A 20: Poster II

Time: Wednesday 16:30–19:00 Location: Empore Lichthof

A 20.1 Wed 16:30 Empore Lichthof

Towards high-resolution imaging of RbSr molecules in an optical lattice — •Simon Lepleux, Noah Wach, Premjith Thekkeppatt, Digvijay Digvijay, Junyu He, Klaasjan van Druten, and Florian Schreck — Van der Waals-Zeeman Institute, University of Amsterdam

Polar, open-shell molecules in their rovibrational ground state exhibit a rich structure along with long range electric dipole interactions and a magnetic dipole moment. Polar molecules in an optical lattice impart long range interactions between lattice sites, which gives rise to exotic phases and extended Hubbard models. Utilizing a high-resolution microscope with single molecule addressing and manipulation techniques in an optical lattice will enable us to study spin lattice models.

We present the design and characterization of a custom microscope objective for an alkali - alkaline earth optical lattice experimental setup that offers us single-site resolution. Our infinity corrected microscope objective is constructed with commercially available lenses. It has a numerical aperture of 0.4 and a long working distance of 42.6 mm. The performance of the microscope is diffraction limited from 461 nm to 795 nm.

A 20.2 Wed 16:30 Empore Lichthof

Towards high-resolution spectroscopy and direct laser excitation of thorium-229 — •Gregor Zitzer[1], Johannes Tiedau[1], Maksim Okhapkin[1], Johannes Thielking[1], Ke Zhang[1], Christoph Mokry[2,3], Jörg Runke[2,4], Christoph E. Düllmann[2,3,4], and Ekkehard Peik[1] — [1]Physikalisch-Technische Bundesanstalt — [2]Department of Chemistry - TRIGA Site, Johannes Gutenberg University Mainz — [3]Helmholtz Institute Mainz — [4]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt

Exciting the electronic levels of an atom with laser light is a well-established workhorse in atomic physics. Likewise, exciting the nuclear core of an atom with electromagnetic radiation is possible, although typical energies are in the keV to MeV range. Here, thorium-229, with a first excited state at only 8 eV excitation energy, is the only known exception that will allow excitation by coherent laser radiation. This unique feature promises advantages for optical clocks and for measurements to uncover physics beyond the standard model.

In our setup, thorium-229 ions are produced as recoil ions from the alpha decay of uranium-233, featuring a 2 % branching to the isomer. The recoil ions are slowed down in helium buffer gas, filtered, and transferred to a linear Paul trap, where they are cotrapped with strontium-88 ions for sympathetic cooling.

In addition, we show our latest progress on direct laser excitation with vacuum-ultraviolet light produced via four-wave-mixing in xenon, producing up to 40 μJ per pulse. As a proof of concept, we investigate atomic transitions of $^{232}Th^{+}$ at 148 nm.

A 20.3 Wed 16:30 Empore Lichthof

Blue-detuned painted optical potentials for microgravity applications — •Kai Frye-Arndt[1,2], Holger Ahlers[2], Waldemar Herr[2], Christian Schubert[2], Ernst Rasel[1], and the BECCAL Team[1,2,3,4,5,6,7,8,9,10] — [1]Leibniz Universität Hannover — [2]DLR-SI, Hannover — [3]Universität Ulm — [4]FBH Berlin — [5]HU, Berlin — [6]JGU, Mainz — [7]ZARM, Universität Bremen — [8]DLR-QT, Ulm — [9]DLR-SC, Braunschweig — [10]Universität Hamburg

Steering a far-off-resonance laser beam to create arbitrarily shaped optical potentials can provide great flexibility for manipulating ultracold atoms. However, experiments are often disturbed by gravity induced dynamics or by levitation techniques, which introduce residual electromagnetic fields, limit the trapping volumes or restricting the choice of species. The Bose-Einstein and Cold Atom Laboratory (BECCAL) will enable the exiting possibility to study ultracold atoms in extended microgravity, lifting these constraints.

Here, we present a design of a compact and robust setup to paint optical potentials using a 2D acousto optic deflector. We show various characterization measurements and simulations investigating the dynamics of the moving light beam and the atoms.

We acknowledge support by the German Space Agency DLR with funds provided by the Federal Ministry of Economics and Technology (BMWi) under the grant numbers 50 WP 1431 and 1700. Supported and funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) under Germany's Excellence Strategy EXC-2123 QuantumFrontiers 390837967.

A 20.4 Wed 16:30 Empore Lichthof

Towards studying the collective effects in laser-driven heavy ion acceleration — •Erin G. Fitzpatrick, Laura D. Geulig, Maximilian J. Weiser, Veronika Kratzer, Vitus Magin, Florian H. Lindner, and Peter G. Thirolf — Ludwig-Maximilians-Universität München

The ultra-high ion bunch density offered from laser-driven ion acceleration may affect the stopping behavior in matter via collective effects and ultimately enable to establish new nuclear reaction schemes like the 'fission-fusion' mechanism, aiming to generate extremely neutron-rich isotopes near N=126 [1]. One prerequisite needed for the realization of this mechanism is laser driven heavy ions with extremely high bunch densities. Experimental campaigns at different PW class lasers resulted in the acceleration of gold ions with bunch densities of about 10^{13} cm^{-3} (10^{16} cm^{-3}) at 1mm (100 μm) from the target [2]. At the Center for Advanced Laser Applications (CALA) we are working towards measuring collective effects in laser-driven ion bunches, like a potential reduction in stopping power. Focusing on ion bunch energy deposition in CR-39 detectors downstream (approx. 0.1mm) from the ion source, we must consider shot-to-shot fluctuations of the ion bunch properties that require an experimental design that quantifies particle stopping while also providing a shot specific reference spectrum. An overview of the current results and developing experimental design is given.

