A 14: Poster: Precision spectroscopy of atoms and ions (with Q)

Time: Monday 16:30–18:30 Location: Spree-Palais

A 14.1 Mon 16:30 Spree-Palais

Relative frequency comb locked to atomic resonances generated by quantum phase modulation — •Zuoye Liu, Christian Ott, Stefano M. Cavaletto, Kristina Meyer, Zoltán Harman, Christoph M. Keitel, and Thomas Pfeifer — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

Recently, a new phase-control mechanism was demonstrated in helium in time-resolved absorption experiments [1]. Here, we theoretically investigate the generation of frequency combs referenced to atomic resonances by extending this phase-control concept to periodic phase manipulations covering the entire evolution of the coherence decay of a two-level system [2]. The comb spectral structure depends on both the atomic and the phase-control properties, which can be cast into closed-form analytical descriptions. As the first envisaged realistic implementation, we perform a simulation for the 1s2*1s2p transition in helium or helium-like beryllium, which agrees excellently with our analytical theory. The mechanism allows to create frequency combs in the x-ray region, providing an opportunity for precision spectroscopy of transitions in highly charged ions [3] in the future. It may thus open the door to fundamental physics applications such as testing the predictions of bound-state QED.

[1] C. Ott et al., Science 340, 716 (2013)

[2] Z. Liu, C. Ott, S. M. Cavaletto, Z. Harman, C. H. Keitel, and T. Pfeifer, ArXiv: 1309. 6335 (2103)

[3] S. Bernitt et al., Nature 492, 225 (2012)

A 14.2 Mon 16:30 Spree-Palais

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

Ultra-cold negative ions could be used in a wide field of applications. We want to demonstrate the first laser cooling of atomic anions. In order to identify suitable negative ions we study them with high-resolution laser spectroscopy. Previously the transition frequencies and transition cross-sections of anions of various Os isotopes have been determined. The hyperfine structure (where applicable) and the isotope shift were resolved, and the Zeeman splitting in a magnetic field was measured. These measurements have shown that laser cooling of Os^- is possible in principle, but at a low cooling transition rate. Therefore we are presently investigating La^- with high-resolution laser spectroscopy, as another potential candidate for anion laser cooling.

A 14.3 Mon 16:30 Spree-Palais

Optical Clock Based on a Single Trapped Ra^+ Ion — •Mayerlin Nunez Portela, Elwin A. Dijck, Amita Mohanty, Nivedya Valappol, Oliver Boell, Klaus Jungmann, Cornelis J. G Onderwater, Sophie Schlesser, Rob G. E. Timmermans, Lorenz Wilmann, and Hans W. Wilschut — University of Groningen, FWN, Zernikelaan 25, NL-9747AA Groningen

Currently single-ion based optical clocks provide the most accurate frequency standards with their stability exceeding that of the latest cesium standards. The ultra-narrow electric quadrupole transitions 7s $^2S_{1/2}$-6d $^2D_{3/2}$ at 828 nm and 7s $^2S_{1/2}$-6d $^2D_{5/2}$ at 728 nm from the ground state to the low lying metastable D-state of Ra^+ are excellently suited for a stable and accurate clock [1]. An important advantage of Ra^+ is that all required optical wavelengths are available from semiconductor diode lasers. This promises a low-cost and compact setup. Fractional frequency uncertainty of 10^{-18} can be reached using a single Ra^+ ion. We note that for radium isotopes with nuclear spin 3/2 the electric quadrupole shift can be largely canceled. We report the status of the project and its integration into a optical fiber linked clock network.

[1] O.O.Versolato et al., Phys. Rev. A 83, 043829 (2011)

A 14.4 Mon 16:30 Spree-Palais

Optical Fiber Link via Telecommunication Networks — •Nivedya Valappol[1], Tjeerd Pinkert[2], Oliver Boll[1], Fred Bosveld[3], Elwin Dijck[1], Kjeld Eikema[2], Klaus Jungmann[1], Jeroen Koelemeij[2], Wim Ubachs[2], and Lorenz Willmann[1] — [1]University of Groningen, Groningen, NL — [2]Vrije Universiteit Amsterdam, Amsterdam, NL — [3]KMNI, De Bilt, NL

Time and frequency distribution over existing communication infrastructure has different applications. A telecommunication channel on a SURFnet fiber link has been established between the VU Amsterdam and Groningen. It is used to transfer stability and accuracy of narrow band lasers (1Hz) in order to compare high precision experiments such as clocks (Al^+, Ra^+) at the two locations. The stability of the 2×317 km underground optical fiber link has been characterized. The long term frequency stability determined with a 3kHz laser linewidth of 2×10^{14} at 5×10^2-5×10^3s can be explained by thermal temperature fluctuations in the ground. This accuracy surpassing, e.g. the satellite based GPS system, can be exploited in superior navigation systems. The full potential with lasers of 1Hz linewidth will permit tests of fundamental physics, such as Atomic Parity Violation measurements, in spatially separated precision experiments.

