A 27: Poster III

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

A 27.1 Thu 16:30 Empore Lichthof

Single ionization of an asymmetric diatomic system by relativistic charged projectiles — •Andreas Jacob, Carsten Müller, and Alexander Voitkiv — Institut für Theoretische Physik I, Heinrich-Heine-Universität Düsseldorf

We study [1] the single ionization of a diatomic system by relativistic charged projectiles. The system is formed by two weakly bound different atomic species, A and B, with the ionization potential of A being smaller than an excitation energy in B. In such case, three ionization channels occur: (i) direct ionization of A, (ii) direct ionization of B, and (iii) two-center ionization of A. While (i) and (ii) represent the well-known mechanism of direct impact ionization of a single atom, in channel (iii) ionization of A proceeds via impact excitation of B with its subsequent relaxation in which the de-excitation energy is transmitted to A that ionizes it. We show that, close to the resonance energy, the two-center channel (iii) is so enormously strong that its contribution remains dominant even when considering a range of emission energies orders of magnitude broader than the resonance width. Furthermore, we demonstrate that relativistic effects, caused by a high collision velocity, can strongly influence the angular distribution of emitted electrons even at rather small values of the Lorentz factor.

[1] A. Jacob, C. Müller, and A. B. Voitkiv, Phys. Rev. A 103, 042804 (2021).

A 27.2 Thu 16:30 Empore Lichthof

A new apparatus for investigating collisions and chemical processes with ultracold NaK molecules — •Jakob Stalmann, Sebastian Anskeit, Fritz von Gierke, Kai K. Voges, and Silke Ospelkaus — Institute of Quantum Optics, Leibniz University Hannover

Ultracold molecular collisions feature many highly complex and still not understood phenomena, such as formation and loss of long-lived collisional complexes, molecular Feshbach resonances and chemical reactions.

Here, we present our efforts for the construction of a new experimental setup for the investigation of such collisional phenomena with ultracold $^{23}Na^{39}K$ ground-state molecules.

For ground-state molecule creation, we first produce optically trapped ultracold atomic ensembles from a dual-species Zeeman slower and MOT setup. The atoms are optically transported to a science chamber, where molecule preparation takes place by first creating weakly bound Feshbach molecules and subsequently transfering them into their ground state by a coherent Raman process. For detection of all educt and product particles of molecular collisions, our setup comprises a time of flight-velocity map imaging mass spectrometer in the science chamber. In combination with a state-selective pulsed laser ionization and fragmentation scheme this will allow us to resolve chemical reaction pathways, explore ultracold reaction dynamics and develop new quantum control techniques for chemical reaction steering.

A 27.3 Thu 16:30 Empore Lichthof

Towards high precision quantum logic spectroscopy of single molecular ions — •Till Rehmert[1], Maximilian J. Zawierucha[1], Fabian Wolf[1], and Piet O. Schmidt[1,2] — [1]Physikalisch- Technische Bundesalnstalt, Braunschweig, Deutschland — [2]Institut für Quantenoptik, Leibniz Universität Hannover, Hannover, Germany

High precision spectroscopy of trapped molecular ions constitutes a promising tool for the study of fundamental physics. Possible applications include the search for a variation of fundamental constants and measurement of the electric dipole moment of the electron. Compared to atoms, molecules offer a rich level structure, permanent dipole moment and large internal electric fields which make them exceptionally well- suited for those applications. However, the additional rotational and vibrational degrees of freedom result in a dense level structure and absence of closed cycling transitions. Therefore, standard techniques for cooling, optical pumping and state detection cannot be applied. This challenge can be overcome by quantum logic spectroscopy, where a well-controllable atomic ion is co-trapped to the molecular ion, both coupled strongly via the Coulomb interaction. The shared motional state can be used as a bus to transfer information about the internal state of the molecular ion to the atomic ion, where it can be read out using fluorescence detection. Using a Ca ion, we implemented a quantum logic scheme to detect population transfer on a co-trapped spectroscopy ion, induced by a far detuned Raman laser setup. We present the latest progress of the experiment, aiming at high precision quantum logic spectroscopy of single molecular ions.

A 27.4 Thu 16:30 Empore Lichthof

A laser system setup for production and cooling of $^{9}Be^{+}$ in a cryogenic Penning trap for precision measurements with (anti-)protons — •Jan Schaper[1], Julia Coenders[1], Juan Manuel Cornejo[1], Stefan Ulmer[3,4], and Christian Ospelkaus[1,2] — [1]Leibniz Universität Hannover, Germany — [2]Physikalisch-Technische Bundesanstalt, Braunschweig, Germany — [3]Ulmer Fundamental Symmetries Laboratory, Riken, Japan — [4]Heinrich-Heine-Universität Düsseldorf, Germany

The BASE collaboration has extensively contributed to high precision CPT symmetry tests on protons and antiprotons by measuring their charge-to-mass ratio and g-factor in a Penning trap at cryogenic temperatures [1-3]. At BASE Hannover we are developing new approaches for cooling and detection of these particles through laser cooling and methods of quantum logic schemes [4]. Since (anti-)protons cannot be directly addressed with laser light, single laser-cooled $^{9}Be^{+}$ ions will be used for sympathetic cooling of single (anti-)protons in a double well potential. In this poster, new developments of the experimental setup will be introduced. The implementation of a dedicated photoionization laser that enables quick loading of a single $^{9}Be^{+}$ ion into the trap will be shown. In addition, a dedicated laser setup for axial cooling of $^{9}Be^{+}$ will be presented.

[1] G. Schneider et al., Science 358, 1081 (2017) [2] C. Smorra et al., Nature 550, 371 (2017) [3] M.J. Borchert et al., Nature 601, 53 (2022) [4] M Niemann et al 2020 Meas. Sci. Technol. 31 035003

A 27.5 Thu 16:30 Empore Lichthof

Charged ultralong-range Rydberg trimers and ion-Rydberg dynamics — •Daniel Bosworth[1,2], Frederic Hummel[3], and Peter Schmelcher[1,2] — [1]The Hamburg Centre for Ultrafast Imaging, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany — [2]Zentrum für Optische Quantentechnologien, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany — [3]Max Planck Institute for the Physics of Complex Systems, Nöthnitzer Straße 38, 01187 Dresden, Germany

We show that the recently observed class of long-range ion-Rydberg molecules can be divided into two families of states, which are characterised by their unique electronic structures resulting from the ion-induced admixture of quantum defect-split Rydberg nP states with different low-field seeking high-l states. We predict that in both cases these diatomic molecular states can bind additional ground state atoms lying within the orbit of the Rydberg electron, thereby forming charged ultralong-range Rydberg molecules (ULRM) with binding energies similar to that of conventional non-polar ULRM. To demonstrate this, we consider a Rydberg atom interacting with a single ground state atom and an ion. The additional atom breaks the system's cylindrical symmetry, which leads to mixing between states that would otherwise be decoupled. The predicted trimer binding energies and excitation series are distinct enough from those of the dimer to be observed using current experimental techniques. Complimentary to this time-independent study, we have developed a semi-classical model for the dynamics of an s-state Rydberg atom in the presence of an ion.

