A 33: Poster VI

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

A 33.1 Thu 17:00 Tent A

Building neutral-atom quantum processors — •Pierre-Antoine Bourdel for the Pasqal-Collaboration — Pasqal SAS, 7 rue Léonard de Vinci, 91300 Massy, France

In the past years, neutral atoms have entered the quantum computing race. Quantum startup PASQAL has stemmed from the group of A. Browaeys and T. Lahaye, who pioneered trapping single atoms in arbitrary, defect-free and reconfigurable tweezer patterns. In this highly scalable platform, excitation to Rydberg states enables controlled interactions between atoms, and entanglement generation. Such platform has already demonstrated quantum simulations in a regime out of reach with current classical approaches. Regarding quantum computation, applications have been proposed and demonstrated for solving hard combinatorial optimisation problems, non-linear differential equations and classifying sets of graphs using machine learning. We will give an overview of the technical building blocks of our platform at PASQAL, discuss its capabilities for digital and analog-based quantum computing in the NISQ era, and present the last results that we have achieved with our neutral atoms quantum processors.

A 33.2 Thu 17:00 Tent A

FermiQP - A Fermionic Quantum Processor — •Yu Hyun Lee[1,3], Frank Hermann[1,4], Janet Qesja[1,2], Robin Groth[1,2], Andreas von Haaren[1,2], Luca Muscarella[1,2], Liyang Qiu[1,2], Immanuel Bloch[1,2,3], Timon Hilker[1,2], and Philipp Preiss[1,2] — [1]Max-Planck Institute of Quantum Optics, Garching, Germany — [2]Munich Center for Quantum Science and Technology, Munich, Germany — [3]Ludwig Maximilian University Munich, Munich, Germany — [4]Karlsruhe Institute of Technology, Karlsruhe, Germany

FermiQP is a demonstrator experiment for a lattice based fermionic quantum processor with neutral Li-6 atoms. The experiment aims to combine the versatility of digital quantum gates with the power of analogue Fermi-Hubbard simulators. Single qubit gates will be implemented as Raman rotations between hyperfine states, while controlled collisions between atoms in a bichromatic lattice will constitute two-qubit gates. Tweezer-based resorting techniques will enable all-to-all connectivity of the qubits. This also allows robust control of the starting configuration for investigating the Fermi-Hubbard phase diagram. We present the status of the experiment, including progress on the implementation of single qubit addressing, single-site and spin resolved quantum gas microscopy, and new cooling schemes for fast degenerate Fermi gas preparation.

A 33.3 Thu 17:00 Tent A

Experimental Observation of Time-Dependent Energy-Level Renormalization near Ultrastrong Couplings in Quantum-Rabi Systems — •Frederike Doerr, Florian Hasse, Alessandra Colla, Ulrich Warring, Heinz-Peter Breuer, and Tobias Schaetz — Institute of Physics, University of Freiburg, Hermann-Herder-Straße 3, D-79104 Freiburg, Germany

A novel theory, extending beyond perturbation theory, elucidates the thermodynamic behavior of open quantum systems interacting with thermal baths: predicting a time-dependent frequency shift, $\Delta\omega(t)$, arising from the interaction with the environmental mode, dependent on the system-environment coupling (g) and temperature (T) [1]. We investigate changes in the electronic energy levels of a trapped ion strongly connected to a single motional degree of freedom. Employing Ramsey interferometry and analyzing the oscillation frequencies of the system's coherences, we observe a clear and time-dependent effective shift in the ion's energy levels, consistent with the theoretical predictions. These findings provide direct evidence of dynamic energy level renormalization in strongly coupled quantum systems, emphasizing the role of memory effects in shaping the system's energy landscape.

[1] A. Colla and H.-P. Breuer, Phys. Rev. A 105, 052216 (2022).

A 33.4 Thu 17:00 Tent A

Coherent control of electron emission direction in helium with ω-2ω SASE FEL pulses — •Muwaffaq Ali Mourtada[1], Harijyoti Mandal[1], Alexander Magunia[1], Weiyu Zhang[1], Yu He[1], Hannes Lindenblatt[1], Florian Trost[1], Lina Hedewig[1], Cristian Medina[1], Arikta Saha[1], Marc Rebholz[1], Ulrike Frühling[2], Carlo Kleine[1], Gergana D. Borisova[1], Steffen Palutke[2], Evgeny Schneidmiller[2], Mikhail Yurkov[2], Stefan Düsterer[2], Rolf Treusch[2], Chris H. Greene[3], Yimeng Wang[3], Robert Moshammer[1], Christian Ott[1], and Thomas Pfeifer[1] — [1]Max-Planck-Institut für Kernphysik, 69117 Heidelberg, Germany — [2]Deutsches Elektronen Synchrotron DESY, 22607 Hamburg, Germany — [3]Purdue University, West Lafayette, IN 47907, USA

Measurements of the photoelectron angular distribution of two-photon single-ionisation in the vicinity of singly excited intermediate states in helium are presented. Using extreme-ultraviolet pulses generated at the high-repetition-rate free-electron laser in Hamburg (FLASH), helium atoms are ionized and the recoil ion momenta are measured with a reaction microscope. In a previous experiment [1], first indications for interfering pathways between FEL fundamental and its second harmonic have been observed. Here we present new measurements to further investigate the possibility of directional asymmetry in the photoelectron angular distribution of interfering one-photon and two-photon single ionization in helium. In this poster we will discuss the ongoing data analysis and show first results.

