin relaxation displays an unexpected dependence on inter-leg distance and dipole orientation. This dependence, stemming from the interplay between intra- and inter-leg interactions, results in three distinct dynamical regimes: (i) ergodic, characterized by the fast relaxation towards equilibrium of correlated pairs of excitations generated at exponentially fast rates from the initial state; (ii) metastable, in which the state is quasi-localized in the initial state and only decays in exceedingly long timescales, resembling false vacuum decay; and, surprisingly, (iii) partially-relaxed, with coexisting fast partial relaxation and partial quasi-localization. Realizing this intriguing dynamics is at hand of current state-of-the-art experiments in dipolar gases

A 15.2 Tue 17:00 Tent A

Nonlinear interference and electron dynamics: Probing photoelectron momentum distribution in strong-field ionization — •Danish Furekh Dar[1,2] and Stephan Fritzsche[1,2] — [1]Helmholtz Institute Jena, Fröbelstieg 3, 07743 Jena, Germany — [2]Friedrich-Schiller-Universität Jena

Nonlinear interference in the interaction of intense laser pulses with atoms profoundly affects the photoelectron momentum distribution (PMD). We theoretically show that the interference pattern in the PMD arises from the interaction of electron with the fundamental frequencies concealed within the pulse. Nonlinear interference also imprints distinctive features on the ionization spectrum, providing valuable information about electron dynamics and phase relationships within the laser pulse. Additionally, the augmentation of optical cycles induces a distinct confinement in the PMD.

A 15.3 Tue 17:00 Tent A

Photonic Insights into Tissue Thermal Responses: A Numerical Analysis Based on a Two-Temperature Model (TTM) — •Hristina Delibašić Marković[1], Violeta Petrović[1], Konstantinos Kaleris[2,3], and Ivan Petrović[4] — [1]Faculty of Science, University of Kragujevac, Radoja Domanovića 12, 34000 Kragujevac, Serbia — [2]Institute of Plasma Physics and Lasers, Hellenic Mediterranean University, Tria Monastiria, 74100 Rethymo, Greece — [3]Physical Acoustics and Optoacoustics Laboratory, Music Technology and Acoustics Dept., Hellenic Mediterranean University, 74100 Rethymno, Greece — [4]Academy of Professional Studies Šumadija, Department in Kragujevac, Serbia

In this research, we investigate the thermal response of tissue to intense laser pulses using the two-temperature model. This model is pivotal for analyzing heat conduction in both vascular and extravascular regions, crucial in laser-tissue interaction studies. It effectively differentiates between blood and tissue temperatures, incorporating a coupling factor and phase lag times essential for accurate predictions under laser exposure. These parameters are closely linked to the physical properties of blood and tissue, the convective heat transfer coefficient, and the blood perfusion rate. Employing the finite difference method, we address this complex problem, and our findings elucidate the tissue's thermal behavior during laser interaction and its susceptibility to optical breakdown. This work significantly contributes to our understanding of laser-tissue dynamics, offering important insights in the field of atomic and molecular physics.

A 15.4 Tue 17:00 Tent A

Entanglement created in ultracold collisions: a realistic model study — •Yimeng Wang, Karl P. Horn, and Christiane P. Koch — Fachbereich Physik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany

Despite being one of the most common and straightforward ways of generating entanglement between two particles, the creation of entanglement in collisions has never been comprehensively studied beyond 1D or toy models. Here, we seek to quantify the degree of entanglement generated in ultracold atomic collisions by computing the inter-particle purity, focusing first on the motional degree of freedom. As the entanglement generated in collisions depends rather sensitively on the initial conditions, we consider two elongated Gaussian wave packets as pre-collision states, whose shapes are determined by the uncertainty of the transverse and longitudinal momenta, to model the realistic experimental settings as possible. Apart from the initial conditions for the particle motion, we study how the partial-wave scattering phase shifts, the energy derivative of which signals a resonance state, influence the degree of entanglement.

A 15.5 Tue 17:00 Tent A

Central energy shift in two-photon ionization process — •Hao Liang and Jan-Michael Rost — Max-Planck-Institut für Physik komplexer Systeme, Dresden, Germany

In photo-ionization process, the energy of photoelectron is equal to photo energy minus ionization potential. However, if the photon has a finite spectrum width, there would be an additional negative shift for the central energy of photoelectron respect to that of photo spectrum due to the decreasing photo-ionization cross section. Such shift is not easy to be observed in usual scheme. Here we proposed that one can measure it with reconstruction of attosecond harmonic beating by interference of two-photon transition techniques (RABBITT) for two-photon ionization process. By numerically solving the time-dependent Schrödinger equation, we found such central energy shift changes for different phase delays, spectrum width ratios and intensity ratios. With the two-photon perturbative theory, one can understand those phenomenon quantitatively. Finally, we found that the measurement of energy shift provides a way to determine two independent ionization time-delays in two-photon ionization process.