A 27.6 Thu 16:30 Empore Lichthof

Construction of a versatile Rydberg atom platform — •Aaron Thielmann, Sven Schmidt, Suthep Pomjaksilp, Thomas Niederprüm, and Herwig Ott — Department of Physics and research center OPTIMAS, RPTU Kaiserslautern-Landau

In recent years, atomic arrays emerged as a ground-breaking platform in quantum physics. These setups do not only feature single-atom control, additionally exciting addressable atoms to Rydberg states introduces further possibilities to study physical problems in different geometric configurations.

We plan to realize arbitrarily arranged two-dimensional arrays with up to 100 lattice sites, each of them containing one or a few atoms. The arrays are holographically generated by an SLM in combination with a 1064 nm YAG-laser. Via a two-photon Rydberg transition, we collectively excite the atoms to Rydberg states. Due to the long-range character of the resulting Rydberg interactions, an interaction of the atoms in and between lattice sites is also intrinsically given. This setup is a prime candidate to investigate both topological systems of single atoms as well as effects arising from many-body properties in a controlled manner.

Adding controlled microwave transitions between different Rydberg states and the incorporation of a second atomic species open up possibilities to study even more complex physical systems in future research.

A 27.7 Thu 16:30 Empore Lichthof

A 1d-optical lattice for a crystal of cold ions — •Amir Mohammadi[1], Daniel Hoenig[1], Leon Karpa[2], and Tobias Schaetz[1] — [1]Albert-Ludwigs Universität, Freiburg, Germany — [2]Leibniz Universität, Hannover, Germany

Crystals of ions are a promising tool for implementing quantum simulation e.g., spin interaction in a solid. For decades rf-traps and Penning traps have confined Coulomb crystals using a ponderomotive force acting on charged particles. Despite stability and reasonable control over charged particles in these traps, they are driven into inherent energetic motion known as excess micromotion that heats up the ions and limits the applications of the system. As an alternative, it has been shown [1] that a chain of ions can also be trapped in a single optical beam that is spatially focused, similar to neutral atoms in an optical dipole trap, and can be seen as a platform for realizing a quantum simulation without any micromotion. As a next step in confining and localizing cold ions with light fields, we introduce the first successful trapping of a 138Ba ion Columb crystal up to three ions in a 1d-optical lattice featured by two counter-propagating 532nm laser beams of parallel polarization. We observe orders of magnitude enhancement in the axial trapping frequencies revealing single-site confinement for each individual trapped ion.

[1] Schmidt, J., et al., Phys. Rev. X 8, 021028 (2018)

A 27.8 Thu 16:30 Empore Lichthof

Assembling Fermi-Hubbard Systems for Random Unitary Observables — •Jin Zhang[1], Naman Jain[1], Daniel Dux[1,2], and Philipp Preiss[1,3] — [1]Max Planck Institute of Quantum Optics, Garching, Germany — [2]Physikalisches Institut der Universität Heidelberg, Heidelberg, Germany — [3]Munich Center for Quantum Science and Technology, Munich, Germany

Recent advances in probing complex many body systems allow us to raise incisive questions about their dynamics, which are classically hard to compute. Studying the Fermi-Hubbard model using random unitary operators enables the observations of global properties of the density matrix of delocalized systems.

We report progress on building a fermionic quantum simulator capable of realizing random unitary operations. Such a high performance simulator requires a fast cycle time and a high fidelity readout process. We will achieve a fast cycle time by evaporative cooling in an optical tweezer array, followed by simultaneously loading into a tunable lattice. Our readout process will reach single site resolution employing matter wave magnification and spin-resolved free-space imaging. This will enable us to measure, for example, entanglement entropy, out-of-time-order correlators, and state tomography.

A 27.9 Thu 16:30 Empore Lichthof

Nonlinear pulse compression in a gas-filled multi-pass cell — •Prachi Nagpal[1], Jan-Hendrik Oelmann[1], Tobias Heldt[1], Lennart Guth[1], Simon Angstenberger[2], Janko Nauta[3], Nick Lackmann[1], Thomas Pfeifer[1], and José R. Crespo López-Urrutia[1] — [1]Max Planck Institut für Kernphysik, Heidelberg, Germany — [2]4th Physics Institute, University of Stuttgart, Germany — [3]Department of Physics, Swansea University, UK

A novel approach is proposed for nonlinear spectral broadening and temporal pulse compression well below the gain-bandwidth limitation of the laser gain medium [1]. We install, in a gas-filled multi-pass cell, a potassium dihydrogen phosphate (KDP) crystal, which exhibits anomalous dispersion around the central wavelength (1030 nm) of the seed laser [2]. The resulting total dispersion is adjusted by changing the pressure of a normal dispersive gas filling the cell. Chirped mirrors become unnecessary, and pulse compression can be tuned by adjusting the number of passes. Shorter pulses and a broader spectrum will enhance high harmonic generation for an extreme ultraviolet frequency comb which will be employed for quantum logic spectroscopy of highly charged ions [3].

[1] Anne-Lise Viotti et al., Optica 9, 197-216 (2022) [2] Zernike, J. Opt. Soc. Am. 54, 1215*1220 (1964) [3] L. Schmöger et al., Science 347, 1233 (2015)

A 27.10 Thu 16:30 Empore Lichthof

Rydberg spectroscopy in the strong driving limit for atoms and molecules — •Florian Binoth, Tanita Klas, Jana Bender, Patrick Mischke, Thomas Niederprüm, and Herwig Ott — Department of Physics and Research center OPTIMAS, RPTU Kaiserslautern-Landau

We experimentally deform the 5S-6P potential of Rubidium atoms at large interatomic distances. This deformation leads to a potential shape that supports bound molecular states. To achieve this, we couple off-resonantly to an ultra-long range Rydberg molecule potential using strong laser driving. Properties that are commonly associated with Rydberg molecules are optically admixed to the 5S-6P pair state.