[1] D. Habs et al., Appl. Phys. B 103, 471-484 (2011)
[2] F.H. Lindner et al., Sci. Rep. 12, 4784 (2022)

A 20.5 Wed 16:30 Empore Lichthof

Towards building and loading a Ioffe trap using a 2D MOT — •Benedikt Tscharn, Lukas Schumacher, Marcel Willig, Gregor Schwendler, and Randolf Pohl — Johannes Gutenberg-Universität Mainz, Institut für Physik, QUANTUM & Exzellenzcluster PRISMA+, Mainz, Germany

Unique information about atomic and nuclear structure of light atoms can be determined by precision laser spectroscopy and provide information about fundamental constants, interactions and properties [1]. We plan to build an apparatus for high-precision laser spectroscopy of ultracold ^{6}Li at 670 nm in a magnetic Ioffe trap.

Only very slow atoms can be captured inside the Ioffe trap. Therefore, a 2D magneto-optical trap using permanent magnets was built that is used to precool hot lithium vapour which is subsequently transported into the Ioffe trap using a push laser beam [2].

In this contribution we provide an overview about the setup of the 2D MOT, the lasers and the cold lithium loading beam and give an outlook to the magnetic trap.

[1] S. Schmidt et al., J. Phys. Conf. Ser. accepted (2018), arXiv 1808.07240
[2] H. Schumacher, Johannes Gutenberg-Universität Mainz, Master Thesis (2022)

A 20.6 Wed 16:30 Empore Lichthof

High-resolution dielectronic recombination spectroscopy with slow cooled Be-like Pb^{78+} ions at CRYRING@ESR — S. Fuchs[1,2], C. Brandau[1,3], E. B. Menz[3,4,5], M. Lestinsky[3], A. Borovik Jr.[1], Y. N. Zhang[6], Z. Andelkovic[3], F. Herfurth[2], C. Kozhuharov[3], C. Krantz[3], U. Spillmann[3], M. Steck[3], G. Vorobyev[3], R. Hess[3], V. Hannen[7], D. Banaś[8], M. Fogle[9], S. Fritzsche[4,5], E. Lindroth[10], X. Ma[11], A. Müller[1], R. Schuch[10], A. Surzhykov[12,13], M. Trassinelli[14], Th. Stöhlker[3,4,5], Z. Harman[15], and •S. Schippers[1,2] — [1]JLU Gießen — [2]HFHF Campus Gießen — [3]GSI — [4]HI Jena — [5]FSU Jena — [6]Xi'an Jiaotong University — [7]WWU Münster — [8]JKU Kielce — [9]Auburn University — [10]Stockholm University — [11]IMPCAS Lanzhou — [12]TU Braunschweig — [13]PTB — [14]INSP Paris — [15]MPIK

Dielectronic recombination (DR) spectroscopy is a very successful and widely used technique to study the properties of highly charged ions. Its high precision and versatility make it an important spectroscopic tool in the physics program of the SPARC collaboration. The heavy-ion storage ring CRYRING@ESR of the international FAIR facility in Darmstadt is a very attractive machine for performing DR spectroscopy because of its electron cooler that is equipped with an ultracold electron beam promising highest experimental resolving power and because of the extreme versatility of the storage ring ESR as its injector. Here, we report on the first DR experiment with highly charged ions at this new facility. The comparison between experiment and theory shows that the resolving power is according to the expectations.

A 20.7 Wed 16:30 Empore Lichthof

Optogalvanic Spectroscopy of Atomic Hydrogen — •Hendrik Schürg, Merten Heppener, and Randolf Pohl — Johannes Gutenberg-Universität Mainz, Institut für Physik/QUANTUM & Exzellenzcluster PRISMA$^+$, Mainz, Germany

Laser spectroscopy on atoms has proven to be a successful path to high-precision results for the root-mean-square charge radii of the lightest nuclei. Similar to studies on deuterium in a cyrogenic atomic beam [1,2], we propose to determine the triton charge radius by measuring the hydrogen-tritium 1S-2S isotope shift on thermal atoms in a sealed discharge cell – providing encapsulation of the radioactive tritium gas. The resonant excitation to the 2S state is intended to be monitored via the optogalvanic effect, corresponding to a laser-induced change of the plasma's impedance. Optogalvanic spectroscopy at the hydrogen Balmer-β dipole transitions in a low-pressure microwave discharge is demonstrated as a pre-stage to two-photon 1S-2S spectroscopy. We present studies on systematic effects and control parameters of the plasma as well as an evaluation of optogalvanic detection methods.

[1] C. G. Parthey et al. Phys. Rev. Lett. 104, 233001 (2010)
[2] U. D. Jentschura et al. Phys. Rev. A 83, 042505 (2011)

A 20.8 Wed 16:30 Empore Lichthof

Towards a strontium quantum gas microscope — •Jonatan Höschele[1], Sandra Buob[1], Antonio Rubio[1], Vasiliy Makhalov[1], and Leticia Tarruell[1,2] — [1]ICFO - Institut de Ciencies Fotoniques, The Barcelona Institute of Science and Technology, 08860 Castelldefels (Barcelona), Spain — [2]ICREA, Pg. Lluís Companys 23, 08010 Barcelona, Spain

Ultracold atoms in optical lattices represent an outstanding tool to create and study quantum many-body systems. Combining these lattice systems with the properties of alkaline-earth atoms like strontium gives rise to exciting phenomena such as cooperative effects in atom-photon scattering and exotic magnetic phases of the Fermi-Hubbard model.