[1] Straub et al., PRL 129, 183204 (2022)

A 33.5 Thu 17:00 Tent A

Experimental investigation of strongly interacting quantum fluids of light in rydberg atoms — •Amar Bellahsene — Université de Strasbourg CESQ-ISIS, Strasbourg, France

Photons are effectively perfect quantum systems as they can be easily and efficiently generated, manipulated and detected, except they have one major drawback: they are inherently non-interacting. If we could engineer strong and tunable interactions between photons it would be a great leap forward for numerous fields, especially in many-body physics, quantum simulation and quantum computing. One of the most promising methods to simultaneously realize strong light-matter couplings and strong effective photon-photon interactions is in ultracold gases which are laser coupled to strongly-interacting Rydberg states under an electromagnetically induced transparency (EIT) resonance. My experimental PhD project consists of investigating the relatively unexplored regime where strongly interacting photons with exotic properties (long-range and nonlocal interactions) propagate inside spatially structured ultracold 39K atoms with optical tweezers.

A 33.6 Thu 17:00 Tent A

Acquisition and analysis of RABBIT measurements — •Muhammad Jahanzeb, Narendra Shah Ronak, Cristian Manzoni, Devkota Diwaka, and Giuseppe Sansone — Institute of Physics, University of Freiburg, Freiburg, Germany

The Reconstruction of Attosecond Beating by Interference of Two-Photon Transitions (RABBIT), is a technique used to measure time delays in photoionization on an attosecond scale [1-2]. In the RABBIT technique, the photoionization delays measured in atoms can be decomposed in a Wigner delay, related to the photoionization process induced by the absorption of a single extreme ultraviolet photon, and a continuum-continuum delay, due to the absorption of additional infrared photons by the freed photoelectron [2].

I will report on the development of an experimental setup aiming at the investigation of the continuum-continuum delay in photoionization. In the experimental setup, high-order harmonics will be generated using a 800 nm driving laser that will be then recombined with a synchronized 1200 nm pulse obtained using a non-collinear optical parametric amplifier [3]. Using this combination of parameters, two sidebands are expected between the each pair of photoelectron peaks associated to the absorption of a single XUV photon. By comparing the oscillations of adjacent sidebands, we are aiming to investigate the contribution of the continuum-continuum phase in the photoionization process. [1] Paul et al, Science, 292 (2001) [2] Dahlström et al, Journal of Physics, 45 (2012) [3] Manzoni et al, Journal of Optics, 18 (2016)

A 33.7 Thu 17:00 Tent A

Variable Multiphoton Lattices for Ultracold Rubidium Atoms — •Stefanie Moll[1], Geram Hunanyan[1], Johannes Koch[1], Enrique Rico[2,3,4,5], Enrique Solano[6], and Martin Weitz[1] — [1]Institut für Angewandte Physik, Universität Bonn, Wegelerstr. 8, 53115 Bonn, Germany — [2]Department of Physical Chemistry, University of the Basque Country UPV/EHU, Box 644, 48080 Bilbao, Spain — [3]Donostia International Physics Center, 20018 Donostia-San Sebastián, Spain — [4]EHU Quantum Center, University of the Basque Country UPV/EHU, P.O. Box 644, 48080 Bilbao, Spain — [5]IKERBASQUE, Basque Foundation for Science, Plaza Euskadi 5, 48009 Bilbao, Spain — [6]Kipu Quantum, Greifswalder Straße 226, 10405 Berlin, Germany

Optical lattices are versatile tools to confine atoms in tuneable periodic potentials, with applications ranging from quantum simulation to the realization of atomic clocks. Usual standing wave lattices are realized by utilizing the ac Stark shift induced by red detuned standing waves to trap cold atoms in the antinodes of the periodic intensity pattern. In a quantum picture the induced potential arises due to virtual two-photon processes. We are exploring lattice potentials created by the dispersion of multiphoton Raman processes, which allows to achieve higher spatial periodicities as well as a state-dependency of the lattice potential. Using a four-photon lattice potential to create a suitable Bloch-band structure, we have performed a quantum simulation of the quantum Rabi model. We are currently exploring the applicability of multiphoton lattices to synthesize a larger variability of potentials.