We spectroscopically observe the photoassociated 5S-6P molecules. The change in binding energy for different experimental coupling parameters is in qualitative agreement with a simple theoretical model.

Another effect we investigate is the Autler-Townes splitting in multilevel systems. The strong coupling lifts degeneracies and mixes closely-spaced states. This results in complex spectra deviating from the symmetrical two-level Autler-Townes splitting.

We experimentally investigate these spectra in a thermal cloud of ^{87}Rb atoms by resonantly coupling the $6P3/2, F = 3$ state to a Rydberg state with varying Rabi frequency. Our experiments confirm that multilevel effects have to be considered in the Autler-Townes regime.

A 27.11 Thu 16:30 Empore Lichthof

A cold atomic lithium beam via a 2D MOT — •Hendrik-Lukas Schumacher, Benedikt Tscharn, Marcel Willig, Gregor Schwendler, and Randolf Pohl — Johannes Gutenberg-Universität Mainz Institut für Physik, QUANTUM und Exzellenzcluster PRISMA+

Laser spectroscopy of atomic ^{6,7}Li has been used to determine the (squared) rms charge radius difference of the stable Li nuclei [1]. One important systematic effect in this experiment, as well as in most other precision spectroscopy measurements, is the distortion and apparent shift of resonance line by quantum interference of close-lying states [2]. Li with its unresolved hyperfine structure is an excellent testbed for precision studies of quantum interference [3].

So we present the current performance and setup of a 2D MOT, used to create a source for a very high flux of cold atomic Li for precision spectroscopy [4], and for using trapped cold Li as a buffer gas to enable trapping of atomic hydrogen, deuterium and later tritium [1].

[1] S. Schmidt et al., J. Phys. Conf. Ser. accepted (2018), arXiv 1808.07240
[2] M. Horbatsch, E.A. Hessels, Phys.Rev. A 84, 032508 (2011)
[3] R. C. Brown et al., Phys.Rev. A 87, 032504 (2013)
[4] H. Schumacher, Johannes Gutenberg-Universität Mainz, Master Thesis (2022)

A 27.12 Thu 16:30 Empore Lichthof

Attosecond-precision dynamics of a laser-driven two-electron wave packet in helium — •Shuyuan Hu, Yu He, Gergana Borisova, Maximillian Hartmann, Paul Birk, Christian Ott, and Thomas Pfeifer — Saupfercheckweg 1, 69117 Heidelberg

We have combined attosecond transient absorption spectroscopy (ATAS) and attosecond streaking spectroscopy to simultaneously measure the resonant photoabsorption spectra of laser-coupled doubly excited states in helium, together with the streaked photoelectron spectra. The streaking measurement reveals the absolute time delay zero and the full temporal profile of the electric fields which is incorporated in a time-dependent few-level simulation of the laser-coupled states in helium. Comparing the 1-fs time-scale modulations across the 2s2p(1P) and sp2,3+(1P) doubly excited states between the time-delay-calibrated simulation and the measurement, we identify the sign convention of the transition dipole matrix elements for the laser-coupled autoionizing states 2s2p-2p2 and 2p2-sp2,3+ to be opposite of each other.

A 27.13 Thu 16:30 Empore Lichthof

Ultracold Plasma: Many-body dynamics across the ionization threshold — •Julian Fiedler[1,2], Mario Grossmann[1,2], Jette Heyer[1,2], Linn Hamester[2], Amir Khan[2], Klaus Sengstock[1,2], Markus Drescher[1,2], Philipp Wessels-

Staarmann[1,2], and Juliette Simonet[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

Ultrashort laser pulses provide pathways for manipulating atomic quantum gases on femtosecond timescales. We use a single ultrashort laser pulse of tunable wavelength to ionize a cloud of ultracold ^{87}Rb atoms via a two-photon process and detect the ionization fragments.

At high excess energies above the ionization threshold, fast electrons are created and we observe the formation of an ultracold microplasma with a rapid electron cooling on picosecond timescales, where the orbit of the electrons lies outside the dense ionic core. Lowering the electron excess energy allows creating a plasma were the electron trajectories predominantly lie inside the ionic core.

By tuning the two-photon excitation energy below the ionization threshold, we create a dense ensemble of Rydberg atoms, which circumvents the Rydberg blockade due to the large bandwidth of the laser pulse. The subsequent dynamics is governed by collisional ionization of the Rydberg atoms and formation of an ultracold plasma. The results are compared to classical molecular dynamics simulations.

A 27.14 Thu 16:30 Empore Lichthof

Interatomic Two-Electron-One-Electron decay following 4d ionization in Xe — •Christina Zindel[1], Catmarna-Sophia Küstner-Wetekam[1], Lutz Marder[1], Niklas Golchert[1], Jenni Autio[2], Teemu Salmela[2], Minna Patanen[2], Arno Ehresmann[1], and Andreas Hans[1] — [1]Institut für Physik and CINSaT, University of Kassel, Heinrich-Plett-Str. 40, 34132 Kassel, Germany — [2]Nano and Molecular Systems Research Unit, Faculty of Science, University of Oulu, Box 3000, FI-90014, Finland

The decay behavior of excited atomic systems is influenced by their environment such that new possible relaxation processes might emerge when changing from isolated particles to van-der-Waals bound rare gas clusters. The latter represent prototype systems, which allow the study of fundamental processes as a first step toward more complex structures. Here, we investigate an interatomic variant of the so-called Two-Electron-One-Electron (TEOE) process, also referred to as three-electron Interatomic or Intermolecular Coulombic Decay (ICD). After 4d photoionization of Xe and following Auger-Meitner decay, a two-vacancy $5s^0 5p^6$ state will be prepared. Subsequently, the simultaneous filling of both inner-valence holes leads to the emission of a third electron from a neighboring atom. Multi-coincidence spectroscopy will be used to analyze the characteristic electron signal.

A 27.15 Thu 16:30 Empore Lichthof

First experiments at the CRYRING@ESR low-energy heavy-ion storage ring — •Michael Lestinsky for the SPARC-Collaboration — GSI Helmholtzzentrum für Schwerionenforschung GmbH, 64291 Darmstadt

The CRYRING@ESR storage ring is a recent installation at the heavy ion accelerator complex of GSI, Darmstadt, and the first completed facility within the FAIR project. CRYRING@ESR provides a combination of access to isotopically pure, heavy, highly charged ions of all natural elements, even to the ultimate case of bare U^{92+}, as well as long storage times for the circulating ions and electron cooling to improve the beam quality. The machine is now in routine operation and commenced its service for experiments proposed by the scientific community through the Stored Particle Atomic Research Collaboration (SPARC). A new generation of experiments was proposed to address precision spectroscopy in the strong fields of highly charged ions, to study the dynamics of slow atomic collisions and on nuclear reactions within e.g. the Gamow window of *p*-process nucleosynthesis. In the years of 2020 to 2022, the first experiments have been installed and commissioning beamtimes could be completed, studying electron-ion collisions, ion-atom collisions, and with laser-spectroscopic methods. The first data confirm the high potential of CRYRING@ESR for precision experiments with highly charged ions.