A 14.5 Mon 16:30 Spree-Palais

Novel technique for precision spectroscopy of fast transitions: photon recoil detection — •Fabian Wolf, Yong Wan, Florian Gebert und Piet O. Schmidt — QUEST Institut, PTB Braunschweig und Universität Hannover

Quantum logic spectroscopy (QLS) has offered the possibility to investigate the electronic structure of many so far inaccessible species, but is limited to transitions involving a long-lived state. Photon recoil spectroscopy (PRS) is an extension of QLS to fast, dipole allowed transitions.

Here we present an absolute frequency measurement of the $S_{1/2} \rightarrow P_{1/2}$ transition of $^{40}Ca^+$ using PRS with a co-trapped $^{25}Mg^+$ logic ion. The axial mode of the two-ion-crystal is cooled to its motional ground state. Afterwards, the spectroscopy laser induces a detuning-dependent momentum transfer from photon recoil onto the spectroscopy ion that is detected on the logic ion via a red sideband STIRAP-like pulse. This method enables us to resolve the Ca transition to 1/300 of its observed linewidth with high accuracy and short averaging times. This renders PRS a powerful spectroscopic tool for the measurement of broad transitions. Due to its high sensitivity of only 10 absorbed photons for a SNR of 1, PRS is a promising technique for spectroscopy of transition that scatter only few photons.

The next step will be the implementation of a similar scheme for rotational state spectroscopy on a molecular ion. The current status of this experiments and simulations for rotational state preparation are presented as well.

A 14.6 Mon 16:30 Spree-Palais

Towards Bound-Electron g-Factor Measurements by Double-Resonance Spectroscopy — •Marco Wiesel[1,2,4], David von Lindenfels[1,2,3], Wolfgang Quint[1,2], Manuel Vogel[1,4], Alexander Martin[4], and Gerhard Birkl[4] — [1]GSI Darmstadt, Germany — [2]Universität Heidelberg, Germany — [3]MPI-K Heidelberg, Germany — [4]TU Darmstadt, Germany

Magnetic moment measurements of electrons bound in highly charged ions provide access to effects of quantum electrodynamics (QED) in the extreme fields close to the ionic nucleus. We report on the cryogenic Penning trap setup ARTEMIS to determine the electronic g-factor of boron-like argon (Ar^{13+}) via the method of double-resonance spectroscopy: A closed cycle between the fine-structure levels $2^2P_{1/2}$ - $2^2P_{3/2}$ is driven by a laser whereas microwaves are tuned to excite transitions between Zeeman-sublevels. With this frequency and the measurement of the ion cyclotron frequency the g-factor can be determined with an expected accuracy of 10^{-9} or better.

After these measurements, the setup will be connected to the HITRAP beamline at GSI, so hyperfine structure transitions of hydrogen-like heavy ions can be studied and electronic and nuclear magnetic moments can be measured.

Supported by DFG

A 14.7 Mon 16:30 Spree-Palais

Parity violation effects in the Josephson junction of a p-wave superconductor — •Nikolay A. Belov and Zoltan Harman — Max Planck Institute for Nuclear Physics, Heidelberg, Germany

The electroweak theory describes nuclear beta-decay and weak effects in particle physics. One of the most characteristic properties of the electroweak interaction is spatial parity violation (PV). PV was experimentally observed in β decay, however, PV terms of the electroweak interaction also affect the interaction of electrons with the nuclei of the crystal lattice in solid state. Possible solid state systems where one may detect PV are superconductors. The main advantage of the investigation of PV effects with superconductors is the compact size and relatively low price of the experimental apparatus as compared to high-energy experiments. While the electroweak contribution is negligibly low in conventional *s*-wave superconductors, we show that the effect is significantly increased in unconventional *p*-wave ferromagnetic superconductors. We predict values several orders of magnitude higher than for the *s*-wave case, forecasting that the PV effect may be observed in superconductors in future.