A 33.8 Thu 17:00 Tent A

Accuracy and efficiency of Particle-in-Cell schemes simulating ultrafast laser-induced plasma dynamics — •Richard Altenkirch[1], Graeme Bart[2], Christian Peltz[1], Thomas Fennel[1], and Thomas Brabec[2] — [1]Universität Rostock, Germany — [2]uOttawa, Canada

Particle-in-cell (PIC) algorithms have been developed since the 1970s and since grown into one of the most widely used tools for studying intense light-matter interactions and the associated plasma kinetics on a macroscopic scale. Lately, the introduction of the microscopic Particle-in-Cell scheme [1] has even allowed for the simulation of strongly coupled plasmas by incorporating the essential short-range interactions that are neglected in typical PIC routines. However, the need to resolve individual particles causes MicPIC to become very computationally expensive for spatial regimes above 1 micron [2]. Therefore, in order to capture effects of the spatial laser beam shape at optical frequencies on ablation processes, macroscopic PIC approaches are needed. However, MicPIC results still function as a very helpful guideline for gauging to what extent these different routines are suitable for simulating specific scenarios. Using MicPIC as a reference, we analysed the efficiency and the accuracy of PIC as well as collisional PIC schemes in the ablation scenario of a laser-induced plasma in a thin gold film.

[1] C.~Varin, C.~Peltz, T.~Brabec, T.~Fennel, Ann. Der Phys., 526 (2014), pp. 135-156

[2] G. Bart, C. Peltz, N. Bigaouette, T. Fennel, T. Brabec, C. Varin, Computer Physics Communications 219 (2017), pp. 269-285

A 33.9 Thu 17:00 Tent A

The scaling method for the numerical solution of the relativistic ionization problem — •Aleksandr V. Boitsov, Karen Z. Hatsagortsyan, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

The coordinates scaling method, previously applied to the numerical solution of the time-dependent Schrodinger equation (TDSE), is generalized for the numerical solution of the problem of an atom ionization in a relativistically strong laser field. As a first step, we focus on a one-dimensional implementation of the general idea. To facilitate the use of the scaling method, Foldy-Wouthuysen transformation is applied in Silenko's form within the quasiclassical approximation, reducing time-dependent Dirac equation (TDDE) to the square-root Klein-Gordon-like equation. The problems related to the use of nonuniform grid in the scaling method are analyzed. Comparison with known solutions of TDDE is provided.

A 33.10 Thu 17:00 Tent A

A dedicated angular streaking setup for attosecond photoionization experiments — •Lasse Wülfing[1], Niclas Wieland[2], Lars Funke[1], Arne Held[1], Wolfram Helml[1], Sara Savio[1], and Markus Ilchen[2] — [1]Technische Universität Dortmund — [2]Universität Hamburg

Angular streaking represents a scheme to resolve photoionization processes down to the attosecond regime, reaching even the natural time frame of fundamental electronic interactions in atomic and molecular systems. This is done by the reconstruction of superfast SASE free-electron laser pulses for use in photoionization experiments. A circularly polarized laser is superimposed onto the X-ray pulses, generating a birth time correlated kick for photoelectrons produced in a given target gas. By using multiple electron spectrometers in one plane around the interaction point, the initial pulses can be reconstructed.

Our group developed a dedicated detector for angular streaking, incorporating two planes of newly designed electron time of flight spectrometers for broad energy-acceptance into a mu-metal shielded vacuum chamber. The setup is meant as a versatile basis for angular streaking experiments realized in different scenarios. This poster presents an overview of the derived design and current status in the construction of the dedicated setup at FLASH (DESY).

A 33.11 Thu 17:00 Tent A

Towards machine learning optimized time-averaged potentials to generate a Bose-Einstein condensate — •Max Schlösinger[1], Victoria Henderson[1], Simon Kanthak[1], Oliver Anton[1], Elisa Da Ros[1], and Markus Krutzik[1,2] — [1]Humboldt-Universität zu Berlin, Institute of Physics & IRIS Adlershof, Newtonstraße 15, 12489 Berlin — [2]Ferdinand-Braun-Institut gGmbH, Leibniz-Institut für Höchstfrequenztechnik, Gustav-Kirchhoff-Strasse 4, 12489 Berlin

Time-averaged potentials (TAPs) are a versatile tool for the generation and manipulation of ultracold atom clouds. In order to fully take advantage of this techniques, we investigate machine learning routines with a setup based on acousto-optic deflectors.

Our aim is to mitigate non-linearities in the electro-optical system and effects due to frequency modulation which restricts predictability of shape and smoothness as well as to counteract temporal and spatial instabilities. In particular we focus on identifying the most suitable fitness function associated with the optimisation of different optical potential geometries using images based on a CCD camera.

In the future, we would like to rely on TAP's capabilities to improve the evaporative cooling routine and to enhance the efficiency of a ^{87}Rb Bose-Einstein condensate-based quantum memory.

This work is supported by the German Space Agency (DLR) with funds provided by the Federal Ministry for Economic Affairs and Climate Action (BMWK) under grant numbers No. 50WM2247.