A 15.6 Tue 17:00 Tent A

Towards quantum logic spectroscopy of heavy few-electron ions — •Peter Micke[1,2,3], Zoran Andelkovic[2], and Thomas Stöhlker[1,2,3] — [1]Helmholtz Institute Jena — [2]GSI Helmholtz Center for Heavy Ion Research, Darmstadt — [3]Institute of Optics and Quantum Electronics, Friedrich Schiller University Jena

Heavy highly charged ions (HCI), e.g. hydrogen-like or lithium-like ions, have forbidden optical transitions in their ground-state hyperfine structure and feature the strongest electromagnetic fields to which we have access in a lab on earth. Therefore, these optical transitions are excellent probes for tests of fundamental physics and offer enhanced sensitivities to search for physics beyond the standard models of particle physics and cosmology. Furthermore, many systematic shifts of these transitions are highly suppressed, making heavy HCI ideal systems for the use in novel high-accuracy optical atomic clocks.

Upon recent advances in precision spectroscopy [1] and clock operation [2] with medium-light HCI of intermediate charge state ($^{40}Ar^{13+}$), we are setting up a unique and versatile spectroscopy platform at the HITRAP facility of GSI which combines the powerful heavy-ion accelerators with quantum logic spectroscopy in a cryogenic Paul trap. This will enable frequency metrology of heavy HCI, such as $^{207}Pb^{81+}$ with a clock transition at 1019.7 nm. The state-of-the-art uncertainty can be improved by many orders of magnitude and unprecedented tests of atomic, nuclear, and fundamental physics become available.

[1] P. Micke et al., *Nature* **578**, 60–65 (2020), [2] S. A. King et at. *Nature* **611**, 43–47 (2022). — PhD positions available! —

A 15.7 Tue 17:00 Tent A

Isotope shift measurements in a calcium beam clock — •Andreas Reuss, Anica Hamer, Lukas Möller, David Röser, Frederick Wenger, and Simon Stellmer — Physikalisches Institut, Universität Bonn

In the quest for finding new physics beyond the standard model, the research on isotope shifts in atomic transitions is a promising field for finding potential new interactions between electrons and neutrons, described by a novel force carrier boson.

Calcium is an excellent candidate for finding such new physics interactions with spectroscopic methods, due to its large number of stable isotopes and small nuclear deformations.

In our research we will employ a calcium beam clock using a Ramsey Bordé spectroscopy scheme, utilizing the $S_0 - P_1$ (657nm) and the $S_0 - D_2$ (458nm) clock transitions.

A 15.8 Tue 17:00 Tent A

Multi-Sideband RABBIT in Atoms and Molecules — •Divya Bharti[1], Hemkumar Srinivas[1], Farshad Shobeiry[1], Kathryn Hamilton[2], Robert Moshammer[1], Thomas Pfeifer[1], Klaus Bartschat[3], and Anne Harth[1,4] — [1]Max-Planck-Institute for Nuclear Physics, Heidelberg, Germany — [2]Department of Physics, University of Colorado Denver, Denver, Colorado, USA — [3]Department of Physics and Astronomy, Drake University, Des Moines, USA — [4]Department of Optics and Mechatronics, Hochschule Aalen, Aalen, Germany

We present findings derived from measuring three-sideband (3-SB) RABBIT (Reconstruction of Attosecond Beating by Interference of Two-Photon Transition) in atoms and molecules. RABBIT utilizes an XUV pulse train to induce ionization, while an IR pulse interacts with the subsequent photoelectrons. In the 3-SB RABBIT setup, interactions with IR photons generate three sidebands positioned between consecutive harmonics. This configuration allows us to explore phases resulting from the interference between transitions of different orders in the continuum. These phases remain independent of any chirps in the harmonics, and we investigate this by comparing RABBIT phases extracted from specific sideband groups formed by adjacent harmonics. Additionally, we explore cases where the oscillation in the sidebands involves intermediary resonance states.

A 15.9 Tue 17:00 Tent A

Diffusion of single ultracold atoms in an accelerated optical lattice — •Silvia Hiebel, Daniel Adam, Florian Schall, Sabrina Burgardt, Julian Fess, and Artur Widera — Department of Physics and Research Center optimas, University of Kaiserslautern-Landau, Erwin Schrödinger Str. 46, 67663 Kaiserslautern, Germany

Diffusion is a transport phenomenon that appears as a fundamental process in almost all physical systems, ranging from subdiffusion to hyperballistic diffusion, depending on the external parameters. In addition to the properties of the bath or the diffusing particle, the diffusion in systems subjected to external forces is critical for understanding transport phenomena in complex systems.