To study these systems experimentally, we aim at the realization of a strontium quantum-gas microscope. We routinely generate Bose-Einstein condensates of strontium atoms, which we plan to load into an optical lattice, operating at a magic wavelength. An imaging setup involving a high-NA objective will allow us to image with single-atom and single-site resolution, enabling the detection of density as well as spin correlations in the prepared many-body states.

A 20.9 Wed 16:30 Empore Lichthof

Trapping and Cooling Thorium Ions with $^{40}Ca^+$ — •Can Patric Leichtweiss[1], Valerii Andriushkov[2], Azer Trimeche[1], Jonas Stricker[2,3], Dennis Renisch[2,3], Leonard Fendel[3], Dmitry Budker[1,2], Christoph E. Düllmann[2,3,4], and Ferdinand Schmidt-Kaler[1] — [1]QUANTUM, Institute of Physics, Johannes Gutenberg-Universität Mainz, Germany — [2]Helmholtz-Institut Mainz, Germany — [3]Department Chemie - Standort TRIGA, Johannes Gutenberg-Universität Mainz, Germany — [4]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany

We are aiming for quantum logic spectroscopy (QLS) with thorium ions. We employ the **t**rapping **a**nd **c**ooling of **t**horium **i**ons [1] in **ca**lcium crystals (*TACTICa*) to investigate different isotopes for the purpose of high-precision spectroscopy. After sympathetical polarization gradient cooling [2] QLS on the Th |6d7s^2, J=3/2>→|6d7s7p, J=5/2> transition at 402 nm will be carried out. QLS is based on the excitation of axial common modes in the Th^+-Ca^+ crystal, using an optical lattice generated by a pair of counterpropagating Gaussian beams or a vortex beam.

[1] K. Groot-Berning et al., *Phys. Rev. A* 99, (2019) 023420
[2] W. Li et al., *New J. Phys.* 24 (2022) 043028.

A 20.10 Wed 16:30 Empore Lichthof

Fragmentation of CH4 in shaped laser fields — •Weiyu Zhang, David Chicharro Vacas, Thomas Pfeifer, and Robert Moshammer — Saupfercheckweg 1, 69117 Heidelberg

Ultrashort laser pulses are widely used to probe the dynamics of atoms and molecules. An intuitive and accessible way to control the laser pulses is always wanted. Limited by the electronic speed, temporal pulse shaping cannot be applied directly. Here, with the spatial liquid modulator, we exhibit one flexible and reliable way to compress and shape pulse. In this talk, the spectral Fourier setup will be introduced. Within the freedom to give and change pulse through amplitude, phase, and polarization, it is possible to better resolve dynamics. Here, we combine the pulse shaper with the Reaction Microscope (REMI) to carry out the real-time pump-probe measurement for methane. Spatially, the methane molecule is a regular tetrahedron structure, which can be distorted by the external laser field and to is dissociated. Different ionization and dissociation channels are compared and analyzed.

A 20.11 Wed 16:30 Empore Lichthof

Towards topological x-ray quantum control — •Jonathan Sturm[1], Petar Andrejić[2], and Adriana Pálffy[1] — [1]Julius-Maximilians Universität Würzburg — [2]Friedrich-Alexander Universität Erlangen-Nürnberg

Thin film cavities with embedded Mössbauer nuclei such as ^{57}Fe have proven themselves as powerful platforms for resonant x-ray control. Arriving at grazing incidence, incoming x-rays form a standing wave inside the cavity that interacts with the resonant layer, allowing for well-controlled nucleus-field coupling. Alternatively, forward incidence enables excitation of multiple field modes, rendering the nanostructure a multi-mode waveguide. Both principles can be well described using a recently developed Green's function formalism for the cavity field [1,2].

We investigate theoretically a multi-mode waveguide with several embedded Mössbauer domains implementing tight-binding models known from molecular and solid-state physics. In particular, we arrange the individual Mössbauer domains such that weak and strong inter-domain couplings alternate, facilitating an x-ray photonic implementation of the topological Su-Schrieffer-Heeger model in order to study the behaviour of the waveguide field in presence of a topological boundary mode.

[1] X. Kong *et al.*, Phys. Rev. A **102**, 033710 (2020).
[2] P. Andrejić and A. Pálffy, Phys. Rev. A **104**, 033702 (2021).

A 20.12 Wed 16:30 Empore Lichthof

Dynamically-controllable resonant x-ray optics via mechanically-induced refractive-index control — •Miriam Gerharz[1], Dominik Lentrodt[1,2,3], Lars Bocklage[4], Kai Schlage[4], Kai Schulze[5,6], Christian Ott[1], Lukas Wolff[1], René Steinbrügge[4], Olaf Leupold[4], Ilya Sergeev[4], Gerhard Paulus[5,6], Christoph H. Keitel[1], Ralf Röhlsberger[4,5,6], Thomas Pfeifer[1], and Jörg Evers[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg, Germany — [2]Physikalisches Institut, Freiburg, Germany — [3]EUCOR Centre for Quantum Science and Quantum Computing, Freiburg, Germany — [4]Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany — [5]Helmholtz-Institut Jena, Jena, Germany — [6]Institut für Optik und Quantenelektronik, Jena, Germany

In this project we introduce a concept for dynamically-controllable resonant x-ray optics. Using piezo-control methods, we can displace a solid-state target much faster than the lifetime of its resonances. This creates a mechanically-induced phase shift, which can be associated with a frequency-dependent effective refractive index $n(\omega)$ of the moving target. Hence, we can achieve polarization control by mechanically-induced birefringence. We theoretically and experimentally demonstrate the approach with a x-ray polarization interferometer, in which the interference is controlled by the mechanically-induced refractive-index control. This setup can be used for temporal gating and provides a sensitive tool for a noise background analysis on sub-Ångstrom level.

