A 35: Poster: Precision spectroscopy of atoms and ions (with Q)

Time: Thursday 17:00–19:00 Location: C/Foyer

A 35.1 Thu 17:00 C/Foyer

Rydberg spectroscopy using optical and electrical read out in thermal vapor cells — •Johannes Schmidt[1,2], Renate Daschner[1], Patrick Schalberger[2], Harald Kübler[1], Norbert Frühauf[2], and Tilman Pfau[1] — [1]5. Physikalisches Institut — [2]Institut für großflächige Mikroelektronik, Universität Stuttgart, Germany

Rydberg atoms in a thermal vapor are discussed as promising candidates for the realization of quantum devices such as single photon sources or single photon subtractors. We present a very sensitive and scalable method to measure the population of highly excited Rydberg states in a thermal vapor cell of rubidium atoms. For this application a cell with structured electrodes and a sealing method based on anodic bonding was invented [1]. The large DC Stark shift of Rydberg atoms provides a possibility to induce transmission or absorption in the medium. Rydberg spectroscopy can be done either by measuring the optical transmission [2] or the Rydberg ionization current [3]. This technique is compatible with state of the art fabrication methods of thin film electronics offering both scalability and miniaturization. Future prospects are arrays of individually addressable sites with integrated electronics, e.g. for signal amplification.

[1] Daschner, R., et al., Appl. Phys. Lett. 105, 041107 (2014)
[2] Daschner, R., et al., Opt. Lett. 37, 2271 (2012)
[3] Barredo, D.,et al., Phys. Rev. Lett. 110, 123002 (2013)

A 35.2 Thu 17:00 C/Foyer

An ultra-stable cryogenic Paul Trap for Quantum Logic Spectroscopy of Highly Charged Ions — •Maria Schwarz[1,2], Lisa Schmöger[1,2], Peter Micke[1,2], Tobias Leopold[1], Joachim Ullrich[1], José Ramon Crespo López-Urrutia[2], and Piet Oliver Schmidt[1,3] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg — [2]QUEST Institute for Experimental Quantum Metrology, Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig — [3]Institut für Quantenoptik, Leibniz Universität Hannover, 30167 Hannover

For the purpose of high precision frequency measurements on highly charged ions (HCI) an ultra-stable cryogenic Paul trap is currently being designed at the MPIK in collaboration with the PTB. The design of this trap is based on the cryogenic Paul trap experiment (CryPTEx), which in combination with the ion injection capability from an electron beam ion trap has been successfully used for the storage and sympathetic cooling of HCIs in a Coulomb crystal. Furthermore, the extremely low background pressure provides a long storage time for HCIs which is essential for precision. The next generation design focuses on the decoupling of the vibrations in order to obtain more stable trapping conditions. Two vibration damping stages are implemented between the cryostat and the trap chamber. A horizontal design of the cryogenic supply parts beneath the laser table guarantees an optimized access to the trap. Our final goal is the application of quantum logic spectroscopy, where a singly charged ion species is responsible for sympathetic cooling and state detection of the HCI.

A 35.3 Thu 17:00 C/Foyer

Single-shot 3D-imaging of mixed-species coulomb crystals with a plenoptic camera — •Baptist Piest[1], Lisa Schmöger[1,2], and José R. Crespo López-Urrutia[1] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg — [2]Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig

It has recently been demonstrated in [1], that it is possible to combine light field microscopy techniques [2] with three-dimensional (3D) deconvolution to obtain the 3D-structure of dilute atomic gas clouds. A similar setup is currently being setup at the Cryogenic Paul Trap Experiment (CryPTEx) [3]. It is of particular interest for understanding the spatial structure of 3D Be^+-coulomb crystals with individually implanted highly charged ions and as input for molecular-dynamics simulations. For this purpose, the construction is optimized for imaging the fluorescent light of the $^2S_{1/2}$ - $^2P_{3/2}$ transition in $^9Be^+$ driven by a cooling-laser at 313 nm. The spatial structure can be obtained in two steps: The first one is the digital refocussing of the light field to a stack of different focal planes. The second step requires the numerical deconvolution of the refocused images with the 3D point spread function (PSF). The measurement of the PSF is thus an essential step for a successful application of this technique.

[1] K. Sakmann and M. Kasevich, arXiv:1405.3598 [physics.atom-ph] (2014).
[2] M. Levoy et al., ACM Transactions on Graphics 25(3), Proc. SIGGRAPH (2006).
[3] M. Schwarz et al. Rev. Sci. Instr. 83, 083115 (2012).