Here, we will give an overview of our facility and the research program, discuss the first experimental data and preview the planned machine upgrades and the experiments for the coming years.

A 27.16 Thu 16:30 Empore Lichthof

A setup for extreme ultraviolet wave packet interferometry using tabletop high harmonic generation — •Sarang Dev Ganeshamandiram, Fabian Richter, Ianina Kosse, Ronak Shah, Lukas Bruder, Giuseppe Sansone, and Frank Stienkemeier — Institute of Physics, University of Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg, Germany

Quantum interference techniques such as wave packet interferometry (WPI) in the extreme ultraviolet (XUV) regime set the basis for advanced nonlinear spectroscopy methods, such as multidimensional spectroscopy. These methods are however very difficult to implement at short wavelengths due to the required high phase stability and sensitivity. Recently, we have overcome these difficulties with the implementation of a special stabilization method based on acousto-optical phase modulation. We will present some of our recent results.

A 27.17 Thu 16:30 Empore Lichthof

XUV frequency comb for precision spectroscopy of trapped highly charged ions — •Lennart Guth[1], Jan-Hendrik Oelmann[1], Tobias Heldt[1], Janko Nauta[1,2], Nick Lackmann[1], Nele Griesbach[1], Thomas Pfeifer[1], and José R. Crespo López-Urrutia[1] — [1]Max-Planck-Institute for Nuclear Physics, Heidelberg, Germany — [2]Department of Physics, Swansea University, Singleton Park, SA2, United Kingdom

Highly charged ions have a few tightly bound electrons, which allow to probe fundamental physics and develop new frequency standards. However, most transitions are in the extreme ultraviolet (XUV)[1]. To perform spectroscopy on these with unprecedented precision, we have built an XUV frequency comb by transferring the coherence and stability of a near-infrared (NIR) frequency comb to the XUV using high-harmonic generation [2]. To reach the required peak intensity, NIR frequency comb pulses (200 fs) are amplified to 80 W in a chirped pulse fiber amplifier and resonantly overlapped in a femtosecond enhancement cavity ($P_{\text{avg}} \approx 25\,\text{kW}$, $I_{\text{peak}} \approx 3 \cdot 10^{14}\,\text{W/cm}^2$) [3]. High harmonics up to the 35th order are coupled out of the cavity and will be used for future direct XUV spectroscopy of highly charged ions, trapped and sympathetically cooled in a superconducting Paul trap [4].

[1] M.S. Safronova et al., Phys. Rev. Lett. 113, 030801 (2014).
[2] G. Porat et al., Nat. Photon, 12, 387 - 391 (2018).
[3] J. Nauta et al., Nucl. Instrum. Meth. B 408, 285 (2017).
[4] J. Stark et al., Rev. Sci. Instrum., 92, 083203 (2021).

A 27.18 Thu 16:30 Empore Lichthof

Continuous cooling below the Doppler Temperature of Sr in a Two-Color Magneto-Optical Trap — •Shubha Deutschle, Milán Negyedi, Andreas Günther, Lörinc Sárkány, and József Fortágh — Physikalisches Institut, Universität Tübingen

We use the $5s^2\ ^1S_0$ ground state and the $5s5p\ ^3P_2$ metastable state of Sr for two-stage laser cooling in a two-color magneto-optical trap. ^{88}Sr atoms are precooled operating on the $5s^2\ ^1S_0$ - $5s5p\ ^1P_1$ transition. Cooling below the Doppler limit is achieved using the $5s5p\ ^3P_2$ - $5s5d\ ^3D_3$ transition.

A 27.19 Thu 16:30 Empore Lichthof

Development of and extreme-ultraviolet beamline for quantum logic spectroscopy of highly charged ions — •Nick Lackmann[1], Jan-Hendrik Oelmann[1], Janko Nauta[2], Tobias Heldt[1], Lennart Guth[1], Prachi Nagpal[1], Nele Griesbach[1], José R. Crespo López-Urrutia[1], and Thomas Pfeifer[1] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany — [2]: Department of Physics, College of Science, Swansea University, Singleton Park, SA2, United Kingdom

Atomic clocks based on highly charged ions are prosperous candidates for quantum sensors with unprecedented precision, sensitive for physics beyond the Standard Model [1,2]. To drive the clock transitions, an extreme-ultraviolet frequency comb was constructed based on cavity-enhanced high-harmonic generation of the driving 100 MHz near-infrared frequency comb [3]. Harmonics up to 42 eV are generated in a gas jet and are subsequently guided through a beamline towards a superconducting Paul trap for direct XUV-comb spectroscopy [4, 5].

[1] M. G. Kozlov et al., Rev. Mod. Phys. 90, 045005 (2018)
[2] Safronova et al., Phys. Rev. Lett. 113, 030801 (2014)
[3] J. Nauta et al., Opt. Express 29, 2624 - 2636 (2021)
[4] P. Micke et al., Nature 578, 60 - 65 (2020)
[5] J. Stark et al., Rev. Sci. Instr. 92, 083203 (2021)

A 27.20 Thu 16:30 Empore Lichthof

Ion-atom-atom collisions: from plasma physics to cold chemistry — •Marjan Mirahmadi[1] and Jesús Pérez-Ríos[1,2,3] — [1]Fritz-Haber-Institut der Max-Planck-Gesellschaft, Berlin, Germany — [2]Department of Physics, Stony Brook University, NY, USA — [3]Institute for Advanced Computational Science, Stony Brook University, NY, USA

We present a study on ion-atom-atom reaction $A+A+B^+$ in a wide range of systems and collision energies ranging from 100 μK to 10^5 K, analyzing the two possible products: molecules (A_2) and molecular ions (AB^+). The dynamics is performed via a direct three-body formalism based on a classical trajectory method in hyperspherical coordinates developed in [J. Chem. Phys. **140**, 044307 (2014)]. Our chief finding is that the dissociation energy of the molecular ion product acts as a threshold energy separating the low and high energy regimes. In the low energy regime, the long-range tail of the three-body potential dictates the main reaction product. On the contrary, in the high energy regime, the short-range of atom-atom and atom-ion interaction potential dominates the dynamics, enhancing molecular formation for the low energy regime. Moreover, we are able to confirm the previously derived threshold law for ion-neutral-neutral three-body recombination in [J. Chem. Phys. **143**, 041105 (2015); Phys. Rev. A **98**, 062707 (2018)] at low temperatures and establish the range of its validity.