Here, we present a system where we can observe the diffusion dynamics of single atoms in tilted optical lattices in the underdamped regime. A one-dimensional optical lattice allows transporting individual cesium atoms with variable lattice depth, constant velocity or acceleration, and thus force. For example, the force exerted on individual atoms can be huge, exceeding standard gravitation by orders of magnitude. Thereby, very different regimes of diffusion can be experimentally accessed. We can tune the system's macroscopic diffusion coefficient by varying the lattice depth and acceleration while applying optical molasses onto the atoms as a "bath of light" for the diffusion. Additionally, the atoms can be transported through a bath of ultracold rubidium atoms. We observe the interplay of the large Rb-bath and the single Cs-atoms trapped in the accelerated lattice and report its effective friction.

A 15.10 Tue 17:00 Tent A

Trap-integrated fluorescence detection with silicon photomultipliers for sympathetic laser cooling in a cryogenic Penning trap — •Markus Wiesinger[1], Florian Stuhlman[2], Matthew Bohman[1], Peter Micke[1,3], Christian Will[1], Hüseyin Yildiz[2], Fatma Abbass[2], Bela Arndt[1,4,5], Jack Devlin[3,5], Stefan Erlewein[1,5], Markus Fleck[5,6], Julia Jäger[1,3,5], Barbara Latacz[3,5], Daniel Schweitzer[2], Gilbertas Umbrazunas[5,7], Elise Wursten[3,5], Klaus Blaum[1], Yasuyuki Matsuda[6], Andreas Mooser[1], Wolfgang Quint[4], Anna Soter[7], Jochen Walz[2,8], Christian Smorra[2,5], and Stefan Ulmer[5,9] — [1]Max-Planck-Institut für Kernphysik, Heidelberg — [2]Institut für Physik, Johannes Gutenberg-Universität Mainz — [3]CERN, Meyrin, Switzerland — [4]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt — [5]RIKEN Fundamental Symmetries Laboratory, Japan — [6]Graduate School of Arts and Sciences, University of Tokyo, Japan — [7]Eidgenössische Technische Hochschule Zürich, Switzerland — [8]Helmholtz-Institut Mainz — [9]Heinrich-Heine-Universität Düsseldorf

We present a fluorescence-detection system for laser-cooled $^9Be^+$ ions based on silicon photomultipliers (SiPM) operated at 4 K and integrated into our cryogenic 1.9 T multi-Penning-trap system. Our approach enables fluorescence detection in a hermetically-sealed cryogenic Penning-trap chamber with limited optical access, where state-of-the-art detection using a telescope and photomultipliers at room temperature would be extremely difficult. We characterize the properties of the SiPM in a cryocooler at 4 K, where we measure a dark count rate below 1/s and a detection efficiency of 2.5(3) %. We further discuss the design of our cryogenic fluorescence-detection trap, and analyze the performance of our detection system by fluorescence spectroscopy of $^9Be^+$ ion clouds during several runs of our sympathetic laser-cooling experiment.

A 15.11 Tue 17:00 Tent A

Indication of critical scaling in time during the relaxation of an open quantum system — •Julian Fess[1], Ling-Na Wu[2], Jens Nettersheim[1], Alexander Schnell[3], Sabrina Burgardt[1], Silvia Hiebel[1], Daniel Adam[1], André Eckardt[3], and Artur Widera[1] — [1]Department of Physics, RPTU Kaiserslautern, Germany — [2]Center for Theoretical Physics and School of Science, Hainan University, Haikou, China — [3]Institut für Theoretische Physik, Technische Universität Berlin, Germany

Critical scaling occurs in phase transitions corresponding to the singular behaviour of physical systems in response to continuous control parameters. Recently, dynamical quantum phase transitions and universal scaling have been observed in the non-equilibrium dynamics of isolated quantum systems, with time as the control parameter. However, signatures of such critical phenomena in time in open systems were so far elusive. Here, we present results indicating that critical scaling with respect to time can also occur in open quantum systems. We experimentally measure the relaxation dynamics of the large atomic spin of individual Caesium atoms induced by the dissipative coupling to an ultracold Bose gas. For initial states far from equilibrium, the entropy is found to peak in time, transiently approaching its maximum possible value, before eventually relaxing to its lower equilibrium value. Moreover, a finite-size scaling analysis shows that it corresponds to a critical point in the limit of large system sizes. It is signalled by the divergence of a characteristic length, characterized by critical exponents that are found to be independent of system details.

A 15.12 Tue 17:00 Tent A

Quantum light in a finite 1-D slab and its effects on high harmonic generation — •Arlans Juan Smokovicz de Lara — Max-Planck-Institut für Physik komplexer Systeme, Dresden, Deutschland

Since its discovery, high harmonic generation (HHG), as a process non-linear in the number of photons, has been realized with intense "classical" light. Recently, progress has been made towards creating non-classical intense light pulses [1], which promises new quantum effects in the interaction with matter. We will present first results of non-classical light, in particular cat states of linearly polarized light interacting with delocalized electrons, realized in a 1-D slab of atoms [2], investigating the combined effects of the non-classical light and the periodic, crystal-like, yet finite target.