A 35.4 Thu 17:00 C/Foyer

Towards investigations of highly charged rare and unstable isotopes — •Hendrik Bekker[1], Michael Blessenohl[1], Sergey Eliseev[1], Klaus Werner[2], Klaus Blaum[1], and José R. Crespo López-Urrutia[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg — [2]Eberhard Karls University, Tübingen

Highly charged ions of unstable isotopes are required for two new projects at the Heidelberg electron beam ion trap (HD-EBIT): (i) Within the framework of the ECHo collaboration the Penning-trap experiment PENTATRAP aims to measure the masses of ^{163}Ho and ^{163}Dy to high precision [1,2]. The Q-value of the electron capture process in ^{163}Ho obtained in this way is an important input for the determinations of the electron neutrino mass. (ii) The lightest unstable element, technetium, was observed in S-type stars in 1952 already and was an important piece of evidence for nucleosynthesis [3]. Presently, spectroscopic data of highly charged technetium is required to further improve our understanding of stellar evolution and dynamics.

For the production of the required ions, the unstable isotopes need to be efficiently injected into HD-EBIT. To this end a wire probe injector [4] is currently under development, first results will be presented.

[1] L. Gastaldo et al., J. Low Temp. Physics., 876-884, 176 (2014)
[2] J. Repp et al., Appl. Phys. B 107 983 (2012)
[3] P.W. Merrill, The Astrophysical Journal 116 21 (1952)
[4] S.R. Elliot and R.E. Marrs, Nucl. Instrum. Methods B 100 529 (1995)

A 35.5 Thu 17:00 C/Foyer

Dating with Atom Trap Trace Analysis of ^{39}Ar — •Sven Ebser[1], Florian Ritterbusch[1,2], Zhongyi Feng[1], Anke Heilmann[1], Arne Kersting[2], Werner Aeschbach-Hertig[2], and Markus K. Oberthaler[1] — [1]Kirchhoff-Institute for Physics, Heidelberg, Germany — [2]Institute of Environmental Physics, Heidelberg, Germany

Atom Trap Trace Analysis (ATTA) is an ultra-sensitive counting method for rare isotopes. It is based on the high selectivity of resonant photon scattering during laser cooling and trapping in order to distinguish the rare isotope from the abundant ones. The special strength of this method lies in small sample sizes required for dating with long-lived isotopes.

We have developed an ATTA-setup for the rare argon isotope ^{39}Ar. As an inert noble gas and with a half-life of 269 years it is the perfect tracer for dating ice and water samples in the time range between 50 and 1000 years before present. In this range no other reliable tracer exists. The experimental challenge lies in the low atmospheric abundance of ^{39}Ar ($^{39}\mathrm{Ar}/\mathrm{Ar} = 8.23\times10^{-16}$) and in the required stable and reproducible performance of all components of the apparatus leading to a robust ^{39}Ar detection efficiency. We achieved a stable atmospheric count rate of 3.58 ± 0.10 atoms/h with which we dated groundwater samples with ^{39}Ar-ATTA for the first time.

A 35.6 Thu 17:00 C/Foyer

Approaching 10^{-19} relative frequency uncertainty with an optical clock based on ion Coulomb crystals — •Tobias Burgermeister[1], Jonas Keller[1], Dimitri Kalincev[1], Miroslav Doležal[2], Petr Balling[2], and Tanja E. Mehlstäubler[1] — [1]Physikalisch-Technische Bundesanstalt, Braunschweig, Germany — [2]Czech Metrology Institute, Prague, Czech Republic

Single ion optical clocks are fundamentally limited in stability by quantum projection noise and require days or weeks of averaging to resolve frequencies with 10^{-18} uncertainty. We want to show that it is possible to increase the stability by building a clock based on ion Coulomb crystals with $^{115}In^+$ ions sympathetically cooled by $^{172}Yb^+$ ions.

Therefore we developed a chip-based linear Paul trap design, which is optimized for minimum axial micromotion [1,2]. Using a prototype trap made out of Rogers4350 we compare different techniques for micromotion minimization and show that we can measure micromotion amplitudes corresponding to fractional frequency shifts of below 10^{-19} for $^{115}In^+$. In the prototype trap a heating rate of less than 2 phonons/s at a trap frequency of 500 kHz was observed.

With an advanced next generation ion trap based on gold coated AlN wafers experiments and simulations of the trap temperature rise due to the applied high RF voltage have been carried out at CMI, Prague. From first results we expect a fractional frequency uncertainty due to black-body radiation of the trap on the level of a few 10^{-19}.

[1] Herschbach *et al.*, *Appl. Phys. B* **107**, 891 (2012)
[2] Pyka *et al.*, *Appl. Phys. B* **114**, 231 (2013)

A 35.7 Thu 17:00 C/Foyer

Towards Precision Spectroscopy of Argon XIV in the SpecTrap Penning Trap — •Tobias Murböck[1], Stefan Schmidt[2,3], Zoran Andelkovic[4], Gerhard Birkl[1], Volker Hannen[5], Kristian König[2], Alexander Martin[1], Wilfried Nörtershäuser[2], Manuel Vogel[1,4], Jonas Vollbrecht[5], Danny Segal[6], and Richard Thompson[6] — [1]IAP, TU Darmstadt — [2]IKP, TU Darmstadt — [3]Institut für Kernchemie, Universität Mainz — [4]GSI Darmstadt — [5]IAP, Universität Münster — [6]Department of Physics, Imperial College London