A 27.21 Thu 16:30 Empore Lichthof

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

We present an experimental and theoretical study for three-sideband (3-SB) RABBIT (The reconstruction of attosecond beating by interference of two-photon transition) in argon and Helium. RABBIT is an interferometric technique in which an XUV pulse train ionizes the target, and an IR pulse interacts with the photoelectrons. In the 3-SB RABBIT scheme, the interaction with the IR photons leads to the formation of three sidebands in between any two main bands formed by two adjacent harmonics. The oscillation phases of the three SBs in the group are independent of a potential chirp in the harmonics. We compare the oscillation phases extracted from specific SB groups formed by two adjacent harmonics. We also compare their angle dependence and discuss the role of the propensity rule and the variation in the continuum-continuum coupling phase with the orbital angular momentum. Results from R-matrix (close-coupling) with time-dependence calculation on Argon and SAE calculations on Helium are also presented.

A 27.22 Thu 16:30 Empore Lichthof

Fluorescence Detection of Rydberg Atoms — •Dillen Lee, Eduard Braun, Moritz Hornung, Gerhard Zürn, and Matthias Weidemüller — Physikalische Institut Universität Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg

Rydberg atom platforms are ideally suited to study the dynamics of closed quantum spin systems with giant interactions. Complementary to experiments with Rydberg spins excited from ground state atoms prepared in optical lattices or optical tweezers that are typically arranged in a ordered configuration, on our platform we excite Rydberg spins from a thermal gas of atoms with random distribution. To not only determine the number of Rydberg spins in the system which can be deduced from the detected number of ions after field ionisation we are heading towards a fluorescence detection scheme which will allow us to also determine not only the spatial distribution but also the spatial correlations of the spin system. In this poster we present a detection scheme for Rubidium Rydberg atoms that is based on free-space fluorescence detection which does not require the presence of a pinning lattice during exposure.

A 27.23 Thu 16:30 Empore Lichthof

Rymax-One: A neutral atom quantum processor to solve optimization problems — •Jonas Witzenrath[1], Niclas Luick[2,3], Benjamin Abeln[2], Daniel Adam[1], Kapil Goswami[4], Rick Mukherjee[4], Lennart Sobirey[2], Thomas Niederprüm[1], Henning Moritz[2,4], Herwig Ott[1], Peter Schmelcher[3,4], Artur Widera[1], and Klaus Sengstock[2,3,4] — [1]Department of Physics and Research Center OPTIMAS, RPTU Kaiserslautern-Landau, 67663 Kaiserslautern, Germany — [2]Institut für Laserphysik, Universität Hamburg, 22761 Hamburg, Germany — [3]The Hamburg Centre for Ultrafast Imaging, Universität Hamburg, 22761 Hamburg, Germany — [4]Zentrum für Optische Quantentechnologien, Universität Hamburg, 22761 Hamburg, Germany

Quantum computers are set to advance various domains of science and technology due to their ability to efficiently solve computationally hard problems, with a particular interest in combinatorial optimization problems. However, achieving a quantum advantage is still prevented by the quality and scale of the available quantum computing hardware.

Here, we present our project Rymax-One - which aims at building a quantum processor specifically designed to solve optimization problems that are intractable on classical devices. We use trapped arrays of ultracold ^{171}Yb atoms whose level structure enables qubit realizations with long coherence times, Rydberg-mediated interactions and high-fidelity gate operations. Solving open questions on the details of the interaction and excitation scheme will yield the high fidelities that allow us realize a scalable platform for quantum processing.

A 27.24 Thu 16:30 Empore Lichthof

Extended Mean-field Theory of strong coupling Bose polarons — •Nader Mostaan[1], Nathan Goldman[2], and Fabian Grusdt[1] — [1]Department of Physics and Arnold Sommerfeld Center for Theoretical Physics (ASC), Ludwig-Maximilians-Universität München, Theresienstr. 37, D-80333 München, Germany. Munich Center for Quantum Science and Technology (MCQST), Schellingstr. 4, D-80799 München, Germany. — [2]CENOLI, Universite Libre de Bruxelles, CP 231, Campus Plaine, B-1050 Brussels, Belgium.

A mobile quantum impurity resonantly coupled to a BEC forms a quasiparticle termed Bose polaron. In cold atom realizations of Bose polaron, the strength of the impurity-boson interactions is tunable via Feshbach resonances. At strong coupling, when an impurity-boson dimer exists, an unstable collective mode exists on top of the mean-field solution; thus, the impurity can bind a diverging number of non-interacting bosons. In this case, inter-boson interactions are crucial to stabilizing the Bose polaron. To describe Bose polaron, we employ an extension of coherent state variational ansatz, which accounts for beyond mean-field correlations of the bound mode. We find that the state of the bound mode is well described by a Fock-coherent state, and the impurity-boson resonance is shifted as a result of screening by the bosons bound to the impurity. In addition, we identify first-order phase transitions between Fock states with increasing occupation numbers. Our results corroborate the existence of multibody resonances between the attractive and repulsive polaron branches, which can be experimentally detected using impurity spectroscopy techniques.

A 27.25 Thu 16:30 Empore Lichthof

Towards Quantum Simulations of Light-Matter Interfaces with Strontium Atoms in Optical Lattices — •Felix Spriestersbach[1,2], Valentin Klüsener[1,2], Dimitry Yankelev[1,2], Jan Trautmann[1,2], Sebastian Pucher[1,2], Immanuel Bloch[1,3,2], and Sebastian Blatt[1,3,2] — [1]MPQ, 85748 Garching, Germany — [2]MCQST, 80799 München, Germany — [3]LMU, 80799 München, Germany

With the recent development of quantum gas microscopes, quantum simulators can now control ultracold atomic systems with single-site resolution.

Here, we present the progress towards a new strontium-based quantum simulator.

We have developed in-vacuum build-up optical cavities to create two-dimensional optical lattices with large mode waists using low input power. We characterized the lattice potential using clock spectroscopy in a non-magic lattice.