A 33.12 Thu 17:00 Tent A

XUV Frequency Comb driven Velocity Map Imaging of Argon — •Nick Lackmann[1], Jan-Hendrik Oelmann[1], Tobias Heldt[1], Lennart Guth[1], Janko Nauta[2], Thomas Pfeifer[1], and José R. Crespo López-Urrutia[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg, Germany — [2]Swansea University, UK

Atomic clocks offer potential for fundamental physics studies due to their remarkable precision [1,2]. Opting for clock transitions in the extreme ultraviolet (XUV) not only increases achievable precision but also facilitates spectroscopy on systems such as highly charged ions and the thorium-229m nuclear transition. To realize this, an extreme-ultraviolet frequency comb was constructed using cavity-enhanced high-harmonic generation, driven by a 100 MHz near-infrared frequency comb [3]. This approach generates harmonics up to 42 eV. The resulting harmonics are employed in a resonant ionization protocol, where the comb excites the transition of interest, followed by ionization with a narrow NIR laser. The electron momenta are captured using the velocity map imaging technique to simultaneously record multiple transitions.

[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)

A 33.13 Thu 17:00 Tent A

Towards Multidimensional XUV Spectroscopy Combined with Spectral Interferometry — •Lina Hedewig, Carlo Kleine, Alexander Magunia, Christian Ott, and Thomas Pfeifer — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, Heidelberg 69117, Germany

Using two infrared (IR) and two extreme ultraviolet (XUV) ultrashort pulses we are currently implementing a method for multidimensional XUV spectroscopy combined with spectral interferometry to gain further insight into gas-phase quantum dynamics of atoms and molecules.

The setup is based on a four quadrant split-and-delay mirror which allows independent time delay control of each beam with attosecond precision, similar to [1]. One XUV pulse excites an electronic wavepacket in the target generating a coherent dipole response. This wavepacket is strong-field coupled by the two intensity-tunable IR pulses, allowing selective control of state-specific quantum dynamics.

Due to phase-matching requirements, the IR-modified response can be diffracted towards the remaining fourth beam, comparable to [2], and creates a nearly background-free signal, partially still overlapping with the initial XUV beam. Spatially resolving the signals in our XUV spectrometer, both collinear and non-collinear pathways are recorded. To additionally extract the phase of the dipole response, the second XUV beam serves as local oscillator for heterodyned spectral interferometry. The poster presents the experimental setup and first measurements.

[1] Zhang et al., Opt. Lett. 38, 356-358 (2013)
[2] Bengtsson et al., Nature Photon 11, 252-258 (2017)

A 33.14 Thu 17:00 Tent A

Fundamental physics tests with an optical clock based on Ca^{14+} — •Malte Wehrheim[1], Lukas J. Spiess[1], Alexander Wilzewski[1], Shuying Chen[1], Jan Richter[1], Agnese Mariotti[4], Elina Fuchs[4], Andrey Surzhykov[1,5], Erik Benkler[1], Melina Filzinger[1], Nils Huntemann[1], José R. Crespo Lopez-Urrutia[2], and Piet O. Schmidt[1,3] — [1]Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig, Germany — [2]Max-Planck-Instituts für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany — [3]Institut für Quantenoptik, Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover, Germany — [4]Institut für Theoretische Physik, Leibniz Universität Hannover, Appelstraße 2, 30167 Hannover, Germany — [5]Technische Universität Braunschweig, Universitätsplatz 2, 38106 Braunschweig, Germany

We conduct quantum logic spectroscopy on highly charged ions enabling us to measure atomic parameters which are compared to ab-initio calculations. Clock operation is performed by stabilizing a laser to the $^3P_0 \rightarrow {}^3P_1$ fine structure transition in Ca^{14+}. Its absolute frequency is determined by comparing it to the atomic clock based on the Yb^+ octupole transition at PTB. Measurements of the five stable isotopes of calcium with even number of nucleons to 2 parts in 10^{16} yield the isotope shifts with a fractional uncertainty of $2 * 10^{-10}$. By combining this result with spectroscopy data in singly charged calcium and precise measurements of the nuclear masses, bounds can be placed on a hypothetical fifth force.

A 33.15 Thu 17:00 Tent A

The LSYM experiment — •Andreas Thoma, Daniel Rubin, Lukas Holtmann, Fabian Raab, Maria Pasinetti, Sangeetha Sasidharan, and Sven Sturm — Max Planck Institut für Kernphysik

One of the currently most important and unsolved questions in physics is the unbalance in quantity of matter and antimatter in the universe, which is in contradiction to Quantum Electrodynamics (QED), the most successful quantum field theory in the Standard Model.

LSym is a cryogenic Penning trap experiment being developed to measure mass, charge and g-factor of positrons and electrons at a precision of 10e-14 magnitude, that could possibly falsify CPT symmetry.

To achieve such accuracy the particles have to be cooled down to 300mK to ensure finding the positron in the ground state where spinflips can be accessed via excitations of the Larmor mode.

Here, the experimental setup and methods as well as challenges of cooling to cryogenic temperatures will be presented.