In few-electron ions, the strong electric and magnetic fields in the vicinity of the ionic nucleus significantly influence the remaining electronic system. By means of laser spectroscopy, the transition energies and lifetimes of fine structure and hyperfine structure transitions in highly charged ions (HCI) can be determined with an accuracy that reveals the contributions of bound-state QED in strong fields. We present the SpecTrap experiment located at the HITRAP facility at GSI and the associated low-energy beamline, which is currently being operated with an EBIS to produce mid-Z HCI such as Ar13+ and a second ion source for Mg+. Laser cooling on Mg+ ions to the mK regime and other functionalities of the trap have already been demonstrated. By use of resistive and sympathetic cooling with Mg+, the HCI can be cooled to cryogenic temperatures to prolong the storage time of the HCI and reduce Doppler broadening to some 10 MHz. Here, we discuss the scientific outline, the experimental apparatus and first results of the detection and manipulation of ions inside the Penning trap.

A 35.8 Thu 17:00 C/Foyer

A power stabilized UV laser system for cooling trapped Be^+ ions — •Stefanie Feuchtenbeiner[1], Lisa Schmöger[1,2], Oscar O. Versolato[1,2], Alexander Windberger[1], Matthias Kohnen[2], Piet O. Schmidt[2,3], and José R. Crespo López-Urrutia[1] — [1]MPI für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg — [2]PTB, Bundesallee 100, 38116 Braunschweig — [3]Institut für Quantenoptik, Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover

Cold, precisely localized highly charged ions (HCIs) are of particular interest for metrology and investigations of fundamental physics. Cold HCIs are prepared by means of sympathetic motional cooling, since direct laser cooling is not possible due to a lack of suitable laser transitions. $^9Be^+$ is the cooling ion of choice here, since it can be co-trapped with HCIs in a cryogenic linear Paul trap. The Doppler cooling laser drives the $^2S_{1/2}$ - $^2P_{3/2}$ transition in $^9Be^+$ at 313 nm. Its design is based on [1], generating the sum frequency of 1051 nm and 1550 nm from two fiber lasers in a PPLN crystal with quasi-phase matching followed by cavity-enhanced second harmonic generation in a BBO crystal stabilized by a Hänsch-Couillaud lock. Time-dependent measurements of fluorescence intensities and efficient laser cooling require a stable output power at 313 nm. For this purpose, two setups working on different time scales have been implemented. The first one compensates slow power drifts at 626 nm using a motorized $\lambda/2$-waveplate and a Glen-α-polarizer, and the second one suppresses fast power fluctuations at 313 nm with an acousto-optic modulator as key element.

[1] A. C. Wilson et al., Appl. Phys. B 105 (2011)

A 35.9 Thu 17:00 C/Foyer

Auflösung radiativer Rekombinationsprozesse durch Absorptionskanten — •Daniel Hollain[1], Hendrik Bekker[1], José Ramón Crespo López-Urrutia[1], Sven Bernitt[1,2] und Michael Blessenohl[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg, Deutschland — [2]Friedrich-Schiller-Universität, Jena, Deutschland

Die Energieauflösung von Röntgen-Photonendetektoren im Bereich von 50 keV ist typischerweise etwa 500 eV FWHM. Für die Untersuchung der Rekombination freier Elektronen mit hochgeladenen Ionen von schweren Elementen ist es nötig, einen etwa zehnmal besseren Wert zu erreichen, weil dadurch der Einfang von Elektronen in verschiedenen Ladungszuständen unterschieden werden kann. Zu diesem Zweck wurden Metallfolien mit charakteristischen Absorptionskanten vor einem Röntgendetektor positioniert. Die Energieschwelle der Absorptionskante ließ sich diskret variieren, indem diverse Materialien, wie Wolfram und Tantal, gewählt wurden. Die Folien absorbieren Photonen oberhalb ihrer Absorptionskante. Dazu wurde die Energie der rekombinierenden Elektronen kontinuierlich variiert, und der inverse Photoeffekt (genannt radiative Rekombination) beobachtet. Die Photonenenergie hängt dabei linear von der Elektronenenergie ab, mit dem Ionisationspotential als konstanter additiver Parameter. Mit Hilfe dieses Effekts wurde in einem Ensemble von Iridiumionen helium- bis fluorartige Ladungszustände untersucht, und die jeweiligen Ionisationspotentiale wurden daraus mit Unsicherheiten in Größenordnungen von 20 eV bestimmt. Theoretischen Vorhersagen aus MCDF-Rechnungen stehen in guter Übereinstimmung mit diesen erstmals gemessenen Werten.