A 14.8 Mon 16:30 Spree-Palais

A computer-control system for electron beam ion traps — •Daniel Hollain[1,2], Hendrik Bekker[1], Sven Bernitt[1], and José Ramón Crespo López-Urrutia[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg, Germany — [2]Ruprecht-Karls-University, Heidelberg, Germany

Modern experiments require computer control and computerized data acquisition systems. This is especially crucial for systematic and repetitive tasks during long runtimes, when many devices and complicated processes run simultaneously. We develop such a system in order to facilitate operations of electron beam ion traps with their attached detectors and power supply units, to reduce operator errors, and to record and evaluate data during beam times as well as at DESY or BESSY. An efficient computer control system reduces the risk of losses of critical experimental data and of operator errors in the laboratory. Automated systems also allow handling larger sets of data and improving the statistics for experiments. Clean programming, uncomplicated maintenance, and complete documentation are important requirements for the software. We develop a framework for the control of devices based on National Instruments I/O cards. We use routines from the PCASPY library from EPICS, the Experimental Physics and Industrial Control System in a client-server model written in Python2. Other system extensions are possible and will be presented. An important advantage is the fact that the recorded data can be directly used for evaluation of the experiment even during runtime.

A 14.9 Mon 16:30 Spree-Palais

Absolute energy determination of He-like Krypton K_α transitions — •René Steinbrügge[1], Sven Bernitt[1], Sascha W. Epp[2], Jan K. Rudolph[1,3], Christian Beilmann[5], Hendrik Bekker[1], Alfred Müller[3], Joachim Ullrich[6], Oscar O. Versolato[1], Hasan Yavaş[4], Hans-Christian Wille[4], and José R. Crespo López-Urrutia[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg — [2]MPI für Struktur und Dynamik der Materie, Hamburg — [3]Institut für Atom- und Molekülphysik, Gießen — [4]DESY, Hamburg — [5]Physikalisches Institut, Heidelberg — [6]PTB, Braunschweig

Heliumlike ions serve as an important testing ground for investigations of many-body relativistic and QED effects, which scale with the fourth power of the atomic number Z. We have carried out absolute energy measurements of the w ($^1S_0 \rightarrow {}^1P_1$) and y ($^1S_0 \rightarrow {}^3P_1$) transitions in He-like krypton (Z=36) ions. These were produced and trapped in the transportable electron beam ion trap FLASH-EBIT [1,2], and excited with X-ray photons at PETRA III. The transition energies were measured by scanning a double-crystal monochromator, and detecting fluorescence photons. By using absorption edges for absolute energy calibration we obtain resonance energies of E(w) = 13114.47(14) eV and E(y) = 13026.15(14) eV, which are in excellent agreement with theory, but disagree with earlier, less accurate experiments. Our results largely exclude claims of an anomalous deviation from bound-state QED predictions.

[1] S. W. Epp et al., Phys. Rev. Lett. **98**, 183001 (2007)
[2] S. Bernitt et al., Nature **492**, 225 (2012)

A 14.10 Mon 16:30 Spree-Palais

Z-scaling of M1-transition wavelengths near level crossings for identification of α-sensitive lines in highly charged ions — •Sebastian Kaul[1], Alexander Windberger[1], Oscar O. Versolato[1], Hendrik Bekker[1], Victor Bock[1], Natalia Oreshkina[1], Christoph H. Keitel[1], Zoltan Harman[1,4], Joachim Ullrich[1,2], Piet O. Schmidt[2,3], and José R. Crespo López - Urrutia[1] — [1]Max Planck Institute for Nuclear Physics, D-69117 Heidelberg, Germany — [2]QUEST Institute for Experimental Quantum Metrology, Physikalisch-Technische Bundesanstalt, 38116 Braunschweig, Germany — [3]Institut für Quantenoptik, Leibniz Universität Hannover, 30167 Hannover, Germany — [4]Extreme Matter Institute, 64291 Darmstadt, Germany

Optical transitions near level crossings in highly charged ions like Ir^{17+} are of special interest for the search of a possible spatial gradient of the value of α, the fine structure constant due to their high sensitivity to its value. However, wavelength predictions for those transitions are not accurate enough for the application of laser spectroscopy. Therefore, we first perform emission spectroscopy in an electron beam ion trap with a grating spectrometer to record spectra between 200 nm and 700 nm with an absolute accuracy of 10^{-2} nm. In order to identify the observed lines we exploit the Z-scaling laws of the wavelengths of M1 transitions within the isoelectronic sequence Re^{15+}, Os^{16+}, Ir^{17+}, and Pt^{18+}. We also study the electron-density dependence of the signal strength of Ir^{17+} spectra between 5-80mA to determine relative Einstein coefficients for various lines.