A 20.13 Wed 16:30 Empore Lichthof

Producing large and stable magnetic fields for Feshbach resonance experiments in a ^{6}Li - $^{138}Ba^+$ hybrid system. — •Wei Wu, Fabian Thielemann, Joachim Siemund, Thomas Walker, and Tobias Schaetz — Physikalisches Institut Albert-Ludwigs-Universität Freiburg Hermann-Herder-Str. 3 79104 Freiburg

For many ultra-cold physics experiments, such as those involving Feshbach resonances, both a high magnetic field strength ($>$ 100 G) and low noise ($<$ 100 mG) are needed. Further, the coils should be compact enough to fit with the experiment. Here we present our Bitter electromagnet configuration for the Feshbach resonances experiments in the atom-ion hybrid system[1,2], and characterize its performance. Meanwhile, we investigate the field's short- and long-term stability with Ramsey spectroscopy of ^{6}Li, discuss plans for improvements to the system.

[1] Weckesser P, Thielemann F, Wiater D, et al. Observation of Feshbach resonances between a single ion and ultracold atoms[J]. Nature, 2021, 600(7889): 429-433.

[2] Schmidt J, Weckesser P, Thielemann F, et al. Optical traps for sympathetic cooling of ions with ultracold neutral atoms[J]. Physical review letters, 2020, 124(5): 053402.

A 20.14 Wed 16:30 Empore Lichthof

Novel cryogenic planar resonators — •Fabian Raab[1], Jonathan Morgner[1], Tim Sailer[1], Fabian Heisse[1], Charlotte König[1], Jost Herkenhoff[1], Fatma Abbass[2], Christian Smorra[2], Sven Sturm[1], and Klaus Blaum[1] — [1]MPIK Heidelberg — [2]JGU Mainz

Resonators are at the core of many Penning trap experiments. They can be used to cool and detect trapped ions. This contribution presents a planar resonator design, using the high-temperature superconductor YBCO, allowing the resonator to be used in a LN2-cooled environment. Furthermore, the geometrical simplicity increases the reproducibility of this design. For frequencies in the range of 5-30 MHz, typical for the cyclotron motion of highly charged ions in a Penning trap experiment, this design is much smaller than previous toriodal resonators. Here, first results of these new types of resonators are presented.

A 20.15 Wed 16:30 Empore Lichthof

Preparation, detection and cooling of single Strontium atoms in optical tweezers — •Aaron Götzelmann[1], Christian Hölzl[1], Moritz Wirth[1], Sebastian Weber[2], and Florian Meinert[1] — [1]5. Physikalisches Institut, Stuttgart, Germany — [2]Institut für Theoretische Physik 3, Stuttgart, Germany

In recent years, ensembles of atoms individually trapped in optical tweezer arrays have proven excellent systems for quantum computing and quantum simulation. Here, I report on our endeavour to prepare, cool, and detect single Strontium atoms in optical tweezers. We have chosen to work at a tweezer wavelength that is magic for the metastable $^3P_2$ and $^3P_0$ fine-structure states, motivated by exploiting this pair of states as a fast qubit for gate-based quantum computing [1].

Atom cooling and detection strategies reported so far for tweezer-trapped Strontium typically exploit the narrow $^1S_0$ to $^3P_1$ laser-cooling transition under magic trapping conditions. I will present our results to control single atoms under conditions, for which the $^1S_0$ to $^3P_1$ transition is non-magic, comprising single-atom preparation, high-fidelity imaging and evidence for near ground state cooling.

[1] F. Meinert, T. Pfau, and C. Hölzl, Quantum computing device, use, and method, EU Patent Application No. EP20214187.5

A 20.16 Wed 16:30 Empore Lichthof

Towards entanglement transfer from external to internal degrees of freedom and holography of laser wave — •Florian Hasse, Deviprasath Palani, Apurba Das, Maharshi Pran Bora, Lucas Eisenhart, Tobias Spanke, Ulrich Warring, and Tobias Schaetz — Physikalisches Institut, University of Freiburg

Trapped ions present a promising platform for quantum simulations [1]. In our linear Paul trap, we switch the trapping potential of two $^{25}Mg^+$ ions fast enough to induce a non-adiabatic change of the ions' motional mode frequencies. Thereby, we prepare ions in a squeezed state of motion. This process is accompanied by the formation of entanglement in the ions' motional degree of freedom and can be interpreted as an experimental analogue to the particle pair creation during cosmic inflation in the early universe [2].

We aim at transferring this entanglement from the external to the internal degree of freedom. To improve the measured contrast, we established a phase coherent combination of our laser- and microwave fields. As benchmarking experiments, we reconstruct holographs of our laser light wave. Here we use Ramsey sequences consisting of two $\pi/2$ pulses, where the second pulse is stroboscopically measured. Additionally, we aim at squeezing the ion(s) wave function to further enhance contrast.

[1] T. Schaetz et al., New J. Phys. 15, 085009 (2013).

[2] M. Wittemer et al., Phys. Rev. Lett. 123, 180502 (2019).