A 35.10 Thu 17:00 C/Foyer

High-resolution spectroscopy with multi-photon transitions in Highly Charged Ions — •Andrii Borodin, José R. Crespo López-Urrutia, and Thomas Pfeifer — Max Planck Institute for Nuclear Physics, Heidelberg

Highly charged ions (HCI), being atomic systems with tightly bound electrons, allow performing accurate tests of quantum electrodynamics, and determination of high-precision values of fundamental constants. Nowadays, HCI are routinely produced using electron beam ion traps. HCI are abundant in hot plasmas in stars, and thus are also of interest for astrophysics. Their advantages for studies of time variations of fundamental constants have been recently emphasized. So far, most observations in HCI are made with ions at temperatures of more than 10^2 eV. Recent progress in trapping HCI in a cryogenic linear quadrupole trap [Schwarz *et al*, Rev. Sci. Inst. **83**, pp. 1-10 (2012)], and sympathetic cooling with Be^+ ions, opens up the possibility for high-precision laser spectroscopy. A very large number of transitions have energies of few ten eV. So far, excitation of these transitions required the use of free-electron lasers. The aim of this project is to perform high-resolution spectroscopy of extreme ultraviolet transitions by multi-photon transitions, induced by femtosecond laser pulses and amplified by an enhancement cavity. An experimental scheme for realizing this approach will be presented.

A 35.11 Thu 17:00 C/Foyer

Parity violation effects in the Josephson junction of a p-wave superconductor — •Nikolay Belov and Zoltán Harman — Max Planck Institute for Nuclear Physics

The electroweak theory, combining two fundamental interactions – electromagnetic and weak, was introduced by Salam, Glashow and Weinberg in 1970s. It explains the nuclear beta-decay and weak effects in particle physics. One of the most interesting properties of the electroweak theory is the spatial parity violation (PV). Firstly PV was experimentally detected in the beta decay. PV terms of the electroweak interaction can also influence the interaction of electrons with the crystal lattice of nuclei in the solid state. Possible solid state systems, where one may detect PV contribution are superconductors (SC). The main advantage of the PV detection in SC is the small size and relatively small price of the possible experimental setup. The idea that parity violation effects can appear in superconductors was supposed by A. I. Vainstein and I. B. Khriplovich in 1974. They have showed that this electroweak contribution is negligible small in conventional s-wave superconductors. In our work we present an estimate for this effect to be observed in unconventional p-wave ferromagnetic superconductors. This estimation gives values several orders of magnitude larger than for the s-wave case and shows that the PV effect may be observed in future.

A 35.12 Thu 17:00 C/Foyer

A superconducting resonator-driven linear radio-frequency trap for strong confinement of highly charged ions — •Julian Stark[1], Lisa Schmoeger[1,2], and José R. Crespo López-Urrutia[1] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg — [2]Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig

Cold, strongly localized highly charged ions (HCI) are interesting candidates for both novel frequency standards at a potential 10^{-19} level accuracy and quantum information protocols. For sympathetic cooling of the HCI, they are simultaneously trapped with laser-cooled Be^+

ions in a cryogenic linear radio-frequency (RF) Paul trap [1]. Its pseudopotential is strongly dependent on the RF amplitude, phase and frequency. Stable localization requires a high voltage RF drive with low noise, since instabilities in the RF drive cause excess micromotion and thus heating of the trapped ions. Employing a RF resonator with high quality factor Q inside the trap enables high amplitudes and drastically reduces the RF noise. In order to be able to trap and sympathetically cool HCI efficiently, we are currently designing a superconducting RF resonator which includes the quadrupole trapping electrodes. Integrating them into the RF cavity will suppress coupling losses and maintain a very high Q value, as well as improve the overall stability of the trapping conditions.

[1] M. Schwarz et al., Rev. Sci. Instrum. 83, 083115 (2012)

A 35.13 Thu 17:00 C/Foyer

Identification of EUV $5s$–$5p$ transitions in Re, Os, Ir, and Pt — •Hendrik Bekker[1], Oscar O. Versolato[1], Alexander Windberger[1], Natalia S. Oreshkina[1], Ruben Schupp[1], Zoltán Harman[1], Christoph H. Keitel[1], Piet O. Schmidt[2,3], and José R. Crespo López-Urrutia[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg — [2]Physikalisch-Technische Bundesanstalt, Braunschweig — [3]Institut für Quantumoptik, Leibniz Universität Hannover

Despite recent theoretical and experimental investigations of $5s$–$5p$ resonance lines in promethium-like highly charged ions near the $4f$–$5s$ level crossing, the transitions were never unambiguously identified yet [1,2]. To resolve this issue we studied the Pm-like and neighboring isoelectronic sequences spanning Re, Os, Ir, and Pt (Z=75–78) produced in the Heidelberg electron beam ion trap. The spectra obtained in the extreme ultra-violet (EUV) region around 20 nm were compared to collisional radiative model calculations which allowed us to identify the $5s$–$5p$ transitions and additional $5s^2$-$5s5p$ transitions. Independent configuration interaction calculations support our identifications. Understanding the $4f$–$5s$ level crossing is of particular importance for future searches for a possible fine structure constant variation, and future optical clocks.