A 14.11 Mon 16:30 Spree-Palais

Testing Lorentz Invariance in the Weak Interaction Using Laser-Polarized ^{20}Na — •Elwin A. Dijck, Auke Sytema, Stefan E. Müller, Steven Hoekstra, Klaus Jungmann, Jacob P. Noordmans, Gerco Onderwater, Coen Pijpker, Rob G. E. Timmermans, Lorenz Willmann, and Hans W. Wilschut — University of Groningen, The Netherlands

Lorentz invariance is one of the fundamental principles underlying our current understanding of nature. In models aiming to unify the Standard Model with (quantum) gravity this symmetry may be broken. Few tests of Lorentz invariance in the weak interaction have been made.

We have performed a novel test of rotational invariance by searching for variations in the decay rate of ^{20}Na nuclei depending on the nuclear spin orientation with respect to a possible Lorentz symmetry breaking background field. Using optical pumping, the nuclei were alternately polarized in opposite vertical directions, while the absolute orientation of the spins changed with the rotation of the Earth.

A polarization-dependent Lorentz symmetry violating effect was searched for, putting a 95% confidence limit on the amplitude of sidereal variations in the decay rate asymmetry at $< 3 \times 10^{-3}$. This result was analyzed in the framework of a recently developed theory that assumes a Lorentz symmetry breaking background field of tensor nature.

A 14.12 Mon 16:30 Spree-Palais

An electrodynamic system for highly charged ion transfer to a Paul trap — •Lisa Schmöger[1,2], Baptist Piest[1], Julian Stark[1], Maria Schwarz[1,2], Oscar O. Versolato[1,2], Piet O. Schmidt[2], and José R. Crespo López-Urrutia[1] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany — [2]Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig, Germany

Electron beam ion traps (EBITs) are efficient tools for highly charged ion (HCI) production and spectroscopy. While narrow optical transitions in HCI at rest are of great interest for precision studies of fundamental physics and for realisations of high accuracy frequency standards [1]. However, due to the high ion temperature inside of an EBIT, laser spectroscopy on HCIs is severely constrained by Doppler broadening [2].

For further improvements, our cryogenic linear Paul trap [3] experiment (CryPTEx) in-line with an EBIT will allow for trapping and sympathetic cooling of a wide range of HCIs. A deceleration beamline allows for efficient HCI transfer and their injection at very low kinetic energy into CryPTEx. The deceleration of the ion bunches is performed by means of a novel pulsed buncher tube. We present time-of-flight spectra and measurements with retarding field analysers showing the deceleration and time focussing properties of the setup.

[1] J.C. Berengut et al., Phys. Rev. Lett. 106, 210802 (2011)
[2] V. Mäckel et al., Phys. Rev. Lett. 107 (2011) 143002
[3] M. Schwarz et al., Rev. Sci. Instr. 83, 083115 (2012)

A 14.13 Mon 16:30 Spree-Palais

A Low Energy Ion Beamline for Highly Charged Ions at SpecTrap — •Kristian König[1], Stefan Schmidt[1,2], Zoran Andelkovic[3], Tobias Murböck[4], Manuel Vogel[4], Volker Hannen[5], Jonas Vollbrecht[5], Gerhard Birkl[4], Richard Thompson[6], and Wilfried Nörtershäuser[1] — [1]Institut für Kernphysik, TU Darmstadt — [2]Institut für Kernchemie, Johannes Gutenberg Universität Mainz — [3]GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt — [4]Institut für Angewandte Physik, TU Darmstadt — [5]Institut für Kernphysik, Westfälische Wilhelms-Universität Münster — [6]Imperial College London, South Kensington Campus London

One of the precision experiments of the HITRAP facility at GSI Darmstadt is SpecTrap, which aims to trap heavy Highly Charged Ions (HCI) in a Penning trap and cool them to cryogenic temperatures. Using laser spectroscopy it is possible to measure their hyperfine structure with an envisaged relative accuracy of the order of 10^{-7} which will serve as a test of strong-field quantum electrodynamics.

This poster will present the current status of the SpecTrap experiment and give an overview of the associated beamline from the Electron Beam Ion Source (EBIS) to the Penning trap. The EBIS can produce HCI up to Xe^{44+} and the beamline is able to transport these ions with small kinetic energy with a few keV to SpecTrap or other experimental setups. Additionally the methods and first experimental results for detecting, cooling and manipulating the ions inside the trap will be shown.

A 14.14 Mon 16:30 Spree-Palais

The Muonic Helium Lamb Shift Experiment — •Johannes Götzfried, Julian Krauth, and The CREMA collaboration — Max-Planck-Institute of Quantum Optics, Garching

Because of its high sensitivity on finite size effects of the nucleus, the measurement of the Lamb shift in exotic atoms has been on the wish-list of atomic and nuclear physics for a long time. Our previous experiment allowed to determine the proton radius with an order of magnitude higher precision compared to spectroscopic measurements of ordinary hydrogen. The successor experiment in muonic helium is currently performed at the Paul-Scherrer-Institute in Switzerland. Using a low energy muon beam line muons are stopped within low pressure helium gas, where exotic atoms are created. Here we measure the 2S-2P transition frequency of muonic helium illuminated by a pulsed TiSa-laser system pumped with a newly developed Yb-YAG thin disk laser. This measurement will ultimately improve the values of the charge radii of 3He+ and 4He+ by an order of magnitude.