A 20.17 Wed 16:30 Empore Lichthof

Dielectronic recombination in He-like oxygen ions investigated at CRYRING@ESR — •Weronika Biela-Nowaczyk[1], Pedro Amaro[2], Carsten Brandau[1,3], Sebastian Fuchs[3,4], Filipe Grilo[2], Michael Lestinsky[1], Esther B. Menz[1,5], Stefan Schippers[3,4], Thomas Stöhlker[1,5,6], and Andrzej Warczak[7] — [1]GSI Darmstadt — [2]LIBPhys-UNL, NOVA Univ. Lisbon — [3]JLU Gießen — [4]HFHF Campus Gießen — [5]HI Jena — [6]FSU Jena — [7]JU Kraków

Multielectron resonant processes like dielectronic recombination (DR) and trielectronic recombination (TR) are governed by the electron-electron interaction and are of great importance in plasmas. These processes are major cooling factors in plasmas and, therefore, especially affect the dynamics of astrophysical objects. A program for DR experiments was started at the low-energy heavy-ion storage ring CRYRING@ESR. One of the first species studied was O^{6+}. As oxygen is one of the most abundant elements in the universe experimental data are of particular importance. The stored ion beam is collinearly merged with the ultra-cold electron beam of the cooler, leading to electron-ion interactions. In our experiment, the resonant condition for dielectronic capture was achieved by detuning the electron energy. The signatures of recombination were O^{5+} product ions, which were directed onto a particle detector and counted with near-unity efficiency. We will discuss the experimental method and show preliminary results of our analysis.

A 20.18 Wed 16:30 Empore Lichthof

Deterministic transport of trapped ions across two-dimensional trap-array — •Deviprasath Palani, Florian Hasse, Apurba Das, Maharshi Pran Bora, Lucas Eisenhart, Tobias Spanke, Ulrich Warring, and Tobias Schaetz — Physikalisches Institut, Albert-Ludwigs-Universität, Freiburg, Deutschland

Radio-Frequency surface electrode traps are promising platforms for envisioning large-scale quantum systems with trapped ions to perform quantum simulations, metrology, and information processing. In our prototype setup, the trap chip is fabricated by Sandia National Laboratories. The generated three-dimensional potential landscape has 13 strongly confined sites for ion storage and intermittent weakly confined areas featuring transport channels. With the sites closer to the surface, forming an equilateral triangular array: local control of sites, 2D inter-site coupling, and floquet-engineered coupling via the motional degrees of freedom had been demonstrated [1-3]. We extend the methods to enable the deterministic redistribution of ions across the array via an ancilla site $\sim$13 μm above the array. Via Ramsey spectroscopy, we reveal that the ion transport doesn't decrease the information stored within the electronic degrees of freedom. We discuss our efforts in addressing technical limitations [4] and the possibilities of three-dimensional coupling. [1] Mielenz, M. et al Nat. Commun. 7, 11839 (2016). [2] Hakelberg, F. et al. Phys. Rev. Lett. 123, 100504 (2019). [3] Kiefer, P. et al. Phys. Rev. Lett. 123, 213605 (2019). [4] Warring, U. et al. Adv. Quantum Technol. 1900137 (2020).

A 20.19 Wed 16:30 Empore Lichthof

Integration of a nano-Foil Target Positioning System for High-Power Laser Ion Acceleration — •Vitus Magin, Laura D. Geulig, Erin G. Fitzpatrick, Maximilian J. Weiser, Veronika Kratzer, and Peter G. Thirolf — Ludwig-Maximilians-Universität München

Over the last years, the laser-based acceleration of heavy ions has reached increasing interest due to their unique beam properties like very short bunch duration and ultra-high particle density [1]. At the High Field (HF) beamline at the Centre for Advanced Laser Applications (CALA) in Garching the acceleration of gold ions using the ATLAS3000 laser is investigated. A major prerequisite for the acceleration of gold ions is the precise positioning of the a few 10 to few 100 nm thin foils in the laser focus. For this, the nano-Foil Target Positioning System (nFTPS) was developed for the Laser-Driven ION (LION) beamline at CALA [2], offering a 5μm precision needed due to the short Rayleigh length of the laser. At HF this system is currently implemented, replacing the tedious task to register the precise positions manually with the required accuracy. Here, we report on the current progress of the related upgrade. For this, a new microscope for x-y positioning and a confocal sensor are set up, soon enabling an autonomous 30 minute routine for all 760 targets which also corrects for imperfections caused by the mounting of the 19 target holders.

[1] D. Habs et al., Appl. Phys. B 103, 471-484 (2011) [2] Y. Gao et al., HPLSE 5, e12 (2017)

A 20.20 Wed 16:30 Empore Lichthof

Towards fermionic weakly-bound open-shell RbSr molecules — •Digvijay Digvijay, Premjith Thekkeppatt, Simon Lepleux, Junyu He, Klaasjan van Druten, and Florian Schreck — Van der Waals-Zeeman Institute, Institute of Physics, University of Amsterdam

Ultracold dipolar molecules are a promising platform for quantum simulation, precision measurement and quantum chemistry. Ultracold molecules produced so far are closed-shell molecules, which limits their range of applications. Our goal is to produce ultracold fermionic RbSr molecules, which are dipolar open-shell molecules, in order to extend the range of possibilities.

Here we present our progress along a novel approach to create these molecules. Our approach uses confinement induced resonances (CIR) in a strongly interacting Bose-Fermi mixture and overcomes the challenge that magnetic Feshbach resonances, which are typically used to create ultracold molecules, are extremely narrow between alkali and alkaline-earth atoms. CIRs couple an atom pair state in a tight trap to a very weakly bound molecule in an excited trap state. Adiabatically lowering the confinement transfers the atom pair into the molecular state. Our experiment will start by preparing a strongly interacting 87Rb-87Sr Bose-Fermi mixture. In order to suppress inelastic collisions we intend to first prepare an n=1 Mott insulator of Rb and then to overlap it with a spin polarized Fermi gas of Sr. After molecule creation by adiabatically ramping the lattice depth across a CIR, we plan to perform STIRAP to the molecular ground state.