[1] U. I. Safronova, A. S. Safronova, and P. Beiersdorfer, Phys. Rev. A 88, 032512 (2013)
[2] Y. Kobayashi et al., Phys. Rev. A 89, 010501 (2014)

A 35.14 Thu 17:00 C/Foyer

Theory of the bound-muon g-factor — •Bastian Sikora, Zoltán Harman, Jacek Zatorski, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

The theory of the g-factor of the muon bound in a nuclear potential is presented. We include one-loop quantum electrodynamic corrections with the interaction with the nuclear potential taken into account to all orders, and finite nuclear size effects. Similarly to the recent high-precision determination of the electron mass [1], the theory of the bound-muon g-factor, combined with possible future experiments with muons bound in a nuclear potential, can be used in principle to determine physical constants with high precision. Furthermore, since nuclear effects are larger in systems with bound muons, nuclear parameters such as nuclear radii can be extracted to high precision from a comparison of the theoretical and experimental bound-muon g-factor.

[1] S. Sturm *et al.*, *Nature* **506**, 467-470 (2014)

A 35.15 Thu 17:00 C/Foyer

Efficient Quantum Algorithm for Readout in Multi-Ion Clocks — •Marius Schulte — Institut für Theoretische Physik, Leibniz Universität Hannover, Appelstraße 2, 30167 Hannover, Germany

New generations of atomic clocks are planned to rely on stable optical transitions. An important criterion for good frequency standards are extremely narrow bandwiths in the considered clock ions, but this choice comes with some problems. Due to very small scattering rates and inaccessible laser frequencies the states of the clock ions can not be measured directly. The techniques of quantum logic spectroscopy and quantum logic readouts were developed to solve these difficulties by using a second ion (logic-Ion) to perform the readout of the internal states. Up to now optical frequency standards were used with just a single clock-Ion and a sigle logic-Ion. Experiments with such configurations were able to find record breaking accuracies in the frequency measurement but suffered from poor stabilities since only one Ion was used. Therefore the next step is to scale this process up by using multiple Ions. The dominant problem there is to find an efficient readout strategy that determines the internal states of the clock-Ions via the logic-Ions. On my poster i present a possible solution to this, using an efficient quantum algorithm. The number of logic ions and gates in this method scales only logarithmically with the number of clock Ions and can therefore provide a good strategy already for small Ion numbers.

A 35.16 Thu 17:00 C/Foyer

Narrowband Light Sources for optical Clocks of Ba^+ and Ra^+ — •Nivedya Valappol, Elwin A. Dijck, Andrew Grier, Klaus Jungmann, Amita Mohanty, Mayerlin Nuñez Portela, and Lorenz Willmann — Van Swinderen Institute, University of Groningen, The Netherlands

Narrow transitions in single ions such as Al^+, Mg^+, Sr^+ and Hg^+ are the basis for optical clocks. The ultra-narrow electric quadrupole transitions ns $^2S_{1/2}$ * (n-1)d $^2D_{5/2}$ in some isotopes of Ra+ (n=7) and Ba+ (n=6) are less sensitive to some of the major clock systematics. Narrowband lasers for the clock transitions (728nm in Ra^+ and 1761.7nm in Ba^+) and cooling transitions for state manipulation are required. These ion clocks will be compared via a 2x300km long fiber link between Groningen and the University of Amsterdam [1] with other stable frequency references. For the cooling transition at 650nm in Ba^+ a diode laser is stabilized to a high finesse optical cavity in order to observe narrow Raman resonances and manipulate the internal state. The design is applicable to light sources for other transitions where laser diodes are available. In addition, the lasers provide for measurements of atomic parity violation in Ba^+ and Ra^+.

[1] T.J. Pinkert et al., arXiv:1410.4600 (2014)

A 35.17 Thu 17:00 C/Foyer

Nonlinear optics with atomic mercury vapor inside a hollow-core photonic crystal fiber — •Ulrich Vogl, Christian Peuntinger, Nicolas Y. Joly, Philip St. J. Russell, Christoph Marquardt, and Gerd Leuchs — Max Planck Institute for the Science of Light, Günther-Scharowsky-Str. 1/Bldg. 24, 91058 Erlangen, Germany

We demonstrate high atomic mercury vapor pressure in a kagomé-style hollow-core photonic crystal fiber at room temperature. After a few days of exposure to mercury vapor the fiber is homogeneously filled and the optical depth achieved remains constant. With incoherent optical pumping from the ground state we achieve an optical depth of 114 at the 6^3P_2 - 6^3D_3 transition, corresponding to an atomic mercury number density of 6 $\times 10^{10}$ cm^{-3} [1]. We present Autler-Townes spectroscopy at low light levels and first results demonstrating all-optical delay of pulses in the system. Currently we investigate soliton dynamics and self-induced transparency phenomena in the mercury-filled fiber system.

[1] U. Vogl, C. Peuntinger, N. Joly, P. Russell, C. Marquardt, and G. Leuchs, "Atomic mercury vapor inside a hollow-core photonic crystal fiber," Opt. Express 22, 29375-29381 (2014).