A 14.15 Mon 16:30 Spree-Palais

Towards precision laser spectroscopy with cold highly charged ions — •Lisa Schmöger[1,2], Oscar O. Versolato[1,2], Maria Schwarz[1,2], Alexander Windberger[1], Matthias Kohnen[2], Tobias Leopold[2], Joachim Ullrich[2], Piet O. Schmidt[2,3], and José R. Crespo López-Urrutia[1] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, Heidelberg — [2]Physikalisch-Technische Bundesanstalt, Bundesallee 100, Braunschweig — [3]Institut für Quantenoptik, Leibniz Universität Hannover, Hannover

Highly charged ions (HCI) are promising candidates for bound-state QED studies (g-factor measurements), metrology (optical clocks) and searches for a possible variation of the fine structure constant.

Electron beam ion traps (EBIT) have recently enabled laser spectroscopic studies of trapped HCI. However, large translational temperatures in HCI trapped in an EBIT severely limit resolution. To overcome this, our cryogenic linear Paul trap experiment -CryPTEx- in combination with an EBIT will enable trapping and sympathetic cooling of a wide range of HCI by means of Be^{+} ions laser-cooled into Coulomb crystals. The external ion injection capabilities of our Paul trap have been successfully tested and the formation of Be^{+} Coulomb crystals is underway.

This new setup opens up a path towards high-precision laser spectroscopy up to optical frequency standards based on narrow transitions in HCI, which are by orders of magnitudes less susceptible to external perturbations than transitions in atoms or singly-charged ions, and which offer fundamental physics test at the highest sensitivities.

A 14.16 Mon 16:30 Spree-Palais

Cooling of highly charged Ions in the HITRAP cooler Penning Trap — •Bernhard Maass[1,2], Zoran Andelkovic[2], Svetlana Fedotova[2], Frank Herfurth[2], Nikita Kotovskiy[2], Claude Krantz[3], Denis Neidherr[2], Wilfried Nörtershäuser[1], Wolfgang Quint[2], and Jochen Steinmann[2] — [1]TU Darmstadt — [2]GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt — [3]MPI-K Heidelberg

The HITRAP cooler Penning trap will be used for cooling and storing of bunches of up to 10^5 ions as heavy as U^{92+}. The aim is to use both electron cooling and resistive cooling to cool ions down to values below 1 meV. Bunches of 10^{10} electrons can be injected into the trap from an electron source installed downstream. The electrostatic potentials of the trap electrodes will be arranged to form a nested trap to capture both, ions and electrons, simultaneously inside the trap. In the last years, the trap has been investigated by measuring ion and electron storage times. Based on the gained experience from these experiments, the trap is now reassembled with various improvements to further increase the trapping and cooling performance. An installed test ion source provides the opportunity to test and align the renewed setup.

A 14.17 Mon 16:30 Spree-Palais

Metallic Magnetic Calorimeters for High-Resolution X-ray Spectroscopy — •M. Krantz[1], C. Schötz[1], D. Hengstler[1], J. Geist[1], S. Kempf[1], L. Gastaldo[1], A. Fleischmann[1], C. Enss[1], R. Märtin[2], G. Weber[2], Th. Stöhlker[2], and J. Crespo[3] — [1]Kirchhoff-Institut, Universität Heidelberg — [2]Helmholtz-Institut, Jena — [3]Max-Planck-Institute of Nuclear Physics, Heidelberg

We are developing metallic magnetic calorimeters (MMC) for x-ray spectroscopy on highly charged ions in the energy range up to 200 keV. MMCs use a paramagnetic temperature sensor, read-out by a SQUID, to measure the energy deposited by single x-ray photons. Recent prototypes include two linear 8-pixel detector arrays, maXs-20 and maXs-200, as well as a first 2-dimensional 8x8 array, maXs-30, optimized for energies up to 20, 200, and 30 keV, respectively. We discuss the physics of MMCs, design considerations concerning cross talk, the micro-fabrication and the performances of the three prototypes. maXs-200 with its 200 μm thick absorbers made of electro-deposited gold has high stopping power for hard x-rays and achieves an energy resolution of 40 eV (FWHM). maXs-20 with its 5 μm thick absorbers has excellent linearity and a stopping power of 98% for 6 keV photons and presently achieves an instrumental line width of 1.6 eV (FWHM), unsurpassed by any other micro-calorimeter. We have been operating maXs-20 at an EBIT at the MPI-K Heidelberg and prepare maXs-30 for measurements at the ESR (GSI). We will report on first atomic physics measurements as well as the particular challenges to detector operation in both experimental settings.