[1] M. Lewenstein, M. F. Ciappina, E. Pisanty, J. Rivera-Dean, P. Stammer, Th. Lamprou & P. Tzallas, Nature Physics volume 17,1104 (2021)

[2] Chuan Yu, Ulf Saalmann, Jan M. Rost, Phys. Rev. A 105, L041101 (2022)

A 15.13 Tue 17:00 Tent A

Measuring the environment of a Cs qubit with dynamical decoupling sequences — •Sabrina Burgardt, Simon Jäger, Julian Fess, Silvia Hiebel, Imke Schneider, and Artur Widera — Department of Physics and Research Center OPTIMAS, University of Kaiserslautern-Landau, Kaiserslautern 67663, Germany

We report the experimental implementation of dynamical decoupling (DD) on a small, non-interacting ensemble of optically trapped, neutral Cs atoms. We observe a significant enhancement of the coherence time when employing Carr-Purcell-Meiboom Gill (CPMG) DD. A CPMG sequence with ten refocusing pulses increases the coherence time by more than one order of magnitude. In addition, we make use of the filter function formalism and utilize the CPMG sequence to measure the background noise floor affecting the qubit coherence. Our findings point toward noise spectroscopy of engineered atomic baths through single-atom DD in a system of individual Cs impurities immersed in an ultracold Rb-87 bath.

A 15.14 Tue 17:00 Tent A

How to: Mean-field calculations with long-range interac-

tions — •Jan Alexander Koziol[1], Giovanna Morigi[2], and Kai Phillip Schmidt[1] — [1]Department of Physics, Staudtstraße 7, Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Germany — [2]Theoretical Physics, Saarland University, Campus E2.6, D-66123 Saarbrücken, Germany

We introduce an approach to set up mean-field calculations for lattice models with long-range interactions. The basic idea of our method is to perform mean-field calculations on all possible unit cells up to a given extend. The long-range interaction is treated without truncation using resummed couplings. One further advantage of the method we present is that all phases with ordering vectors fitting on any of the considered unit cells can be detected within out framework. We describe in detail the underlying theoretical ideas behind the method, the technicalities on how to implement the unit cell generation, and several results we obtained for (hardcore) bosons on the two-dimensional square and triangular lattice.

A 15.15 Tue 17:00 Tent A

Coincidence experiments on atomic collisions using the TrapREMI. — •Medina Cristian[1], Schotsch F.[1], Zebergs I.[1], Augustin S.[2], Lindenblatt H.[1], Hoibl L.[3], Djendjur D.[3], Schroeter C.D.[1], Pfeifer T.[1], and Moshammer R.[1] — [1]Max-Planck-Institute for Nuclear Physics, Saupfercheckweg 1, 69117 Heidelberg — [2]Paul Scherrer Institut, Forschungsstrasse 111, 5232 Villigen, Switzerland — [3]Department of Physics and Astronomy, Ruprecht-Karls University , 69120 Heidelberg, Baden-Württemberg, Germany

The reaction dynamics of collisions between atomic argon ions and various atomic projectiles have been investigated using the TrapREMI [1]. This setup combines an electrostatic ion beam trap (EIBT) [2,3] with a reaction microscope (REMI) [4]. Fast argon ions (2 keV) are stored in the EIBT in a linear oscillatory motion while inside the REMI; argon, helium, or neon atomic beams are crossed with the ion bunch. The resulting reaction products are detected in coincidence allowing the reconstruction of their 3D momenta. Additionally, with the implementation of a new ion source that allows higher ion current and an additional gas jet using different noble gasses, Ar+-Atom collisions were performed. Initial results showed that mainly singly-charged argon ion captures an electron, i.e. from the neutral argon beam. Coincidence measurements for all other gasses are similarly shown.

References [1] F. Schotsch, Rev. Sci. Instrum. 92 (2021) [2] D. Zajfman, Phys. Rev. A 55 (1997) [3] M. Lange, Rev. Sci. Instrum. 81 (2010) [4] F. Schotsch, Ph.D. thesis, Heidelberg (2020).

A 15.16 Tue 17:00 Tent A

Towards Ground State Cooling of a Highly Charged Ion - Beryllium Crystal at low Secular Frequency — •Stepan Kokh, Vera M. Schäfer, Elwin A. Dijck, Christian Warnecke, Lukas F. Storz, José R. Crespo López-Urrutia, and Thomas Pfeifer — Max-Planck-Institut für Kernphysik, Heidelberg

Spectroscopy of ions and atoms for generalized King Plot analysis is a rapidly developing field with the potential to identify new physics, such as unknown particles or forces [1]. Using highly charged ions (HCI) for it gives access to previously unavailable transitions. For such an analysis, high precision is required, and suppression of external perturbations is essential. Our superconducting Paul trap shields external fields by 57 dB, a level comparable to dedicated magnetically shielded rooms [2]. However, the current setup limits our secular frequency due to the loss of superconductivity at high RF power. Therefore, we operate only in an intermediate Lamb-Dicke regime. We report on the progress towards ground-state cooling of sympathetically cooled HCI in the given experimental setup.