A 35.18 Thu 17:00 C/Foyer

Quantum Logic Spectroscopy of Highly Charged Ions — •Peter Micke[1,2], Tobias Leopold[1], Maria Schwarz[1,2], Lisa Schmöger[1,2], Oscar O. Versolato[1,2], Joachim H. Ullrich[1,2], José R. Crespo López-Urrutia[2], and Piet O. Schmidt[1,3] — [1]Physikalisch-Technische Bundesanstalt, Braunschweig, Germany — [2]Max-Planck-Institut für Kernphysik, Heidelberg, Germany — [3]Leibniz Universität Hannover, Germany

Highly charged ions (HCIs) offer forbidden optical transitions near level crossings due to reordering of the electronic levels as the charge state grows. Some of these transitions have an enhanced sensitivity to a possible variation of the fine-structure constant. Furthermore, HCIs are insensitive to external fields because of their strong internal Coulomb field. This can be exploited for building optical clocks with small systematic shifts. We are currently setting up an experiment for the Physikalisch–Technische Bundesanstalt aiming at quantum logic spectroscopy of HCIs. A novel compact EBIT based on permanent magnets breeds HCIs. Next, they are extracted, decelerated and injected into an ultra-stable cryogenic Paul trap. Generally, HCIs do not have transitions appropriate for direct laser cooling. However, they can be sympathetically cooled with another ion species – in our case Be^+. Spectroscopic measurements can be carried out by using quantum logic: A single HCI is co-trapped together with a Be^+ logic ion, which provides not only cooling, but also both state preparation and readout.

A 35.19 Thu 17:00 C/Foyer

Neutrino Oscillation Observations using 400 MeV/u Highly Ionized 142Pm60+ Ions — •Fatma Cagla Ozturk[1,2] and Yuri Litvinov[1] — [1]GSI, Darmstadt, Germany — [2]Istanbul University, Istanbul, Turkey

GSI accelerator facility leads the scientific innovations on highly charged, heavy ions and search for the structure of atomic nucleaus and the universe. Experimental Storage Ring (ESR) gives a great opportunity to study the periodic time modulations, found recently in the two-body orbital electron capture (EC) decay of 142Pm60+ ion, with period near to 6 seconds by using a 245 MHz resonator cavity with a high sensitivity and time resolution. This study presents the results obtained from the latest experiment on EC decays of Pm ions which are produced in FRS in ESR ring.

A 35.20 Thu 17:00 C/Foyer

Bound-electron g-factor correction due to coupling of global and internal dynamics of ions — •Niklas Michel and Jacek Zatorski — Max Planck Institute for Nuclear Physics, Saupfercheckweg 1, 69117 Heidelberg, Germany

Penning-trap precision measurements of the bound electron g-factor in hydrogen-like ions have proved to be very useful for the determination of certain physical constants and parameters, i.e. the electron mass. They have also provided one of the most stringent tests of quantum electrodynamics in a strong external electric field.

With the prospect of further improvement of experimental precision, we calculated the dominant correction to the experimental value of the g-factor due to coupling of the ion's global movement to the ion's internal dynamics. Also, we estimated the influence of an analogous effect on measurements in a Paul trap.

A 35.21 Thu 17:00 C/Foyer

Towards Doppler Laser Cooling of Negative Ions — •Elena Jordan, Giovanni Cerchiari, and Alban Kellerbauer — Max-Planck-Institut für Kernphysik, Heidelberg

We want to demonstrate the first direct laser cooling of negative ions in a Penning trap. For the cooling the hyperfine structure and the Zeeman splitting in the magnetic field of the trap need to be known. We carried out collinear ion beam spectroscopy and determined the transition frequencies in negative lanthanum ions with unprecedented precision. The transition cross sections of bound-bound transitions were measured. The transition studied in this work had been found potentially suitable for Doppler laser cooling both from theory and experiment [1,2,3]. Presently, lanthanum is the most promising candidate among the atomic negative ions.
Once one species of negative ions is cooled, any other species can be cooled sympathetically [4].

[1] C.W. Walter et al. *Physical Review Letters* 113, 063001 (2014)
[2] S.M. O'Malley and D.R.Beck, *Physical Review A* 81, 032503 (2010)
[3] L.Pan and D.R.Beck, *Physical Review A* 82, 014501 (2010)
[4] A.Kellerbauer and J.Walz, *New Journal of Physics* 8, 45 (2006)

A 35.22 Thu 17:00 C/Foyer

The Muonic Helium Lamb Shift experiment — •Marc Diepold and The CREMA Collaboration — Max-Planck-Institute of Quantum Optics, Garching

This poster gives a detailed overview about the working principle and setup of the Muonic Helium Lamb shift experiment at the Paul-Scherrer-Institute in Switzerland.

Newly implemented features in the ongoing data analysis are emphasised and preliminary results for different $2S \rightarrow 2P$ transitions measured in both the μ^4He^+ and μ^3He^+ exotic ions are provided.

These results shed new light on the Proton Radius Puzzle created by the 7 sigma discrepancy between different determinations of the rms charge radius of the proton.