Additionally, we further present precision spectroscopy of the ultranarrow magnetic quadrupole transition $^1S_0$ - $^3P_2$ in Sr. Using a magnetic field gradient, we managed to trap ^{88}Sr atoms in a single two-dimensional layer within the optical lattice. Recently, our group successfully implemented single-site resolution fluorescence imaging of this two-dimensional layer.

By combining the advantage of a large system size and the realization of state-dependent optical lattices, we aim to emulate strongly coupled two-dimensional light-matter interfaces.

A 27.26 Thu 16:30 Empore Lichthof

FermiQP - A Fermion Quantum Processor — •Andreas von Haaren[1,2], Gleb Neplyakh[1,2], Er Zu[1,2], Robin Groth[1,2], Simon Krumm[1,2], Janet Qesja[1,2], Maximilian Schattauer[1,2], Timon Hilker[1,2], Philipp Preiss[1,2], and Immanuel Bloch[1,2,3] — [1]Max-

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FermiQP is a demonstrator for a neutral atom lattice quantum processor based on ultracold fermionic lithium.

In its digital mode, it will serve as a fully programmable quantum computer with single qubit gates implemented as Raman rotations between hyperfine states and controlled collisions between atoms in the superlattice as two-qubit gates. Tweezer-based resorting techniques will enable entangling operations across the entire lattice.

In the analog mode, it will operate as a quantum simulator for the Fermi-Hubbard model with additional control over the starting configuration. As a quantum-gas-microscope, the experiment will feature single-site-resolved imaging and also spin-resolved state detection.

We are building the experiment using a single-chamber design with the goal to reduce cycle times. The compact vacuum chamber allows for easier maintenance and increases flexibility.

On the poster, we present the most recent developments on the experiment.

A 27.27 Thu 16:30 Empore Lichthof

Laser systems for quantum logic with molecular ions — •Guanqun Mu, Brandon Furey, Stefan Walser, Zhenlin Wu, Rene Nardi, and Philipp Schindler — Institut für Experimentalphysik, Universität Innsbruck, 6020 Innsbruck, Austria

Multiple lasers are required for loading, photoionization, cooling, state preparation, and repumping trapped 40Ca+ ions. We installed these lasers, their distribution boards, and a wavemeter for frequency locking into a standard 19 inch rack. This reduced the footprint of these systems in our lab significantly. We have also installed an optical parametric amplifier (OPA) as a tunable ultrafast light source and a frequency comb for driving Raman transitions between molecular rotational states. Details of building and installing these systems will be discussed.

A 27.28 Thu 16:30 Empore Lichthof

Towards a continuous atom laser — •Junyu He[1], Noé Grenier[2], Rodrigo González Escudero[1], Chun-Chia Chen[1], Jiri Minář[3,4], Shayne Bennetts[1], Benjamin Pasquiou[5], and Florian Schreck[1,4] — [1]Van der Waals-Zeeman Institute, Institute of Physics, University of Amsterdam, The Netherlands — [2]École normale supérieure Paris-Saclay, France — [3]Institute for Theoretical Physics, University of Amsterdam, The Netherlands — [4]QuSoft, The Netherlands — [5]Laboratoire de Physique des Lasers, Université Sorbonne Paris Nord, France

A continuous atom laser would be a promising source for quantum sensing, providing a high-flux, low-divergence beam while avoiding measurement dead time [1]. We plan to outcouple such a beam from a Bose-Einstein condensate that we can continuously sustain [2]. Our approach sends a Sr beam from an oven through a sequence of spatially separated laser cooling stages till the atoms accumulate in a protected area where they condense. Our next steps will be to enhance the purity of the BEC and to outcouple a continuous atom laser beam using a three-photon transfer to an untrapped state [3].

[1] Phys. Rep. 529, 265 (2013). [2] Nature 606, 683 (2022). [3] Phys. Rev. A 93, 053417 (2016).

A 27.29 Thu 16:30 Empore Lichthof

Cavity-mediated correlated pairs in both internal and external degrees of freedom — •Panagiotis Christodoulou, Fabian Finger, Rodrigo Rosa-Medina, Nicola Reiter, Tobias Donner, and Tilman Esslinger — Institute for Quantum Electronics, ETH Zurich, 8093 Zurich, Switzerland

Using a 87Rb spinor Bose-Einstein condensate inside a high-finesse optical cavity, we engineer correlated atom pairs in both their internal (spin) and external (momentum) degree of freedom. This mechanism has intrinsically many similarities with the parametric down-conversion process in optical systems and the binary spin-changing collisions in atom gases, as we verify in a series of experiments. At the same time, this mechanism provides new opportunities, like a deterministic controllability between the underlying coherent and dissipative processes, and an interplay of different intermediate channels for the production of such pairs which we can experimentally distinguish. The produced paired state is well placed to constitute the basis for a number of studies, ranging from proof-of-principle investigations of the mechanism of entanglement to fast quantum-enhanced interferometry to generating many-body models relevant to Quantum Information theory.

A 27.30 Thu 16:30 Empore Lichthof

Reversible mode shaping in a linear ion crystal via Rydberg excitation — •Robin Thomm[1], Harry Parke[1], Shalina Salim[1], Marion Mallweger[1], Natalia Kuk[1], Andre Cidrim[2], Alan Santos[2], and Markus Hennrich[1] — [1]Stockholm University, Sweden — [2]Departamento de Fisica, Universidade Federal de São Carlos, Brazil

We propose an experiment to shape the mode structure of one of the radial modes of a linear ion crystal confined in a linear Paul trap. Single phonons in one radial motional mode of a ground state cooled ion string exhibit a quantum random walk between the ions (Tamura *et al.* PRL 124, 200501 (2020)). Exciting one or multiple ions into Rydberg state will lead to a change in their trapping frequency, decoupling their motion from the other ions. This way, Ryberg excitation acts as a reversible barrier that can be adjusted by controlling population in the Rydberg state. This allows to restrict the movement of the phonons between the ions on the one hand, and spatially isolate parts of the ion crystals mode structure on the other hand (Li *et al.* PRL A 87, 052304 (2013)). With the techniques presented it is possible to both simplify and parallelize gate schemes based on common motional modes and to investigate bosonic transport in the presence of (adjustable) barriers.