A 14.18 Mon 16:30 Spree-Palais

Production of highly charged ions and their applications — •Hendrik Bekker[1], Daniel Hollain[1], Nihmal Daya[2], Elias Sideras-Haddad[2], Sergey Eliseev[1], Sven Sturm[1], Klaus Blaum[1], and José R. Crespo López-Urrutia[1] — [1]Max-Planck-Institut für Kernphysik — [2]University of the Witwatersrand

Preparations are under way to bring the Heidelberg electron beam ion trap (HD-EBIT) to higher energy operation, with the aim to reach electron beam energies up to 350 keV at currents up to 500 mA. This will allow us to produce and trap hydrogen-like charge states of all the stable elements. The first goal is the production of hydrogen-like holmium and rhenium, which have a ground-state hyperfine splitting (HFS) in the optical regime. We expect to be able to measure the HFS with a precision at the ppm level, a hundred-fold improvement over previous measurements. An application of extracted ions has been the use of a range of Xe charge states to study the effects of highly charged ions on graphene. The produced defects are expected to generate magnetic defects which should give rise to a measurable Kondo effect. Future plans include the production of high charge states of lead, which will be transported to the Penning traps PENTATRAP and ALPHATRAP for precise measurements of masses and of the bound electron g-factor, from which the 1*s* electron binding energy and the fine-structure constant can be extracted.

A 14.19 Mon 16:30 Spree-Palais

Towards cavity-based non-destructive readout of a Strontium lattice clock — •Ulrich Eismann, Chunyan Shi, Jean-Luc Robyr, Sébastien Bize, Rodolphe Le Targat, and Jérôme Lodewyck — LNE-SYRTE - Observatoire de Paris, CNRS, UPMC, 61 Avenue de l'Observatoire, 75014 Paris, France.

Recently, the Cesium fountain clocks currently defining the SI second have been superseded in both stability and accuracy by atomic clocks referenced to optical transitions. A way to significantly improve the stability of these clocks is to implement a non-destructive readout of the clock state populations, potentially allowing new applications like relativistic geodesy.

We propose a novel route and demonstrate first results of a doubly-differential non-destructive detection scheme for Strontium atoms inside a high-finesse dual-wavelength cavity. Furthermore, spin squeezing of the coupled atom-cavity system allows pushing of the readout noise below the standard quantum limit.

A 14.20 Mon 16:30 Spree-Palais

High-finesse silicon optical resonators at cryogenic temperatures — •Eugen Wiens, Qun-Feng Chen, Ingo Ernsting, Heiko

Luckmann, Alexander Nevsky, and Stephan Schiller — Institut für Experimentalphysik Heinrich-Heine Universität Düsseldorf, Universitätsstr.1, 4ß225 Düsseldorf

Ultra-stable high-finesse optical resonators are widely used in precision experiments for frequency stabilization of the lasers. In our work we investigate a high-finesse silicon optical resonator down to 1.5 K. It is made of a mono-crystalline silicon cylindrical spacer (25 cm long). The silicon high-reflection mirrors are optically contacted to the spacer, forming a high-finesse (> 200 000) resonator at the wavelength of 1560 nm. The resonators are mounted inside a pulse tube cooler cryostat on a vibration-insensitive support. A fiber laser at 1560 nm is locked to the resonator using a Pound-Drever-Hall technique. The frequency stability of the resonator is measured using a femto-second frequency comb, stabilized to an active hydrogen maser and an ultra-stable laser at 1156 nm. Systematic effects such as tilt of the resonator, laser power fluctuations, temperature instability etc. have been evaluated.

A 14.21 Mon 16:30 Spree-Palais

Ultrapure microwave generated from a comb stabilized to a robust reference — •Qunfeng Chen[1], Alexander Nevsky[1], Marco Cardace[1], Uwe Sterr[2], Stephan Schiller[1], and Ingo Erensting[1] — [1]Institut für Experimentalphysik, Heinrich-Heine Universität Düsseldorf — [2]Physikalisch-Technische Bundesanstalt (PTB), Braunschweig

Towards possible use in space for clocks on the ISS or custom satellites, we have developed a microwave-optical local oscillator. It is based on a reference resonator assembly for a Nd:YAG laser consisting of a 10 cm ULE cavity in a special holder allowing movement and tilt of the assembly. The laser instability is 3×10^{-15}. Using a fiber frequency comb stabilized to the cavity-stablized laser, we have produced ultrapure microwaves. The characterization of the system will be presented.