[1] Nils-Holger Rehbehn, et al., Phys. Rev. Lett. 131, 161803 (2023) [2] Elwin A. Dijck, et al., Rev. Sci. Instrum. 94, 083203 (2023)

A 15.17 Tue 17:00 Tent A

Exploring the vibrational series of pure trilobite Rydberg molecules — •Richard Blättner, Markus Exner, Max Althön, and Herwig Ott — RPTU Kaiserslautern-Landau, Kaiserslautern, Deutschland

We report on the observation of two vibrational series of pure trilobite rubidium Rydberg molecules. These kinds of molecules consist of a Rydberg atom and a ground state atom. The binding mechanism is based on the scattering interaction between the Rydberg electron and the ground state atom. The trilobite molecules are created via three-photon photoassociation and lie energetically more than 15 GHz below the atomic 22F state. In agreement with theoretical calculations, we find an almost perfect harmonic oscillator behavior of six vibrational states. We show that these states can be used to measure electron-atom scattering lengths for low energies in order to benchmark current theoretical calculations. The molecules have extreme properties: their dipole moments are in the range of kilo-Debye and the electronic wave function is made up of high angular momentum states with only little admixture from the nearby 22F state. This high-l character of the trilobite molecules leads to an enlarged lifetime as compared to the 22F atomic state. Furthermore, our ion pulse spectrometer provides insights into the decay processes.

A 15.18 Tue 17:00 Tent A

Quantum Phases from Competing Van der Waals and Dipole-Dipole Interactions of Rydberg Atoms — •Zeki Zeybek[1,2], Rick Mukherjee[1], and Peter Schmelcher[1,2] — [1]Zentrum für Optische Quantentechnologien, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany — [2]The Hamburg Centre for Ultrafast Imaging, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

Competing short- and long-range interactions represent distinguished ingredients for the formation of complex quantum many-body phases. Their study is hard to realize with conventional quantum simulators. In this regard, Rydberg atoms provide an exception as their excited manifold of states have both density-density and exchange interactions whose strength and range can vary considerably. Focusing on one-dimensional systems, we leverage the Van der Waals and dipole-dipole interactions of the Rydberg atoms to obtain the zero-temperature phase diagram for a uniform chain and a dimer model. For the uniform chain, we can influence the boundaries between ordered phases and a Luttinger liquid phase. For the dimerized case, a new type of bond-order-density-wave phase is identified. This demonstrates the versatility of the Rydberg platform in studying physics involving short- and long-ranged interactions simultaneously.

A 15.19 Tue 17:00 Tent A

A High-Resolution Ion Microscope to Spatially Observe Ion-Rydberg Interactions — •Jennifer Krauter, Moritz Berngruber, Viraatt Anasuri, Óscar Andrey Herrera-Sancho, Ruven Conrad, Raphael Benz, Florian Meinert, Robert Löw, and Tilman Pfau — 5. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany

We report on our recent studies on ion-Rydberg atom interactions performed in the ultra-cold quantum regime using a high-resolution ion microscope. This apparatus provides temporal and spatial imaging of charged particles with a resolution of 200 nm.

Ion-Rydberg atom pair-states on the one hand allow for the observation of collisional dynamics on steep attractive potential energy curves. Avoided crossings with high-l states can cause significant speed up in the dynamics which is dependent on the individual Landau-Zener probabilities. On the other hand, the avoided crossings also lead to potential wells that give rise to bound molecular states. These bound states between an ion and a Rydberg atom feature large bond length, which enable the direct observation of vibrational dynamics. In an effort to further understand the binding mechanism of the Ion-Rydberg atom molecule their lifetime is currently under investigation.

A 15.20 Tue 17:00 Tent A

Precise FEM-solution of Dirac equation and the calculation of the electron bound-g-factor for H_2^+ molecular ion. — •Ossama Kullie — 1 Theoretical Physics, Institute of Physics, University of Kassel

A new generation of experiments is under way aiming at performing high-resolution spectroscopy of molecular hydrogen ions in Penning traps. In some of these traps, the internal state of the molecule is detected via the spin state, using electron spin resonance excitation. In order to perform this excitation, knowledge of the resonance frequency is required. The frequency depends on the bound-g-factor of the electron in the molecule. We calculate this g-factor by perturbatively evaluating the Zeeman energy of the electron in a weak magnetic field. Our FEM-solution of the two-center Dirac equation using 2-spinor minmax method, is highly accurate and the resulting wave function is used to calculate the electron bound-g-factor for H_2^+ molecular ion. We present results for the two (magnetic) field orientations, parallel and perpendicular to the molecule orientation (internuclear axis). [1] O. Kullie and S. tchiller, Phys. Rev. A **105**, 052801 (2022). [2] O. Kullie, J. of Mol. Struc., submitted (2023). [2] O. Kullie and S. Schiller, in progress.