A 27.31 Thu 16:30 Empore Lichthof

Passive vibration reduction of a femtosecond enhancement cavity — •Lukas Matt, Jan-Hendrik Oelmann, Tobias Heldt, Lennart Guth, Janko Nauta, Thomas Pfeifer, and José R. Crespo López-Urrutia — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

To perform spectroscopy of highly charged ions in the extreme ultraviolet (XUV), we developed an XUV-frequency comb [1]. Since high intensities are necessary for the high-harmonic generation producing the XUV and a high repetition rate of 100 MHz needs to be maintained, the use of an enhancement cavity is necessary. Which is vibration sensitive, because the cavity length has to be hold on resonance. Therefore the cavity has to be build very stable and decoupled from the noisy turbomolecular pumps. As no rigid connection between vacuum chamber and optical table is allowed, the realtive position between both has to be monitored, to avoid contact that would lead to vibrational coupling. We accomplish that with 6 laser-distance sensors. We present the technical realisation of this system. [1] (J. Nauta, A. Borodin, H. B. Ledwa, J. Stark, M. Schwarz, L. Schmöger, P. Micke, J. R. Crespo López-Urrutia and T. Pfeiffer, Nuclear Instruments and Methods in Physics Research, Section B: Beam Interactions with Materials and Atoms 408, 285 (2017))

A 27.32 Thu 16:30 Empore Lichthof

Single-Pass Non-Destructive Ion Bunch Characterisation — •Stefan Ringleb[1], Markus Kiffer[1], Sugam Kumar[2], Manuel Vogel[3], Wolfgang Quint[3,4], Gerhard G. Paulus[1,5], and Thomas Stöhlker[1,3,5] — [1]Friedrich-Schiller-Universität Jena, Jena — [2]Inter-University Accelerator Center, Delhi — [3]GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt — [4]Ruprecht Karls-Universität Heidelberg, Heidelberg — [5]Helmholtzinstitut Jena, Jena

In recent years, ion beam applications in research and industry increased much. Especially, low-energy beamlines have shrunk to table-top size and can be set up fast and with comparably low financial effort.

In most applications each ion bunch passes the beamline only once and there is a need to characterise the ions non-destructively within a single pass. To this end, we have developed, built and tested two devices of different design based on the measurement of induced mirror charges of the passing ions in a set of pick-up electrodes. We have elaborated a robust evaluation procedure and have tested the devices in the energy regime of keV.

One device is capable of measuring the number and kinetic energy of an ion bunch and the second is used to determine the position of the ion beam with respect to the beamline centre.

We will present the device and its physical background as well as characterisation results.

A 27.33 Thu 16:30 Empore Lichthof

THz optics interfaced with hot vapors — •Daniel Rainer Häupl[1,2], Markus Lippl[1,2], Nicolas Couture[3], Jean-Michel Ménard[3], Robert Löw[4], and Nicolas Joly[1,2] — [1]University of

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Hollow-core photonic crystal (PCF) fibers filled with hot alkali vapor are a versatile platform for studying Rydberg physics at ambient temperature. In detail we discuss the possibility to use a Rydberg transition in rubidium to generate THz radiation. Previous work shows that even small hollow-core fibers can be rapidly and homogeneously filled with rubidium vapor [NJP, 24, 113017 (2022)]. Here, we excite the Rb atoms to the 17S1/2 Rydberg state, from where they decay with the highest probability to the 16P1/2 state, emitting during this atomic transition radiation at around 1.3 THz. The emitted light is expected to be narrowband and the wavelength can be tuned through the excitation scheme. To enhance the intensity of the generated THz radiation, the cell is nested in a tailored THz waveguide.

A 27.34 Thu 16:30 Empore Lichthof

X-ray Spectroscopy of U^{90+} Ions with a 64-pixel Metallic Magnetic Calorimeter Array — •A. Orlow[1], S. Allgeier[1], A. Abeln[1], A. Brunold[1], M. Friedrich[1], A. Gumberidze[2], D. Hengstler[1], F. M. Kröger[2,3,4], P. Kuntz[1], A. Fleischmann[1], M. Lestinsky[2], E. B. Menz[2,3,4], Ph. Pfäfflein[2,3,4], U. Spillmann[2], B. Zhu[4], G. Weber[2,3,4], Th. Stöhlker[2,3,4], and C. Enss[1] — [1]KIP, Heidelberg University — [2]GSI/FAIR, Darmstadt — [3]IOQ, Jena University — [4]HI Jena

Metallic magnetic calorimeters (MMCs) are energy-dispersive X-ray detectors which provide an excellent energy resolution over a large dynamic range combined with a very good linearity. MMCs convert the energy of each incident photon into a temperature pulse which is measured by a paramagnetic temperature sensor. The resulting change of magnetisation is read out by a SQUID magnetometer.

To investigate electron transitions in U^{90+} at CRYRING@FAIR within the framework of the SPARC collaboration, we developed the 2-dimensional maXs-100 detector array. It features 8x8 pixels with a detection area of 1 cm^2 and a stopping power of 40 % at 100 keV. Four on-chip thermometers allow to correct for temperature drifts and to achieve an energy resolution of 40 eV at 60 keV. We show preliminary X-ray spectra of the recent U^{90+} beamtime. Due to the small rate of emitted X-rays, a good supression of background radiation is mandatory, which was ensured by a coincidence measurement with a particle detector. To increase the stopping power to above 60 % at 100 keV we develop a new maXs-100 detector with 100 μm thick absorbers.

A 27.35 Thu 16:30 Empore Lichthof

Vanishing avoided crossings in Rydberg systems — •Matthew Eiles — Max Planck Institut für Physik komplexer Systeme, Dresden, Deutschland

The electronic potential energy curves describing a diatomic molecule repel one another rather than intersecting, as the conditions to find an exact crossing are not generically satisfied in a system depending on a single parameter. Diatomic long-range Rydberg molecules, however, provide an avenue to escape this restriction as their potential energy curves depend additionally on the principle quantum number of the Rydberg atom. Although this is not a continuous parameter, it can vary over such a wide range that it is possible to find nearly arbitrarily close avoided crossings, and with them, strong non-adiabatic coupling and the breakdown of the Born-Oppenheimer approximation. Here, we show several different ways that this behavior arises in Rydberg molecules and discuss its importance for their vibrational spectra.