A 20.21 Wed 16:30 Empore Lichthof

Engineering Inter-Layer Couplings in Thin-Film X-Ray Cavities — •Hanns Zimmermann[1,2], Petar Andrejić[3], and Adriana Pálffy[2] — [1]Universität der Bundeswehr München — [2]Julius-Maximilians-Universität Würzburg — [3]Friedrich-Alexander-Universität Erlangen-Nürnberg

The resonant interaction between x-rays and Mössbauer nuclei is a promising method for achieving quantum control of high-frequency photons. A particularly promising platform are thin-film cavities, with one or several embedded layers of resonant nuclei such as ^{57}Fe with a Mössbauer transition at 14.4 keV. At grazing incidence, incoming x-rays couple evanescently to the cavity. In turn, the cavity field drives the nuclear transitions. The resulting nuclear response is well described by a recently-developed quantum-optical model based on the electromagnetic Green's function [1,2].

Here, we investigate theoretically thin-film cavities with multiple ^{57}Fe layers and design structures which allow for engineering of the inter-layer coupling. Via geometrical properties and control of the evanescent field pattern, we aim at implementing alternating coupling strengths between the resonant layers. Such couplings could lead to localization of the nuclear excitation in certain embedded layers and could eventually be useful to observe topological effects in x-ray thin-film cavities.

[1] X. Kong, et al. Phys. Rev. A 102, 033710 (2020)
[2] P. Andrejić and A. Pálffy, Phys. Rev. A 104, 033702 (2021)

A 20.22 Wed 16:30 Empore Lichthof

Spectroscopic Real-Time Temperature Diagnostic for Laser Heated Thin Gold Foils — •Veronika Kratzer, Laura D. Geulig, Erin G. Fitzpatrick, Florian H. Lindner, Vitus Magin, Maximilian J. Weiser, and Peter G. Thirolf — Ludwig-Maximilians-Universität München, Munich, Germany

Aiming to investigate the properties of heavy, neutron-rich nuclei, the novel 'fission-fusion' nuclear reaction mechanism, requiring an efficient laser-driven acceleration of heavy ions to kinetic energies above 7MeV/u, was proposed [1]. Previously, it was found that target heating significantly enhances the efficient acceleration of ions heavier than protons (in our case Au ions), by evaporating surface contaminants and thus suppressing namely the acceleration of protons and carbon ions [2,3]. For our setup at the Centre for Advanced Laser Applications in Garching we built a heating system that additionally allows us to determine (and thus control) the target surface temperature [4]. The gold foil is heated with a cw laser (532nm, max. 3W). The emitted thermal spectrum is measured with a NIR spectrometer allowing to measure the surface temperature by fitting Planck*s radiation law. So far, the setup has successfully been tested in air. In a next step it will be operated in vacuum to determine the effects of e. g. heating duration and laser power on the performance of gold ion acceleration.
[1] D. Habs et al., Appl. Phys. B 103, 471-484 (2011) [2] F. H. Lindner et al., Phys. Plasm. Contr. Fusion 61, 055002 (2019) [3] F. H. Lindner et al., Sci Rep 12, 4784 (2022) [4] M. J. Weiser, Master Thesis, LMU Munich, 2021

A 20.23 Wed 16:30 Empore Lichthof

A Coincidence Electron Velocity-Map-Imaging and Ion Microscopy Unit for Ultracold Atoms — •Jette Heyer[1,2], Julian Fiedler[1,2], Mario Grossmann[1,2], Amir Khan[2], Linn Hamester[2], Klaus Sengstock[1,2], Markus Drescher[1,2], Juliette Simonet[1,2], and Philipp Wessels-Staarmann[1,2] — [1]The Hamburg Centre for Ultrafast Imaging, Luruper Chaussee 149, 22761 Hamburg, Germany — [2]Center for Optical Quantum Technologies, University of Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

By combining an ultracold quantum gas of ^{87}Rb with local strong-field ionization in femtosecond laser pulses, we investigate many-body systems with long-range interaction and atom-ion hybrid systems.
A novel coincidence unit consisting of an ion microscope and a velocity-map-imaging (VMI) spectrometer is developed to detect the ionization products, allowing simultaneous resolution of the spatial distribution of the ions and the momentum of the photoelectrons. Simulations for the ion microscope suggest a resolution in the 100 nm range, surpassing the optical resolution limit of quantum gas microscopes. The VMI spectrometer is designed to detect electrons with a kinetic energy of $0.05\,\mathrm{meV} - 3.2\,\mathrm{eV}$, with a simulated resolution of $\Delta E/E \leq 10\,\%$ with angular resolution.
Additionally, a pulsed extraction of the ions and electrons allows a coincidence detection for investigating correlations as well as the dynamics of the many-body system.

A 20.24 Wed 16:30 Empore Lichthof

Realizing and probing programmable 2D optical lattices with flexible geometries and connectivity — •Suchita Agrawal[1,2], David Wei[1,2], Daniel Adler[1,2], Kritsana Srakaew[1,2], Pascal Weckesser[1,2], Immanuel Bloch[1,2,3], and Johannes Zeiher[1,2] — [1]Max-Planck-Institut für Quantenoptik, 85748 Garching, Germany — [2]Munich Center for Quantum Science and Technology (MCQST), 80799 Munich, Germany — [3]Fakultät für Physik, Ludwig-Maximilians-Universität, 80799 Munich, Germany

Over the past decade, ultracold atoms in optical lattices have become a vital platform for experimental quantum simulation, enabling precise studies of a variety of quantum many-body problems. For most experiments, the layout of the confining lattice beams restricts the accessible lattice configurations and thus the underlying physics. Here, we present a novel tunable lattice, which provides programmable unit cell connectivity and in principle allows for changing the geometry mid-sequence. Our approach builds on the generation of phase-stable realisation of a square or triangular base lattice combined with microscopically projected repulsive local potential patterns. With this technique, we realise Lieb and Kagome lattices, and benchmark the various configurations by exploring single particle quantum walks. We explore many-body physics in these lattices by observing parity fluctuations associated with the superfluid-to-Mott insulator transition. As an outlook, we will explore how the presented lattices can be applied for spin-selective imaging as well as doublon detection.