A 15.21 Tue 17:00 Tent A

ATOMIQ: A block based, highly flexible and user friendly extension for ARTIQ — •Christian Hölzl[1], Suthep Pomjaksilp[2], Thomas Niederprüm[2], and Florian Meinert[1] — [1]5th Institute of Physics, Universität Stuttgart, Stuttgart, Germany — [2]Department of Physics and research center OPTIMAS, Technische Universität Kaiserslautern, Germany

The demand for fast and reliable experiment control hardware and software has sharply increased with recent advances in quantum technology. For the fast cycle times required in atom computing and simulation, highly flexible yet nanosecond-precise systems are needed. By providing fully open source software and hardware the ARTIQ/Sinara ecosystem has propelled itself to a leading solution for ion and neutral atom based quantum experiments.

However the out of the box software functionality is heavily limited and requires major time commitment from the end user. Our ATOMIQ extension aims to mitigate this problem by adding a user-friendly abstraction layer, implementing common routines needed for quantum control of neutral atoms. By using a block-based experiment structure, modularity and drastic reduction of boiler plate is achieved without compromising the speed of ARTIQ. Combining simple primitives through multiple inheritance patterns to graspable lab devices like lasers ensures high flexibility and easy extendability. By providing many interfaces to lab infrastructure for data management and non-realtime devices it is also easy to implement ATOMIQ in an already existing system running ARTIQ.

A 15.22 Tue 17:00 Tent A

Towards a Strontium Circular Rydberg Atom Quantum Simulator — •Aaron Götzelmann, Christian Hölzl, Einius Pultinevicius, Moritz Wirth, and Florian Meinert — 5. Physikalisches Institut, Universität Stuttgart

Ensembles of individually trapped highly excited Rydberg atoms have proven to be an excellent platform for quantum simulation of many-body systems. We aim to improve the limited coherence time of state of the art approaches using low-l Rydberg states by using very long lived high-l circular Rydberg states (CRS). We will report on the realization of single atom arrays of individual strontium atoms in an experimental setup which aims to achieve tens of milliseconds lifetimes for CRSs without cryogenic cooling. Specifically, we prepare the array inside a capacitor structure made from indium tin oxide (ITO) thin films, designed to suppress detrimental blackbody decay while providing excellent high-NA optical access. Starting from the preparation of ground-state cooled defect free atom arrays, we will present our path to CRSs via rapid adiabatic passage and coherent microwave coupling between CRSs. With this tool we apply single qubit operations on next-neighboring CRSs. Finally, we will discuss prospects for optical control and imaging of CRS exploiting the second valence electron of strontium.

A 15.23 Tue 17:00 Tent A

Study of Rydberg states in ultra cold ytterbium — •Alexander Miethke, Nele Koch, and Axel Görlitz — Institut für Experimentalphysik, Heinrich-Heine-Universität, Düsseldorf, Deutschland

In recent years Rydberg atoms with their special features, like dipole-dipole interaction or van-der-Waals blockade, have become more and more important for quantum optics. Particularly ultra cold Rydberg atoms are of great interest for the investigation of long range interaction.

A special feature of ytterbium is that due to its two valance electrons atoms in Rydberg states can be easily manipulated and imaged using optical fields. A first step towards studies of ultra cold ytterbium is to gain precise knowledge on the Rydberg states.

Here we present the study of the Rydberg states of ultra cold ytterbium. Using a Micro-Channel-Plate to detect the Rydberg atoms it is possible to measure lifetimes and hyperfine structures of several states. In addition we could measure the energy and polarizability of s, p and d states in the region of high principal quantum numbers n (n=70-90). Using a second stage trap we are able to cool the atoms down to several micro K to reduce their distances and investigate interactions.

A 15.24 Tue 17:00 Tent A

A Dysprosium Dipolar Quantum Qas Microscope — •Fiona Hellstern[1], Kevin Ng[1], Paul Uerlings[1], Jens Hertkorn[1], Lucas Lavoine[1], Ralf Klemt[1], Tim Langen[1,2], and Tilman Pfau[1] — [1]5. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany — [2]Atominstitut, TU Wien, Stadionallee 2, 1020 Vienna, Austria

We present the progress of our dipolar quantum gas microscope, which will enable single particle and single site resolved detection of Dysprosium atoms.