A 35.23 Thu 17:00 C/Foyer

A way to detect the isomeric state I= $(3/2)^+$ in ^{229}Th with the use of LIF method — •Jerzy Dembczyński[1], Magdalena Elantkowska[2], and Jarosław Ruczkowski[1] — [1]Institute of Control and Information Engineering, Poznań University of Technology, Poznań, Poland — [2]Laboratory of Quantum Engineering and Metrology, Poznań University of Technology, Poznań, Poland

The existence of a low-lying isomeric state at an energy of 7.6 ± 0.5 eV was inferred from high-resolution gamma-ray spectroscopy [1]. Inamura and Haba [2] search for this state at a region 3.5 eV using a hollow-cathode electric discharge. Sakharow [3] questioned existing of this state at whole. Peik et al. [4] show that is possible to reach high lying electronic levels using a laser beam for the ^{232}Th$^+$. If the metastable state $I = 3/2$ exist we should observe the effects of mixing of the nuclear wave functions of the ground state $I = 5/2$ and the isomeric $I = 3/2$ state via electronic shells. It will be revealed at the differences between the A- and B constants measured by means of the LIF methods and those predicted by semi-empirical calculations. Therefore, we consider advisable a systematic study of the hyperfine structure of the electronic levels of the ^{229}Th atom or ions.

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[2] T.T. Inamura, H. Haba, Phys. Rev. C 79, 034313 (2009)
[3] S. L. Sakharov, Physics of at. Nuclei 73, 1-8 (2010)
[4] O. A. Herrera-Sancho et al.,Phys. Rev. A 85, 033402 (2012)

A 35.24 Thu 17:00 C/Foyer

The Multipass Cavity of the μHe$^+$ Lamb Shift Experiment — •Julian J. Krauth, Beatrice Franke, and the CREMA Collaboration — Max-Planck-Institute of Quantum Optics, Garching

A multipass laser cavity is presented which can be used to illuminate an elongated volume from a transverse direction. The illuminated volume can have a several cm^2 large transverse cross section. Convenient access to the illuminated volume for other experimental components is granted at a large solid angle. The multipass cavity is very robust against misalignment, and no active stabilization is needed. The scheme is suitable e.g. for beam experiments, where the beam path must not be blocked by a laser mirror, or if the illuminated volume has to be very large. Measurements of the intensity distribution inside the multipass cavity are found to be in good agreement with the simulation.

On this poster, the technical developments used to operate the cavity are presented, and an overview on possible applications is given: It was used for the muonic-hydrogen experiment in which $6\,\mu$m laser light illuminated a volume of $7 \times 25 \times 176\,\mathrm{mm}^3$, consisting of mirrors that are only 12 mm in height. Furthermore it may be suited for transverse cooling of a beam of atoms/molecules (using two of such cavities) or the creation of a "light curtain" illuminating a region of about $20 \times 10\,\mathrm{cm}^2$ over a distance of 1 cm or more along the beam axis.

A 35.25 Thu 17:00 C/Foyer

Towards future kilo-pixel x-ray detector arrays: SQUIDs and SQUID multiplexers for the readout of high-resolution x-ray detectors — •Mathias Wegner, Anna Ferring, Andreas Fleischmann, Loredana Gastaldo, Sebastian Kempf, and Christian Enss — Kirchhoff-Institute for Physics, Heidelberg University.

Calorimetric low-temperature particle detectors such as superconducting transition edge sensors, metallic magnetic calorimeters and magnetic penetration thermometers have proven to be suitable devices for performing high-resolution x-ray spectroscopy. They are therefore very frequently used for precision experiments in atomic and nuclear physics. To read out these kind of detectors, superconducting quantum interference devices (SQUIDs) are the devices of choice since they provide very low noise, a large system bandwidth and are compatible with sub-Kelvin operation temperatures. Driven by the need for devices that allow for the readout of future kilo-pixel x-ray detector arrays as well as of single-channel detectors with sub-eV energy resolution, we have recently started the development of low-T_c current-sensing SQUIDs. In particular, we are developing cryogenic frequency-domain multiplexers based on non-hysteretic rf-SQUIDs for array readout as well as dc-SQUIDs for single channel detector readout. We discuss our SQUID designs and the performance of prototype SQUIDs that are based on Nb/Al-AlO$_x$/Nb Josephson junctions. We also outline that our SQUIDs might be very useful for other applications such as penning-trap mass spectroscopy due to their excellent noise performance.

A 35.26 Thu 17:00 C/Foyer

Metallic Magnetic Calorimeters for High-Resolution X-ray Spectroscopy with Highly Charged Ions — •C. Schötz[1], D. Hengstler[1], M. Keller[1], M. Krantz[1], J. Geist[1], T. Gassner[2,3], K.H. Blumenhagen[2,3], R. Märtin[2,3], G. Weber[2,3], S. Kempf[1], L. Gastaldo[1], A. Fleischmann[1], Th. Stöhlker[2,3,4], and C. Enss[1] — [1]KIP, Heidelberg University — [2]Helmholtz-Institute Jena — [3]GSI Darmstadt — [4]IOQ, Jena University