A 20.25 Wed 16:30 Empore Lichthof

Nonsequential double ionization of Ne with elliptically polarized laser pulses — •Fang Liu[1,2,3], Zhangjin Chen[4], and Stephan Fritzsche[1,2,3] — [1]Helmholtz-Institut Jena — [2]Theoretisch-Physikalisches Institut, Friedrich-Schiller-Universität Jena — [3]GSI Helmholtzzentrum für Schwerionenforschung GmbH — [4]Department of Physics, College of Science, Shantou University

We show through simulation that the improved quantitative rescattering model (QRS) can successfully predict the nonsequential double ionization (NSDI) process by intense elliptically polarized laser pulses. Using the QRS model, we calculate the correlated two-electron and ion momentum distributions of NSDI in Ne exposed to intense elliptically polarized laser pulses with a wavelength of 788 nm at a peak intensity of 5.0×10^{14} W/cm^2. We analyze the asymmetry in the doubly charged ion momentum spectra observed by Kang et al. in going from linearly to elliptically polarized laser pulses. Our model reproduces the experimental data well. Furthermore, we find that the ellipticity-dependent asymmetry arises from the drift velocity along the minor axis of the elliptic polarization. We explain how the correlated electron momentum distributions along the minor axis provide access to the subcycle dynamics of recollision.

A 20.26 Wed 16:30 Empore Lichthof

Non-Dipole Effects in Strong Field Ionization using Few-Cycle Laser Pulses — •Danish Furekh Dar[1,2,3], Birger Böning[1,2], and Stephan Fritzsche[1,2,3] — [1]Helmholtz-Institut Jena, Fröbelstieg 3, D-07743 Jena, Germany — [2]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Planckstrasse 1, D-64291 Darmstadt, Germany — [3]Theoretisch-Physikalisches Institut, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, D-07743 Jena, Germany

We present the extension of non-dipole strong field approximation that incorporates few-cycle laser pulses. We investigate the non-dipole effects of strong-field ionization. To do so, an atomic gas target is irradiated by circularly-polarized mid-infrared few-cycle laser pulse. To the end, we compute the photo-electron momentum distribution of argon and deduce the peak shifts of transverse electron momentum distribution in the laser propagation direction. Compared to recent work by [Phys. Rev. A 99,053404(2019)], we demonstrate a better agreement between theory and experimental investigations.

A 20.27 Wed 16:30 Empore Lichthof

Vibrational energy transfer between trapped atoms via Rydberg Excitation — •Abhijit Pendse[1], Sebastian Wüster[2], Matthew Eiles[1], and Alexander Eisfeld[1] — [1]Max Planck Institute for the Physics of Complex Systems, Dresden, Germany — [2]Indian Institute of Science Education and Research (IISER), Bhopal, India

The study of heat transfer between spatially separated ultracold atoms serves as a fundamental probe of thermodynamics of mesoscopic quantum systems [1,2]. To study the basic dynamics of this heat transfer, we consider three collinear harmonically trapped ultracold atoms. Coupling the central atom to a high-lying Rydberg s-state ($l = 0$) creates interactions in the system due to scattering of trapped atoms by the Rydberg electron. We numerically study the exact dynamics of an excited oscillator state in this Rydberg-coupled system. It turns out that the time scale of excitation transfer dynamics is smaller than the lifetime of the Rydberg state thus enabling experimental observation. The weak excitation of the central Rydberg atom, when the Rydberg electron-atom interaction energy becomes comparable to the oscillator energy, is an interesting feature of the system dynamics. As the harmonic trapping frequency of the Rydberg excited atom is increased with respect to that of other two atoms, the probability of multi-phonon excitation transfer increases.

References :

[1] Giazotto, et al. (2006), Rev. Mod. Phys., 78 (1), 217.

[2] Charalambous, et al. (2019), N. J. Phys., 21(8), 083037.

A 20.28 Wed 16:30 Empore Lichthof

The ARTEMIS Experiment: Determination of bound-electron magnetic moments in highly charged ions — •Arya Krishnan[1,2], Khwaish Anjum[1,4], Patrick Baus[2], Gerhard Birkl[2], Manasa Chambath[1,5], Jan Hellmann[1,6], Kanika Kanika[1,3], Jeffrey Klimes[1,3], Wolfgang Quint[1,3], Bianca Reich[1,3], and Manuel Vogel[1] — [1]GSI Helmholtz Center for Heavy Ion Research, Germany — [2]Technical University of Darmstadt, Germany — [3]University of Heidelberg, Germany — [4]University of Jena, Germany — [5]NITTE University, India — [6]University of Giessen, Germany

The ARTEMIS experiment at the HITRAP facility situated at GSI focuses on precision measurement of electron magnetic moments in highly charged ions as a benchmark of QED in extreme fields. The resistively cooled ions are detected using non-destructive techniques, followed by laser-microwave double-resonance spectroscopy on the desired few-electron heavy ions in a cryogenic Penning trap. The high magnetic fields leading to higher order Zeeman effects provide different outlooks to the theory of quantum electrodynamics for an atomic nucleus. The system has been commissioned with ions produced internally and is now being upgraded to dynamic capture and storage of ions produced from external sources like EBITs and the HITRAP facility. We present the current status of the experiment and recent results on ion cooling.