A 33.16 Thu 17:00 Tent A

Pairing dome from an emergent Feshbach resonance in a strongly repulsive bilayer model — •Hannah Lange[1,2,3], Lukas Homeier[1,3], Eugene Demler[4], Ulrich Schollwöck[1,3], Annabelle Bohrdt[3,5], and Fabian Grusdt[1,3] — [1]LMU Munich, Germany — [2]MPI for Quantum Optics, Garching, Germany — [3]Munich Center for Quantum Science and Technology, Germany — [4]ETH Zurich, Switzerland — [5]University of Regensburg, Germany

A key to understanding unconventional superconductivity lies in unraveling the pairing mechanism of mobile charge carriers in doped antiferromagnets, giving rise to an effective attraction between charges even in the presence of strong repulsive Coulomb interactions. In this talk, I will consider a mixed-dimensional t-J ladder, a system that has recently been realized with ultracold atoms [1], and show how it can be extended with a nearest neighbor Coulomb repulsion. With repulsion turned off, the system features tightly bound hole pairs and large binding energies (closed channel). When the repulsion strength is increased, a crossover to more spatially extended, correlated pairs of individual holes (open channel) can be observed. In the latter regime, we still find robust binding energies that are strongly enhanced in the finite doping regime. The effective model in the strongly repulsive regime reveals that the attraction is mediated by the closed channel, in analogy to atomic Feshbach resonances between open and closed channels [2].

[1] Hirthe et al., Nature 2023
[2] Lange et al., arXiv:2309.15843, 2309.13040

A 33.17 Thu 17:00 Tent A

ARPES spectroscopy of an extended Majumdar-Ghosh model — •Simon M. Linsel[1,2], Nader Mostaan[1,2,3], Annabelle Bohrdt[2,4], and Fabian Grusdt[1,2] — [1]LMU Munich, Germany — [2]Munich Center for Quantum Science and Technology, Germany — [3]Université Libre de Bruxelles, Brussels, Belgium — [4]University of Regensburg, Germany

Experimental and numerical spectroscopy have revealed novel physics in anti-ferromagnets, in particular in frustrated and doped systems. The Majumdar-Ghosh (MG) model has an analytically known spin-disordered ground state of dimerized singlets as a result of magnetic frustration. Here we study the single-hole angle-resolved photoemission spectroscopy (ARPES) spectrum of an extended MG model, where we introduce a spin-density interaction that is experimentally accessible with ultracold molecules. We report a bound spinon-holon ground state and clear signatures of a spinon-holon molecule state and polarons in the ARPES spectrum at different magnetizations. We also apply a Chevy ansatz to gain analytical insights into the molecule spectrum. Our results provide new insights into the physics of dopants in frustrated t-J models.

A 33.18 Thu 17:00 Tent A

Advances in microfabrication of Metallic Magnetic Calorimeters — •Daniel Kreuzberger, Andreas Reifenberger, Andreas Abeln, Alexander Orlow, Daniel Hengstler, Andreas Fleischmann, and Christian Enss — Heidelberg University

Metallic Magnetic Calorimeters (MMCs) are low temperature particle detectors which can reliably be produced with multilayer microfabrication techniques. Moreover, the consequent use of these techniques allows for the fabrication of thousands of virtually identical detectors as required for large, dense packed arrays. Using various examples of current MMC detectors which are actively used for high resolution x-ray spectroscopy, we present the status of our microfabrication processes. This includes the fabrication of overhanging x-ray absorbers made of gold with a thickness up to $100\,\mu$m. For this, a newly developed fabrication process is presented, preventing almost all athermal phonons from escaping in the substrate without thermalization in the sensor. We also discuss copper filled Through-Silicon-Vias (TSV) used to heatsink the detector pixels to the wafer backside.

A 33.19 Thu 17:00 Tent A

Tests of QED and determination of nuclear parameters with the hydrogenlike beryllium-9 ion — •Bastian Sikora, Vladimir A. Yerokhin, Zoltan Harman, and Christoph H. Keitel — Max Planck Institute for Nuclear Physics, Heidelberg, Germany

In an external magnetic field, the ground state of the $^9Be^{3+}$ ion is split into multiple sublevels due to hyperfine and Zeeman effect. The bound electron's g-factor, the ground-state hyperfine splitting as well as the shielded magnetic moment of the nucleus can be determined by measurements of transition frequencies between these sublevels [1].

We present theoretical calculations of the nuclear shielding constant, the ground-state hyperfine splitting and the bound-electron g-factor [2]. The nuclear shielding constant is used to extract the magnetic moment of the bare nucleus with unprecedented precision, enabling a first test of multi-electron shielding calculations performed for the lithiumlike $^9Be^+$ ion. Furthermore, we improve the accuracy of the effective nuclear Zemach radius using the theory of hyperfine splitting. We also present the contributions of muonic and hadronic vacuum polarization to hyperfine splitting, calculated for different nuclear models [3]. We also study a weighted difference of hyperfine splittings of the hydrogenlike and ithiumlike Be ions which is found to be in excellent agreement with experimental results.