A 14.22 Mon 16:30 Spree-Palais

Active control of the magnetic field in an ion trap — •Matthias Kreis, Stephan Kucera, and Jürgen Eschner — Experimentalphysik, Universität des Saarlandes, Saarbrücken, Germany

Experiments using coherent atom–photon interaction require control of the energy splitting of the involved atomic levels and therefore a controlled magnetic field. Magnetic–field noise is caused by electric appliances and current fluctuations in bias field coils but cannot directly be measured at the position of the trapped ions. We present a method for servo control of the magnetic field whereby we calculate the magnetic–field value at the ion's location from values measured with several sensors positioned outside the trap chamber. We demonstrate the compensation of different noise contributions.

A 14.23 Mon 16:30 Spree-Palais

Decoherence-assisted spectroscopy of a single Mg^+ ion — •Govinda Clos[1], Martin Enderlein[1], Ulrich Warring[1], Dietrich Leibfried[2], and Tobias Schaetz[1] — [1]Physikalisches Institut, Albert-Ludwigs-Universität Freiburg, Hermann-Herder-Straße 3, 79104 Freiburg, Germany — [2]National Institute of Standards and Technology, 325 Broadway, Boulder, Colorado 80305, USA

Quantum systems that are well isolated from their environments, in particular trapped atoms, offer a high level of control. Several spectroscopic methods have been devised especially for single trapped ions. High-resolution spectroscopy measurements with a precision of better than 10^{-8} are of interest for studying spatial and temporal fine structure variations of the universe. In such experiments, decoherence is typically considered as a source of error. However, here we present a novel and versatile spectroscopy method that is assisted by decoherence: Preparing a superposition of two ground states, the absorption of a single spectroscopy photon and the subsequent spontaneous emission destroy its coherence which can be detected by final state analysis. We experimentally demonstrate the method on trapped and laser-cooled $^{25}Mg^+$ to measure one-, two-, and three-photon transitions from the ground state to the 3P, 3D, and 4P excited states which are relevant for astrophysical data analysis.

A 14.24 Mon 16:30 Spree-Palais

Quantum Logic Enabled Test of Discrete Symmetries — •Malte Niemann[1], Anna-Greta Paschke[1], Kai Voges[1], Stefan Ulmer[2], and Christian Ospelkaus[1,3] — [1]Institut für Quantenoptik, Leibniz Universität Hannover — [2]RIKEN, Ulmer Initiative Research Unit — [3]PTB Braunschweig

Much progress has been made recently towards a CPT test with baryons based on the (anti-)proton's magnetic moment [1, 2]. A big challenge in any such experiment is the spin state measurement for single (anti-)protons. This requires single particle spectroscopy in strong magnetic gradients at ultra-low background noise and long measuring times.

We describe concepts and simulations for an experiment which will implement single-shot spin state readout using quantum logic operations according to the proposal by Heinzen and Wineland [3]. The spin state will be analysed by coupling the (anti-)proton to a co-trapped $^9Be^+$ ion. Compared to the current techniques much faster experimental cycles are expected, and eventually, a significant boost in precision. We discuss trapping geometries, concepts for single (anti-)proton rf sideband control, and for ground state cooling of the atomic quantum logic ion at a magnetic field of several Tesla in a miniaturized Penning trap stack.

[1] A. Mooser et al., Phys. Let. B 723, 78-81 (2013)
[2] A. Mooser et al., Phys. Rev. Let. 110, 140405(2013)
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A 14.25 Mon 16:30 Spree-Palais

Towards quantum logic spectroscopy of highly charged ions — •Tobias Leopold[1], Maria Schwarz[1,3], Oscar Versolato[1,3], Matthias Kohnen[1], Alexander Windberger[3], Lisa Schmöger[1,3], Peter Micke[1,3], Joachim Ullrich[1], José Crespo Lopez-Urrutia[3], and Piet Schmidt[1,2] — [1]Physikalisch-Technische Bundesanstalt, Braunschweig, Germany — [2]Institut für Quantenoptik, Leibniz Universität Hannover, Hannover, Germany — [3]Max-Planck-Institut für Kernphysik, Heidelberg, Germany

Highly charged ions (HCIs) are of special interest in high precision laser spectroscopy. Optical dipole (E1) forbidden transitions offer narrow linewidths perfectly suited for optical clocks. Due to high field strengths in the ions, their energy levels have a low sensitivity to external field shifts. A possible temporal change of the fine structure constant can be probed by spectroscopy of HCIs with unprecedented precision due to highly sensitive transitions.

