A 13: Highly Charged Ions and their Applications II

Time: Tuesday 11:00–12:45 Location: N 25

Invited Talk A 13.1 Tue 11:00 N 25

Identifications of clock transitions in heavy highly charged ions with high sensitivity to physics beyond the Standard Model — Nils-Holger Rehbehn[1], Lakshmi P. Kozhiparambil Sajith[1,2], Michael K. Rosner[1], Charles Cheung[3], Sergey G. Porsev[3], Marianna S. Safronova[3], Samuel M. Brewer[8], Steven Worm[2], Dmitry Budker[4,5,6,7], Thomas Pfeifer[1], José R. Crespo López-Urrutia[1], and •Hendrik Bekker[4,5,6] — [1]Max-Planck-Institut für Kernphysik, 69117 Heidelberg, Germany — [2]DESY, D15738 Zeuthen, Germany — [3]Department of Physics and Astronomy, University of Delaware, Newark, Delaware 19716, USA — [4]Johannes Gutenberg-Universität Mainz, 55122 Mainz, Germany — [5]Helmholtz Institute Mainz, 55099 Mainz, Germany — [6]GSI Helmholtzzentrum für Schwerionenforschung GmbH, 64291 Darmstadt, Germany — [7]Department of Physics, University of California, Berkeley, CA 94720-7300, USA — [8]Department of Physics, Colorado State University, Fort Collins, Colorado 80523, USA

Atomic theory predicts numerous optical transitions in a plethora of highly charged ions with exquisite sensitivity to new physics. However, large ucertainties arise due to the complexity of the atomic structures, precluding direct application of state-of-the-art frequency metrology techniques. We present measurements of $Os^{15,16,17+}$ and Pr^{10+} at an electron beam ion trap leading to atomic-theory-supported identifications of transitions suitable for new-physics searches. The discovered electric quadrupole (E2) transitions of Os^{16+} are especially suitable for frequency metrology due to their small linewidth down to 44 μHz.

A 13.2 Tue 11:30 N 25

Laser cooling of bunched relativistic ion beams at the FAIR SIS100 — •Danyal Winters[1], Michael Bussmann[2,3], Tamina Grunwitz[4], Jens Gumm[4], Volker Hannen[5], Thomas Kühl[1,6], Sebastian Klammes[1], Benedikt Langfeld[4], Ulrich Schramm[2,7], Denise Schwarz[4], Mathias Siebold[2], Peter Spiller[1], Thomas Stöhlker[1,6,8], Ken Ueberholz[5], and Thomas Walther[4,9] — [1]GSI Darmstadt — [2]HZDR Dresden — [3]CASUS Görlitz — [4]TU-Darmstadt — [5]Uni Münster — [6]HI-Jena — [7]TU-Dresden — [8]Uni-Jena — [9]HFHF Campus Darmstadt

The heavy-ion synchrotron SIS100 is (at) the heart of the Facility for Antiproton and Ion Research (FAIR) in Darmstadt, Germany. It is designed to accelerate intense beams of heavy highly charged ions up to relativistic velocities and to deliver them to unique physics experiments, such as those planned by the APPA/SPARC collaboration. In order to cool these extreme ion beams, bunched beam laser cooling will be applied using a dedicated facility at the SIS100. We will use a novel 3-beam concept, where laser beams from three complementary laser systems (cw and pulsed) will be overlapped in space, time and energy to interact simultaneously with a very broad ion velocity range in order to maximize the cooling efficiency. We will present this project and give an update of its current status. We will also give an overview of the laser and detector systems that will be used.

A 13.3 Tue 11:45 N 25

Stringent Constraints on New Pseudoscalar & Vector Bosons from Precision Hyperfine Splitting Measurements — •Cedric Quint[1], Fabian Heisse[1], Joerg Jaeckel[2], Lutz Leimenstoll[2], Christoph H. Keitel[1], and Zoltán Harman[1] — [1]Max Planck Institute for Nuclear Physics, Saupfercheckweg 1, 69117 Heidelberg — [2]Insitute for Theoretical Physics, Philosophenweg 16, 69120 Heidelberg