Our optical setup allows for the integration of both square and triangular lattice geometries (utilizing a wavelength of 360 nm), offering the capability to observe and manipulate diverse quantum phase transitions such as the (fractional) mott insulator to supersolid transitions. We present our design of an accordion lattice, a versatile optical trapping system, for loading Dysprosium atoms into the optical lattice. Additionally, our method to efficiently transport ultra-cold atoms from another vacuum chamber into the accordion lattice will be presented.

We will utilise an objective with a high numerical aperture (NA=0.9) and employ a spin- and energy-resolved super-resolution imaging technique, allowing us to achieve single-site detection with 180 nm resolution. The close spacing of the ultraviolet optical lattice significantly amplifies the nearest-neighbor dipolar interactions, reaching approximately 200 Hz (at 10 nK). This places us in the regime of strongly interacting Bose- and Fermi-Hubbard physics.

A 15.25 Tue 17:00 Tent A

Quantum Simulations: Towards EIT ground-state cooling of single trapped ions on a surface electrode trap — •Apurba Das, Deviprasath Palani, Florian Hasse, Ole Pikkemaat, Frederike Dörr, Leon Göpfert, Ulrich Warring, and Tobias Schaetz — Physikalisches Institut, University of Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg i. Br.

Tailored trap configurations for individually confined ions, employing both localized and global control fields, allows us to design and fine-tune intricate quantum systems. Two-photon stimulated Raman transition are typically utilized for individual state control and the coupling of internal and external degrees of freedom within our systems. In forthcoming endeavors, the objective is to incorporate ground state cooling via electromagnetically-induced transparency. This broadband cooling method aims to efficiently cool multiple modes to deterministically prepare the system close to its motional ground state. The poster offers an overview of essential technical advancements, recent progress towards experimental quantum simulations.

A 15.26 Tue 17:00 Tent A

Measurements of the Bound Electron *g*-factor at ALPHATRAP — •Matthew Bohman[1], Athulya George[1], Fabian Heisse[1], Charlotte König[1], Jonathan Morgner[1], Tim Sailer[1], Kunal Singh[1], Bingsheng Tu[1,2], Klaus Blaum[1], and Sven Sturm[1] — [1]Max-Planck-Institut für Kernphysik, 69117 Heidelberg — [2]Institute for Modern Physics, Fudan University, Shanghai 200433

ALPHATRAP [1] is a precision Penning-trap apparatus for high-precision measurements on simple atomic systems. Image current detection enables measurement of the motional frequencies of single particles and, when combined with the Larmor frequency, we extract fundamental properties such as bound-state magnetic moments with high precision. Recent measurements of the bound electron magnetic moment in H-like, Li-like, and B-like tin, for example, tested quantum electrodynamics (QED) at extremely high fields with sub-ppb accuracy [2]. Similarly, we developed a technique to measure direct g-factor differences of co-trapped particles at even higher precision. In a measurement with ^{20,22}Ne^{9+}, the difference of the two bound electron g-factors was measured to sub-ppt accuracy and set competitive bounds on scalar dark matter candidates [3]. We recently upgraded the apparatus and are building a new electron beam ion trap (EBIT) to produce ions at higher charge states, including H-like lead - testing QED and the Standard Model at even more extreme fields.

[1] Sturm, S. et al. Eur. Phys. J. Spec. Top. 227, 14251491 (2019).
[2] Morgner, J., Tu, B., König, C.M. et al. Nature 622, 5357 (2023).
[3] Sailer, T., Debierre, V. et al. Nature 606, 479483 (2022).

A 15.27 Tue 17:00 Tent A

Magnetic field stability in our ion trap and the ion as a quantum sensor — •Ole Pikkemaat, Apurba Das, Deviprasath Palani, Florian Hasse, Leon Goepfert, Frederike Doerr, Ulrich Warring, and Tobias Schaetz — Institute of Physics, University of Freiburg, Hermann-Herder-Straße 3, D-79104 Freiburg, Germany

Setting up an ion trap includes well-prepared considerations regarding the choice of both magnetic field strength and stability [1]. For a chosen qubit in the ions energy level structure, in general described by the superposition state $|\Phi\rangle = c_1|0\rangle + c_2 e^{i\varphi}|1\rangle$, magnetic field fluctuations destroy the well-defined phase relation φ between the energy level states, leading to loss of coherence, i.e. lower T_2 times. We want to archive an equivalent hybrid $\overrightarrow{B}$-field setup as in [1] to enhance the stability, i.e. to increase T_2 times for the $^{25}Mg^+$ ions we are trapping. In the hybrid setup, permanent magnets are used to create a magnetic field of $\simeq$ 109G to permit $\overrightarrow{B}$-field independent transitions. They replace high-current coils, intending to reduce the related heat which causes instability of the magnetic field. In addition, three small coil pairs in a cartesian setup allow changing minor deviations and establishing active stabilization. Next to the characterization of the magnetic field using 'classical' sensors, the ion will be exploited as a quantum sensor to probe the magnetic field directly. Looking forward to future applications of quantum sensors, turning the 'disadvantage' of the qubits being prone to external influences into a feature for excellent sensors. [1] Hakelberg, F. et al. Sci Rep 8, 4404 (2018)