A 20.29 Wed 16:30 Empore Lichthof

An Atomic Source for an Ytterbium Optical Lattice Clock — •Julian Pick[1], Lion Günster[1], and Carsten Klempt[1,2] — [1]Institut für Quantenoptik, Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover — [2]Institut für Satellitengeodäsie und Inertialsensorik, Deutsches Zentrum für Luft-und Raumfahrt e.V., Callinstraße 30b, 30167 Hannover

Optical lattice clocks based on neutral ytterbium atoms belong to today's most precise frequency standards. Clock operation requires ultracold atoms trapped in an optical lattice, which demands the implementation of laser cooling techniques. In our setup, an atomic ytterbium beam emerges from an oven at a temperature of 500 °C. The atoms are decelerated by a transversal-field permanent-magnet Zeeman slower and subsequently redirected and recollimated by a 2D magneto-optical trap (MOT), for loading into a 3D MOT.

The cooling light at 399 nm operating at the $^1S_0 - ^1P_1$ transition is generated by two frequency-doubled external cavity diode lasers, of which the fundamental wavelengths are used for frequency stabilization. The primary laser is stabilized to an ultrastable optical resonator using the electronic sideband locking method. The secondary laser is stabilized to the primary laser with a frequency offset lock.

I will present the setup of the ytterbium source and the laser frequency stabilization scheme, as well as a characterization of the atomic flux and its velocity distribution behind the 2D MOT.

A 20.30 Wed 16:30 Empore Lichthof

A dedicated 2-dimensional array of metallic magnetic microcalorimeters to resolve the 29.18keV doublet of ^{229}Th — •A. Brunold, A. Abeln, S. Allgeier, J. Geist, D. Hengstler, A. Orlow, L. Gastaldo, A. Fleischmann, and C. Enss — Heidelberg University

The isotope ^{229}Th has the nuclear isomer state with the lowest presently known excitation energy, which possibly allows to connect the fields of nuclear and atomic physics with the potential application as a nuclear clock. In order to excite this very narrow transition with a laser a precise knowledge of the transition energy is needed. Recently the isomer energy (8.338±0.024) eV [Kraemer et al., arXiv:2209.10276, 2022] could be precisely determined. To get additional valuable insights, we will improve our recent high-resolution measurement [Sikorsky et al., PRL 125, 2020] of the γ-spectrum following the α-decay of ^{233}U. This decay results in excited ^{229}Th with a nuclear state at 29.18 keV. Resolving the doublet, that results from subsequent deexcitation to the ground and isomer state, respectively, would allow an independent measurement of the isomer energy and the branching ratio of these transitions. To resolve this doublet, we develop a 2D detector array consisting of 8×8 metallic magnetic calorimeters (MMCs). MMCs are operated at millikelvin temperatures and convert the energy of a single incident γ-ray photon into a temperature pulse which is measured by a paramagnetic temperature sensor. The detector array features an active detection area of 4 mm^2, a stopping power of 63.2% for 30 keV photons and an energy resolution below 3 eV (FWHM).

A 20.31 Wed 16:30 Empore Lichthof

Closed-cycle noble gas recycling system for an extreme-ultraviolet frequency comb — •Nele Griesbach, Jan-Hendrik Oelmann, Lennart Guth, Tobias Heldt, Roman Hector, Nick Lackmann, Janko Nauta, Thomas Pfeifer, and José R. López-Urrutia — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

To perform ultra-high spectroscopy of highly charged ions in the extreme ultraviolet (XUV), we developed an XUV-frequency comb [1]. Focusing the fundamental comb into a gas jet, high harmonic generation converts the near-infrared spectrum into the XUV regime. Usually, noble gases such as xenon, neon or krypton are used because of their high ionization potentials. As the worldwide demand for noble gases is increasing strongly and the abundancy of most noble gases in air is very low, the costs have increased to a point where long-term experiments are impossible. Therefore, we have developed a gas recycling system. The gas is injected through a 30 μm nozzle into the laser focus and is collected by a differential pumping system [1] to maintain the vacuum and is then re-compressed to a pressure of up to 200 bar. A good vacuum with low contamination level is indispensable as the cavity mirrors are susceptible to degradation and XUV light is strongly absorbed by air. We present the technical design of the system as well as measurements of the leakage and contamination rates.

[1] J. Nauta, *An extreme-ultraviolet frequency comb enabling frequency metrology with highly charged ions*, Phd thesis, Universität Heidelberg (2020).

A 20.32 Wed 16:30 Empore Lichthof

VAUQSI: Second Generation Superconducting Radio-Frequency Trap for Highly Charged Ion Qubits — •Stepan Kokh, Elwin A. Dijck, Christian Warnecke, Claudia Volk,

Alvaro Garmendia, Julia Eff, Andrea Graf, José R. Crespo López-Urrutia, and Thomas Pfeifer — Max-Planck-Institut für Kernphysik, Heidelberg

Quantum computing is a rapidly developing field with the potential to revolutionize science and information technology by enabling previously intractable calculations. Qubits based on laser-cooled ions in Paul traps form one of the most promising implementations of a quantum computer. Using highly charged ions trapped and sympathetically cooled inside a Be^+ Coulomb crystal, the sensitivity to external noise, which generally limits coherent operations, could be reduced. Working towards the first quantum computer based on highly charged ion qubits, we are constructing a new cryogenic, superconducting Paul trap VAUQSI (Viel-Frequenz-Ansteuerung Ultrastabiler Qubits in Supraleitenden Ionenfallen). The trap further develops our existing design, which integrates a linear Paul trap with a superconducting radio-frequency resonator. The storage and interrogation of ions is improved through better thermalization, which increases the resonator quality factor, and the addition of further electrodes, which allows finer control of the trapping potential in multi-qubit operation. A redesign of the electrodes improves the recapture of injected highly charged ions. We will present the technical implementation of the trap and its improvement regarding our current trap.