[1] A. Schneider, B. Sikora, S. Dickopf, et al., Nature **606**, 878 (2022)
[2] S. Dickopf, B. Sikora, et al., in preparation
[3] J. Heiland and B. Sikora, in preparation

A 33.20 Thu 17:00 Tent A

Off-resonant measurements of trapped ions using a dual hot-end resonator — •Stefan Ringleb[1], Markus Kiffer[1], Manuel Vogel[2], and Thomas Stöhlker[1,2,3] — [1]Friedrich Schiller-Universität Jena, 07743 Jena, Germany — [2]GSI Helmholtzzentrum für Schwerionenforschung, 64291 Darmstadt, Germany — [3]Helmholtz-Institut Jena, 07743 Jena, Germany

Ion detection in Penning traps is typically done using resonant circuits which consist of a wound coil connected to one electrode. The oscillating ions induce a current via mirror charges which drives the resonator resulting in a voltage for ion detection. Using such configurations in combination with superconducting coils, also single ions can be detected. This technique also allows for fast resistive ion cooling to reduce the centre-of-momentum energy of an ion or an ion ensemble with a correlated ion motion.
In our setup, we have investigated another approach - a normal-conducting resonator connected to two opposing electrodes. In this configuration, we are able to detect ion ensembles with a considerably high centre-of-momentum motion both in resonance and off resonance. This allows for ion detection without concurrent ion cooling opening new possibilities to characterise the ion bunch properties - in particular the transfer of ion energy from the centre-of-mass motion to the uncorrelated axial motion.
We will present our experimental setup and will give insight into the methods we can apply to determine the dephasing behaviour of the ion bunch.

A 33.21 Thu 17:00 Tent A

Quantum orbit simulations of above-threshold ionization (ATI) on nanometric tips with few-cycle pulses — •Timo Wirth and Peter Hommelhoff — Lehrstuhl für Laserphysik, Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Erlangen

When nanometric tips are exposed to light in the strong field regime, electrons in the tip are ionized through tunnel ionization (step 1). The free electrons are then driven in the laser field (step 2). While most of these electrons will not return to the tip (direct electrons), a fraction is driven back to the tip and elastically scatters at the tip surface (step 3). This rescattering process can be understood classically within the three-step model. Classical simulations can give insights into the rescattering process, but a quantum-mechanical approach allows deeper insights. This can be done with the time-dependent Schrödinger equation (TDSE). However, TDSE simulations often do not allow a good qualitative understanding of the results. Such an understanding can be gained from quantum orbit simulations. The quantum orbit theory is based on the strong-field approximation (SFA) and includes the crucial quantum mechanics ab initio. We discuss the results of quantum orbit simulations of the ATI process at nanometric needle tips.

A 33.22 Thu 17:00 Tent A

Momentum induced tunneling of Bose-Einstein Condensates — •Daida Thomas[1], Knut Stolzenberg[1], Dustin Lindberg[2], Sebastian Bode[1], Denys Bondar[2], Ernst M Rasel[1], Naceur Gaaloul[1], and Dennis Schlippert[1] — [1]Leibniz Universität Hannover, Institut für Quantenoptik, Welfengarten 1, 30167 Hannover — [2]Tulane University, 6823 St. Charles Avenue, New Orleans, LA 70118

Quantum tunneling of BEC's in a double well potential has been explored in the realm of entanglement generation and Josephson tunneling. Traditional approaches for creating a double well mostly involved inserting barriers in a single well leading to the creation of a double-well system. We accelerate atoms towards a barrier in a double-well system, inducing momentum driven tunneling and envision testing our technique with asymmetric barriers. This is done in optical dipole traps, incorporating acousto-optical deflectors, thereby allowing versatile control over the trapping potentials with respect to position and trap depth. The sample used is a ^{87}Rb Bose-Einstein condensate, prepared in a magnetically insensitive state, with a sample size of up to 300×10^3 atoms. We report on preliminary implementation prospects of tunneling to study the preferential tunneling direction of BEC's and quantum correlations stemming from the nonlinear dynamics of atomic interactions.

A 33.23 Thu 17:00 Tent A

Ion microscope as a versatile tool for probing Rydberg physics, ultracold ions and hybrid systems — •Viraatt S.V. Anasuri[1], Moritz Berngruber[1], Jennifer Krauter[1], Ruven Conrad[1], Raphael Benz[1], Óscar Andrey Herrera Sancho[1,2,3,4], Florian Meinert[1], Robert Löw[1], and Tilman Pfau[1] — [1]5. Physikalisches Institut and Center for Integrated Quantum Science and Technology, Universität Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany — [2]Escuela de Física, Universidad de Costa Rica, 2060 San Pedro, San José, Costa Rica — [3]Centro de Investigación en Ciencia e Ingeniería de Materiales, Universidad de Costa Rica, 2060 San Pedro, San José, Costa Rica — [4]Centro de Investigación en Ciencias Atómicas, Nucleares y Moleculares, Universidad de Costa Rica, San José, Costa Rica

The long-range interactions in ion-atom hybrid systems lead to fascinating phenomena that can be spatially and temporally studied using our high-resolution ion microscope. Our recent studies on a cold ion-Rydberg system with rubidium atoms include observation of novel bound molecular states. Owing to the nature of the long range interactions, the s-wave scattering regime for ion-atom hybrid systems has thus far been elusive. Our proposed initialization of the scattering event via photo-ionization of an ultra-long range Rydberg molecule of lithium atoms combined with the excellent resolution and electric field stability of our ion microscope makes it possible to enter the few partial wave regime.