A 27.36 Thu 16:30 Empore Lichthof

Impact of coherent phonon dynamics on high-order harmonic generation in solids — •Jinbin Li[1,2], Ulf Saalmann[2], Hongchuan Du[1], and Jan Michael Rost[2] — [1]School of Nuclear Science and Technology, Lanzhou University, Lanzhou, China — [2]Max Planck Institute for the Physics of Complex Systems, Dresden, Germany

We theoretically investigate the impact of coherent phonon dynamics on high-order harmonic generation (HHG), as recently measured [Hollinger et al, EPJ Web of Conferences 205, 02025 (2019)]. A method to calculate HHG in solids including phonon excitation is developed for a model solid. Within this model we calculate the signal of specific harmonics. The harmonic yields oscillate at the frequency of the optical phonon mode of the model system when the pump-probe delay increases. Further analysis shows that the phonons are excited by the electron density change induced by the laser field and then influence the band structure and harmonic yields. This work suggests that phonons can be manipulated by controlling electron density using laser fields.

A 27.37 Thu 16:30 Empore Lichthof

Compton polarimetry on Rayleigh scattering of highly linearly polarized hard x-rays on gold atoms — •Wilko Middents[1,2,3], Günter Weber[1,3], Alexandre Gumberidze[3], Thomas Krings[4], Philip Pfäfflein[1,2,3], Uwe Spillmann[3], Sophia Strnat[5,6], Andrey Surzhykov[5,6], and Thomas Stöhlker[1,2,3] — [1]Helmholtz Institut Jena — [2]Friedrich-Schiller-Universität Jena — [3]GSI Helmholtzzentrum für Schwerionenforschung GmbH — [4]Forschungszentrum Jülich — [5]Physikalisch-Technische Bundesanstalt Braunschweig — [6]Technische Universität Braunschweig

Rayleigh scattering of hard x-rays refers to the elastic scattering of photons on bound electrons [1]. State-of-the-art calculations in the framework of QED predict a strong dependence of the polarization characteristics of the scattered radiation on the scattering geometry [2].

We performed an experiment on the polarization transfer in Rayleigh scattering of a highly polarized hard x-ray beam on a thin gold target, extending on a previous study by Blumenhagen et al. [3]. A state-of-the-art Compton polarimeter [4] was used to precisely determine the linear polarization of the scattered radiation both within and out of the polarization plane of the incident synchrotron beam. In this contribution we will report on the setup and first results of the experiment.

[1] Kane, P. P. et al., (1986), Phys. Rep. 140(2), 75, [2] Strnat, S. et al., (2021), Phys. Rev. A, 103(1), 012801, [3] Blumenhagen, K. H. et al., (2016), New J. Phys. 18, 119601, [4] Vockert, M. et al., (2017), NimB 408, 313

A 27.38 Thu 16:30 Empore Lichthof

A new experiment on atomic tweezer arrays in a cryostat — Kai-Niklas Schymik[1], Bruno Ximenez[2], Etienne Bloch[2], •Davide Dreon[2], Adrien Signoles[2], Florence Nogrette[1], Daniel Barredo[1,3], Antoine Browaeys[1], and Thierry Lahaye[1] — [1]Université Paris-Saclay, Institut d'Optique Graduate School, CNRS, Laboratoire Charles Fabry, 91127 Palaiseau Cedex, France — [2]PASQAL SAS, 7 Rue Léonard de Vinci, 91300 Massy, France — [3]Nanomaterials and Nanotechnology Research Center (CINN-CSIC), Universidad de Oviedo (UO), Principado de Asturias, 33940 El Entrego, Spain

Optical-tweezer arrays are a powerful platform for realising analog and digital quantum simulators. However, they share the scalability problem common to all quantum hardware. Here, we present a new experimental setup that integrates the tweezer technology in a cryogenic environment.

At 4K, we are able to measure a vacuum-limited lifetime of more than 6000 seconds, which represents a two-order-of-magnitude improvement over room temperature setups. In addition, we have implemented an optimised trap loading equalisation procedure that, in combination with the extended lifetime, allows us to build arrays with more than 300 atoms while maintaining high accuracy of defect-free realisations.

These results are the first step towards Rydberg quantum simulators with more than a thousand particles.

A 27.39 Thu 16:30 Empore Lichthof

Imaging the Morphology of Rare Gas Clusters — •Mario Sauppe[1], Andre Al Haddad[2], Alessandro Colombo[1], Linos Hecht[1], Gregor Knopp[2], Katharina Kolatzki[1], Bruno Langbehn[3], Caner Polat[1], Kirsten Schnorr[2], Zhibin Sun[2], Paul Tümmler[4], Carl Frederic Ussling[1], Simon Wächter[1], Alex Weitnauer[1], Julian Zimmermann[1], Maha Zuod[1], Thomas Möller[3], Christoph Bostedt[2], and Daniela Rupp[1] — [1]ETH Zurich — [2]PSI Switzerland — [3]TU Berlin — [4]Uni Rostock

Rare gas clusters are an ideal testbed to probe the interaction of intense light with matter, in theoretical and experimental approaches. The dynamics may be altered by the clusters' structure, differing from an assumed ideal shape. Short wavelength free-electron lasers (FEL) allow to retrieve real-space images of nano-sized particles via coherent diffraction imaging (CDI). Recent CDI studies have shown that large rare gas clusters (100 nm radius), produced by a supersonic gas expansion, can have rather complex structures, not necessarily following an icosahedral or spherical shape, as known for smaller clusters.

Instead, they may be agglomerates of two or three spheres or have a hailstone-like structure. To investigate the structure with a high spatial resolution, we performed a CDI-experiment on argon clusters at the SwissFEL with photon energies of up to 1 keV (1.24 nm). We find a great variety of structures, like complex agglomerates and protrusions connected to the main cluster only via a few nanometers thin neck, not contained in the current picture of cluster growth.

A 27.40 Thu 16:30 Empore Lichthof

Switching a subwavelength atomic array by a single Rydberg atom — •Pascal Weckesser[1,2], Kritsana Srakaew[1,2], Simon Hollerith[1,2], David Wei[1,2], Daniel Adler[1,2,3], Suchita Agrawal[1,2], Immanuel Bloch[1,2], 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

Understanding and tuning light-matter interactions is essential for numerous applications in quantum science. Cooperative response between light-coupled atoms has recently led to the realization of a subradiant mirror formed by an atomic monolayer with strong light-matter coupling even down to the level of single photons. Here, we control the optical response of such an atomic mirror using a single ancilla atom excited to a Rydberg state. The switching behavior is controlled by admixing Rydberg character to the atomic mirror and exploiting strong dipolar Rydberg interactions with the ancilla. Driving Rabi oscillations on the ancilla atom, we demonstrate coherent control the degree of transmission and reflection. Finally, increasing the mirror size directly reveals the spatial area around the ancilla atom where the switching is effective. Our results pave the way towards novel quantum metasurfaces and the creation of controlled atom-photon entanglement.