Electron beam ion traps (EBITs) are an easy way to produce and trap HCIs. However, the trapping potential reaches several kiloelectronvolts so that the temperature of the trapped ions is too high for precision spectroscopy. As direct laser cooling is not applicable in HCIs, we combine an EBIT with a cryogenic linear Paul trap and sympathetically cool with Be^+ ions.

Our aim is to perform quantum logic spectroscopy with Ir^{17+} as spectroscopy ion. The Be^+ ion serves as cooling reservoir and readout of the HCI's electronic state. That technique allows to resolve highly forbidden transitions to their natural linewidth.

A 14.26 Mon 16:30 Spree-Palais

Absolute Kα line energies in highly charged Fe ions using X-ray fluorescence spectroscopy — •Jan K. Rudolph[1,2], Sven Bernitt[2], René Steinbrügge[2], Alfred Müller[1], and José R. Crespo López-Urrutia[2] — [1]Institut für Atom- und Molekülphysik, Gießen, Germany — [2]Max-Planck-Institut für Kernphysik, Heidelberg, Germany

Active galactic nuclei X-ray spectra show prominent features originating from iron Kα transitions. Line emissions of iron ions up to the heliumlike charge state from 6.4 keV to 6.7 keV photon energy provide rich information on the dynamics of X-ray binary stars. To study these transitions we used the Heidelberg transportable electron beam ion trap called FLASH-EBIT [1] to produce a dense target of highly charged iron ions. Kα transitions in this ion cloud were resonantly excited by a monochromatic X-ray beam at the PETRA III synchrotron photon source. Afterwards the fluorescence signal was detected and used to measure line profiles.

We report on absolute line energies with an accuracy of a few ppm for several electric dipole allowed Kα transitions in $Fe^{(17-24)+}$ ions [2]. Also the natural line widths of the investigated fluorescence lines were determined. Well known absorption K-edges were taken as a reference for energy calibration.

This method of measuring absolute line energies combining an EBIT with a high resolved and focused X-ray beam at a synchrotron overcomes classical methods like crystal spectrometer measurements.

A 14.27 Mon 16:30 Spree-Palais

Highly charged ions as new X-ray standard for synchrotrons — •Sven Bernitt[1,2], Thomas Stöhlker[2], and José Ramon Crespo López-Urrutia[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg, Germany — [2]IOQ, Friedrich-Schiller-Universität, Jena, Germany

Atomic transitions excited by lasers are an established and extremely precise wavelength standard in the optical region. In contrast, work in the X-ray region has to rely on crystallographic standards or K-edge absorption. To overcome the limitations of those methods we aim at establishing transitions in highly charged ions (HCI) as new X-ray standards. To this end we use electron beam ion traps (EBIT) to provide targets of highly charged ions for synchrotron radiation. We present results of precise wavelength measurements of He-like Fe [1] and Kr at the synchrotron PETRA III, as well as a new experimental setup based on a small EBIT with permanent magnets. The latter will provide means of linking transitions in HCI to other wavelength standards, like the ^{57}Fe Mößbauer wavelength, and ultimately a precise calibration of the dynamics beamline P01 at PETRA III.

[1] J. K. Rudolph et al., Phys. Rev. Lett. 111, 103002 (2013).

A 14.28 Mon 16:30 Spree-Palais

X-ray laser spectroscopy with an electron beam ion trap at a free-electron laser — •Sven Bernitt and José Ramon Crespo López-Urrutia — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

Highly charged ions (HCI) of various elements are found in the plasmas of many astrophysical objects. Ions of iron play a particularly important role, often dominating the X-ray spectra. High precision X-ray spectroscopy in the laboratory is necessary to test the underlying theory. With X-ray free-electron lasers now available, the techniques of laser spectroscopy can be applied in the X-ray region. By resonantly exciting transitions with photons it is possible to overcome many of the limitations of conventional spectroscopy with HCI, which used to rely on electron impact excitation. We present the results of experiments carried out at the Linac Coherent Light Source (LCLS) free-electron laser. An electron beam ion trap was used to produce and trap Fe^{13+}, Fe^{14+}, Fe^{15+}, and Fe^{16+} and the fluorescence from resonantly excited transitions between 795 and 830 eV was detected. The relative oscillator strength of two prominent lines in Fe^{16+} provided new insight into a 40 year old enigma [1], and an until then only posulated line of Fe^{15+} was directly observed for the first time.

[1] S. Bernitt, Nature 492, 225 (2012).