A 33.24 Thu 17:00 Tent A

A dedicated 2-dimensional array of metallic magnetic microcalorimeters to resolve the 29.18keV doublet of ^{229}Th — •A. Striebel, A. Abeln, S. Allgeier, A. Brunold, J. Geist, D. Hengstler, D. Kreuzberger, 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 valuable insights, we will improve our high-resolution measurement [Sikorsky et al., PRL 125, 2020] of the γ-spectrum following the α-decay of ^{233}U. This decay partially results in excited ^{229}Th with a nuclear state at 29.18 keV. Resolving the doublet, that in turn results from de-excitation to the ground and isomer state, respectively, would allow an independent measurement of the isomer energy as well as the branching ratio of both transitions. To resolve this doublet, a 2D detector array consisting of 8×8 metallic magnetic calorimeters (MMCs) was fabricated. MMCs are operated at mK temperatures and convert the energy of a single incident γ-ray photon into a temperature pulse which is measured by a paramagnetic temperature sensor. We discuss the detector properties, including an energy resolution of 3.1 eV (FWHM) at 5.9 keV and present first spectra of ^{229}Th taken with this detector.

A 33.25 Thu 17:00 Tent A

Progress towards a novel apparatus for unit testing of ion trap prototypes and development of ion transport protocols — •Ludwig Krinner[1,2], Christian Joohs[1,2], Tobias Pootz[1], Emma Vandrey[1], Nila Krishnakumar[2], and Friederike Giebel[2] — [1]Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover — [2]Physikalisch Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig

We report on progress towards an apparatus for testing and characterization of an in-house fabricated surface-electrode ion-trap chip [1], for realization of the QCCD-architecture [2, 3]. The apparatus will mount the combination of trap-chip and chip-interposer on a socket made from PEEK and copper, which also house various ablation-targets for loading beryllium, calcium and strontium. The apparatus has an integrated system for in-situ surface cleaning using argon ions [4], to enable low heating rates.

We will present the current status of the the setup, specifically the characterization of imaging optics, progress on the beam-delivery setup as well as a realization of transport waveforms to be tested on the trap chip currently in micro-fabrication.

[1] A. Bautista-Salvador et al., N. J. Phys., Vol. 21, 043011 (2019)
[2] D.J. Wineland et al., J. Res. Natl. Inst. Stand. Technol. 103, 259 (1998)
[3] D. Kielpinski, C. Monroe, and D. J. Wineland, Nature 417, 709 (2002)
[4] D. A. Hite et al., Phys. Rev. Lett., Vol. 109, 103001 (2012)

A 33.26 Thu 17:00 Tent A

Nonlinear Pulse Compression Multi-Pass Cell characterized by Frequency-Resolved Optical Gating for Extreme-Ultraviolet Frequency Comb Generation — •Fiona Sieber[1], Lennart Guth[1], Jan-Hendrik Oelmann[1], Tobias Heldt[1], Prachi Nagpal[1], Nick Lackmann[1], Simon Angstenberger[1], Stepan Kokh[1], Hannah Unold[1], Lukas Matt[1], Janko Nauta[2], Thomas Pfeifer[1], and José R. Crespo López-Urrutia[1] — [1]Max-Planck-Institut for Nuclear Physics, Heidelberg, Germany —

[2]Department of Physics, Swansea University, Singleton Park, SA2, United Kingdom

To conduct precision spectroscopy beyond the optical regime, we transfer a near-infrared frequency comb with 100 MHz repetition rate via high harmonic generation to the Extreme-Ultraviolet [1]. We aim to increase the yield of the harmonics by further compressing the 80 W pulses in a Herriott-type Multi-Pass Cell (MPC). In the MPC the pulses are focused into a nonlinear medium where they undergo self-phase modulation. Multiple passes stepwise broaden the spectrum implying a decreased fourier transform limit for the pulse duration [2]. Using a post-compression set-up with chirped mirrors, we decreased our pulse length of 200 fs to 100 fs. A Frequency-Resolved Optical Gating set-up is used to evaluate the pulse shape and duration.