A 15.28 Tue 17:00 Tent A

QRydDemo - A Rydberg Atom Quantum Computer Demonstrator — •Achim Scholz[1,2], Philipp Ilzhöfer[1,2], Ratnesh Kumar Gupta[1,2], Govind Unnikrishnan[1,2], Jiachen Zhao[1,2], Sebastian Weber[3,2], Hans-Peter Büchler[3,2], Simone Montangero[4], Jürgen Stuhler[5], Tilman Pfau[1,2], and Florian Meinert[1,2] — [1]5th Inst. of Physics, University of Stuttgart — [2]IQST — [3]Inst. for Theoretical Physics III, University of Stuttgart — [4]Inst. for Complex Quantum Systems, University of Ulm — [5]TOPTICA Photonics AG

Within the QRydDemo project, our goal is to realize a neutral atom quantum computer setup using strontium Rydberg atoms trapped in optical tweezers. For this platform we demonstrate a novel fine-structure qubit, encoded in the metastable triplet manifold of ^{88}Sr. First measured single-atom Rabi operations implemented via strong two-photon Raman transitions between the qubit states pave the road towards fast single-qubit gates. Aiming towards the realization of high-fidelity two-qubit gates via single-photon Rydberg transitions, we furthermore investigate a triple magic wavelength, for which not only both qubit states but also the Rydberg state is „magically“ trapped.

Our experimental platform is based on a dynamic, two-dimensional tweezer array of up to 500 qubits, generated by a setup of 20 AODs to allow shuffling operations during the qubit coherence time. The atom array is protected by an electric field control with ITO coated windows. To support the hardware we developed a compiler backend tailored to our Rydberg platform. With an available WebUI this allows emulation and future operation of the quantum computer by public access.

A 15.29 Tue 17:00 Tent A

Acceleration-enhanced Coulomb correlations between free electrons in a transmission electron microscope beam — •Lisa Beimel[1,2], Rudolf Haindl[1,2], Sergey V. Yalunin[1,2], Armin Feist[1,2], and Claus Ropers[1,2] — [1]Department of Ultrafast Dynamics, Max Planck Institute for Multidisciplinary Sciences, Göttingen, Germany — [2]4th Physical Institute, University of Göttingen, Göttingen, Germany

Correlated electrons are at the heart of many phenomena in condensed matter, as well as atomic and molecular physics. Generally, highly correlated free-electron states are of interest both from a fundamental perspective and for their potential in manifold electron beam applications.

For the generation of free electrons, we employ femtosecond-triggered photoemission from a nanoscale Schottky field emitter in an ultrafast transmission electron microscope [1]. When n electrons are generated by the same laser pulse at the emitter, their initially weak inter-particle Coulomb repulsion is acceleration-enhanced to a strong energy exchange of about 2 eV, as confirmed by trajectory simulations. In our experiment, we measure distinct energy correlations in transverse and longitudinal direction of pair, triple and quadruple free-electron states [2].

In this contribution, we will present recent results on the study of free-electron correlations in an electron microscope beam.

[1] A. Feist *et al.*, *Ultramicroscopy* **176**, 63-73 (2017).
[2] R. Haindl *et al.*, *Nat. Phys.* **19**, 1410-1417 (2023).

A 15.30 Tue 17:00 Tent A

Light-induced correlations in cold dysprosium atoms — •Marvin Proske, Ishan Varma, Rhuthwik Sriranga, and Patrick Windpassinger — Institut für Physik, Johannes-Gutenberg-Universität Mainz

When the average atomic distance in a cloud of ultracold atoms, is below the wavelength of the scattering light, a direct matter-matter coupling is introduced by electric and magnetic interactions. This alters the spectral and temporal response of the sample, where the atoms cannot be treated as individual emitters anymore. We intend to experimentally study light-matter interactions in dense dipolar media with large magnetic moments to explore the impact of magnetic dipole-dipole interactions onto the cooperative response of the sample. With the largest ground-state magnetic moment in the periodic table (10 Bohr-magneton), dysprosium is the perfect choice for these experiments.

This poster reports on the progess made in generating extremely dense cold dysprosium clouds. We discuss the measures taken to optically transport the atoms into a home-built science cell, which serves as a highly accessible platform to manipulate the atomic cloud. The small dimensions of the cell allow for extremely tight dipole trapping, enabled by a self-designed high NA objective. Further, we give a perspective on future measurements exploring collective effects in the generated atom cloud.