Metallic magnetic calorimeters (MMCs) are energy dispersive particle detectors which have a high energy resolution over a wide energy range. They operate at milli-Kelvin temperatures and convert the energy of a single absorbed photon into a temperature rise, which lead to a magnetization change in an attached paramagnetic sensor. The magnatization change in the temperature sensor is inductively read out by a SQUID-magnetometer. We show our developed maXs-200 detector, a 1x8 array with 200 μm thick absorber and an active area of 8 mm^2 that is optimized to measure X-rays up to 200 keV. The performance under ideal condition showed an energy resolution of 45 eV for 60 keV γ-photons of an ^{241}Am calibration source. We discuss two different sucessfully performed measurements at the Experimental Storage Ring (ESR) at GSI with the maXs-200. The detector was mounted on the cold finger of a pulse tube cooled ^{3}He/^{4}He-dilution refrigerator. The achieved energy resolution in an energy range from 0 keV up to 60 keV was below 60 eV. In addition we show the simulation results of different designs of a compton polarimeter including the efficiency of the 90° scattered photons, wherein the maXs-200 is also involved.

A 35.27 Thu 17:00 C/Foyer

Investigations of the hyperfine interaction in Ti-like bismuth — •Michael A. Blessenohl, Hendrik Bekker, Alexander Windberger, and José R. Crespo López-Urrutia — Max Planck Institute for Nuclear Physics, Heidelberg, Germany

The ground state configuration [Ar]$3d^4$ of titanium-like ions split into 34 different levels that feature a $J = 2 \rightarrow 3$ magnetic dipole transition in the optical regime for a broad range of atomic numbers Z. This allows for very accurate measurements of the quantum electrodynamical (QED) corrections of the electron potential in atoms. Predictions made with the Flexible Atomic Code (FAC) place the transition at 340.6 nm for the Bi^{61+} ion. We plan to present first results of high-resolution measurements of this transition at the Heidelberg electron beam ion trap (HD-EBIT) using a Czerny-Turner type spectrometer equipped with a cooled CCD camera. Due to the large magnetic moment of the bismuth nucleus a prominent hyperfine splitting is expected to appear, enabling us to probe nuclear size effects in a regime where the hyperfine structure (HFS) splitting is of a magnitude similar to the strong magnetic field of an EBIT, and the QED relative contributions to the transition energy are extremely large.

A 35.28 Thu 17:00 C/Foyer

Description of the Ho-163 electron capture spectrum — •Loredana Gastaldo for the ECHo-Collaboration — Kirchhoff Institute for Physics, Heidelberg University

The sensitivity to the neutrino mass achievable with the analysis of calorimetrically measured Ho-163 electron capture spectrum is strongly dependent on the precise understanding of the expected spectral shape. The high energy resolution calorimetric measurements of the Ho-163 spectrum performed by the ECHo collaboration pointed out that several parameters for the description of the spectral shape need to be defined with higher accuracy. Two aspects are of particular importance: the determination of Q-value, that is the value of the energy available to the decay, and the determination of the contribution to the atomic de-excitation of the daughter atom, dysprosium, of higher order processes. We compare the parameters obtained by the analysis of the calorimetrically measured Ho-163 spectrum with the ones available in literature and discuss the discrepancies with present models and available data. We present new experimental methods and improved theoretical models to achieve a better accuracy in the determination of the parameters describing the Ho-163 spectrum.

A 35.29 Thu 17:00 C/Foyer

Angular Distribution of DR-Induced X-ray Transitions in Be-like Uranium — •Sergiy Trotsenko[1,2], Alexandre Gumberidze[2], Yong Gao[3], Christophor Kozhuharov[2], Stephan Fritzsche[1,4], Andrey Surzhykov[1,4], Heinrich Beyer[2], Siegbert Hagmann[2,5], Pierre-Michel Hillenbrand[2], Nikolaos Petridis[2], Uwe Spillmann[2], Daniel Thorn[2,6,7], Günter Weber[1], and Thomas Stöhlker[1,2,4] — [1]Helmholtz-Institut Jena, Fröbelstieg 3, 07743 Jena, Germany — [2]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Planckstraße 1, 64291 Darmstadt, Germany — [3]Institute of Modern Physics, Chinese Academy of Sciences, Lanzhou, China — [4]Institut für Optik und Quantenelektronik, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, 07743 Jena, Germany — [5]Institut für Kernphysik, Universität Frankfurt, 60486 Frankfurt am Main, Germany — [6]ExtreMe Matter Institute EMMI, GSI Helmholtzzentrum für Schwerionenforschung, Planckstraße 1, 64291 Darmstadt, Germany — [7]FIAS Frankfurt Institute for Advanced Studies, Ruth-Moufang-Straße 1, 60438 Frankfurt am Main, Germany

X-rays following 116.15 MeV/u collisions of Li-like uranium with hydrogen target were measured at different observation angles with regard to the ion beam direction. From the measured experimental spectra combined with radiative electron capture calculations, we obtain angular distribution of characteristic x-rays following the resonance transfer and excitation. Our result shows a good qualitative agreement with theoretical predictions.