[1] J. Nauta et al., Optics Express, Vol. 29, No. 2, 2624 (2018)
[2] A.-L. Viotti et al., Optica, Vol. 9, No. 2, 197 (2022)

A 33.27 Thu 17:00 Tent A

Multi-Pass Process Tomography: precision and accuracy enhancement — •Stancho Stanchev — Department of Physics, St Kliment Ohridski University of Sofia, 5 James Bourchier blvd, 1164 Sofia, Bulgaria

In this work, we introduce an alternative method to enhance the precision and accuracy of Quantum Process Tomography (QPT) by mitigating the errors caused by state preparation and measurement (SPAM), readout and shot noise. Instead of conducting QPT solely on a single gate, we propose performing QPT on a pulse train (multi-pass) consisting of multiple identical instances of the gate. By obtaining the Pauli transfer matrix of the multi-pass process, we outline a post-processing procedure for a more precise and accurate characterization of the single process. We demonstrate the effectiveness of this approach through simulation on the IBM Quantum - ibmq qasm simulator and experimental implementation on the processor ibmq manila, Falcon r5.11L.

A 33.28 Thu 17:00 Tent A

On The Generation Of Arbitrary Tweezer Geometries For Neutral Atom Quantum Computing — •Jakob Wüst[1], Stefan Boschmann[1], Jonas Gutsche[1], Jens Nettersheim[1], Jonas Witzenrath[1], Niclas Luick[2], Thomas Niederprüm[1], Dieter Jaksch[2], Henning Moritz[2], Herwig Ott[1], Peter Schmelcher[2], Klaus Sengstock[2], and Artur Widera[1] — [1]RPTU Kaiserslautern-Landau, Kaiserslautern, Germany — [2]University of Hamburg, Hamburg, Germany

The advent of commercially viable quantum computation will critically improve our ability to solve hard optimization problems. This requires an easily scalable and stable platform, for which neutral atom based systems are a promising candidate. As core components of such quantum computers, the generation and control of homogeneous trapping arrays as well as their deterministic loading are of particular interest.

Here, we report on the generation of large arrays of optical tweezers with a Spatial Light Modulator (SLM). We characterize the tweezer array and quantify the limitations imposed on the patterns by our experimental conditions. Furthermore, we present a method for characterizing a sorting beam controlled by two separate acousto-optic deflectors and the response of the beam to different forms of radio frequency ramps and different ramping speeds.

A 33.29 Thu 17:00 Tent A

Tracking XUV strong couplings with absorption line-shape changes and underlying population transfer with a convolutional neural network — •Alexander Magunia, Daniel Richter, Marc Rebholz, Christian Ott, and Thomas Pfeifer — Max-Planck-Institut für Kernphysik, 69117 Heidelberg, Germany

The electronic states within an atom or molecule determine their properties, also while interacting with their environment. As shown recently in helium atoms, electronic population can be effectively transferred from the ground state to valence states with intense extreme-ultraviolet (XUV) free-electron laser pulses via Rabi cycling (1). The underlying strong-field coupling of states during the Rabi dynamics also leads to changes in the absorption line shape (2,3).

In our contribution, we will describe methods to model and understand ultrafast strong couplings in a two-level system and resulting absorption line-shape changes. Furthermore, we extend the system by including two excited bound states or an ionization continuum. We also present a convolutional neural network, which can predict time-resolved electronic bound-state populations from the (simulated) absorption spectra.

(1) S.N. et al., Nature 608, 488-493 (2022)
(2) Phys. Rev. Lett. 123, 163201 (2019)
(3) Appl. Sci. 10, (18) 6153 (2020)

A 33.30 Thu 17:00 Tent A

All-optical matter-wave lensing to pK energie — •Alexander Herbst[1], Timothé Estrampes[1,2], Robin Corgier[3], Wei Liu[1], Knut Stolzenberg[1], Eric Charron[2], Ernst Rasel[1], Naceur Gaaloul[1], and Dennis Schlippert[1] — [1]Leibniz Universität Hannover, Institut für Quantenoptik, Welfengarten 1, 30167 Hannover, Germany — [2]Université Paris-Saclay, CNRS, Institut des Sciences Moléculaires d'Orsay, 91405 Orsay, France — [3]LNE-SYRTE, Observatoire de Paris, Université PSL, CNRS, Sorbonne Université 61 avenue de l'Observatoire, 75014 Paris, France

We report on an all-optical collimation method for matter-waves, utilizing time-averaged potentials and tunable interactions. By rapid decompression of an optical dipole trap, we induce size oscillations to a BEC, which are then used to minimize the momentum spread of the ensemble with a well-timed release. Additionally, we choose ^{39}K as atomic species which allows to tailor the atomic scattering length by means of magnetic Feshbach resonances. Minimizing interactions, we show an enhancement of the collimation compared to the strong interaction regime, realizing ballistic 2D expansion energies of 438 ± 77 pK in our experiment. We analyze the individual contributions to the ensemble dynamics, using an accurate simulation of our results. Based on our findings we present an advanced scenario which allows for 3D expansion energies below 16 pK by implementing an additional pulsed delta-kick collimation directly after release from the trapping potential.