Axion-like particles and similar new pseudoscalar as well as vector bosons coupled to nucleons and electrons are predicted to lead to spin-dependent forces in atoms and ions. We argue that hyperfine structure measurements in hydrogen- and lithium-like charge states are a sensitive probe to this effect. Employing specific differences of these splittings reduces uncertainties due to nuclear effects in hyperfine structure calculations and measurements. Using this, we show that existing measurements on Be provide competitive limits in the region $m_\phi \gtrsim 100$ keV, improving upon existing constraints by up to a factor of 2 for pseudoscalar couplings. We also find that future measurements on Cs have a further factor of $2-2.5$ improved discovery potential for pseudoscalars and an order of magnitude for new vector bosons when compared with the corresponding current constraints.
Reference: 2506.03274

A 13.4 Tue 12:00 N 25

Atomic parity violation in highly charged ^{40,48}Ca and ^{208}Pb ions — •Anna Viatkina[1,2], Christopher Mertens[3], Ben Ohayon[4], Vladimir Yerokhin[5], and Andrey Surzhykov[1,2] — [1]Technische Universität Braunschweig, 38106 Braunschweig, Germany — [2]Physikalisch-Technische Bundesanstalt, 38116 Braunschweig, Germany — [3]Rheinisch-Westfälische Technische Hochschule Aachen, 52062 Aachen, Germany — [4]Technion-Israel Institute of Technology, Haifa 3200003, Israel — [5]Max-Planck-Institut für Kernphysik, 69117 Heidelberg, Germany

We calculate parity-violation-induced E1 amplitudes for the $1s \to 2s$ and $1s^2 2s \to 1s^2 3s$ transitions in H- and Li-like ions of ^{40}Ca, ^{48}Ca, and ^{208}Pb; neutron skin effects and nuclear uncertainties are included for each nucleus. We consider spin-independent weak-interaction contribution of the Z^0 boson described by standard model, as well as the effects of a hypothetical new Z' boson of varying mass. We conclude that the neutron-skin corrections in the ^{40,48}Ca isotope pair can be mostly neglected when considering Z' boson effects, which is an advantage for the search for new parity-violating physics. On the other hand, both the neutron skin effect and the sensitivity to hypothetical Z' interactions in ^{208}Pb is shown to be significant.

A 13.5 Tue 12:15 N 25

Particle Motion Inside the HITRAP Penning Trap — •Jonas Ködel for the HITRAP-Collaboration — Institut für Kernphysik, TU Darmstadt, Schloßgartenstr. 9, Darmstadt, Germany — Helmholtz Graduate School for Hadron and Ion Research, Germany

The HITRAP (**hi**ghly charged ion **trap**) facility located at the GSI Helmholtzzentrum für Schwer-ionenforschung in Darmstadt provides the unique ability to decelerate heavy, accelerator-produced highly charged ions (HCI) down to 6keV/nucleon and cool to eV equivalent temperature. To facilitate electron cooling of a single charge state inside HITRAP's Penning trap, the motion of HCI inside a cylindrical Penning trap is explored.

We present our findings on the modes of motion of highly charged Argon ions inside the HITRAP Penning trap. By leveraging intentional over-excitation of stored ions by radio frequency, the characteristic frequencies of axial-, magnetron- and reduced cyclotron motion are extracted. With the full length of the cylindrical trap used for ion capture, the electrode potential is flat, rather than hyperbolic, hence the typical eigenmotion frequencies are mixed. Lastly, the effects of changes in the Penning trap's magnetic field, the ion's charge state, and the Penning trap's potential on the three characteristic frequencies are shown.

A 13.6 Tue 12:30 N 25

The Microwave Cavity Penning Trap for the Lsym Experiment — •Paul Holzenkamp, Maria Pasinetti, Fabian Raab, Leonie Marzel, Sarah Placek, Andreas Thoma, Sangeetha Sasidharan, and Sven Sturm — MPIK, Heidelberg, Germany

Lsym is a cryogenic Penning trap experiment, aiming to significantly improve the precision of CPT tests for the electron and positron. Specifically, we will look for an asymmetry in their charge-to-mass ratio as well as their g-factors or determine stringent limits. The trap will be cooled to about 300 mK to minimize transition rates out of the ground states of the cyclotron and axial motion, respectively. While the cyclotron motion cools via synchrotron radiation, for the axial motion, cavity assisted side-band cooling will be employed. To this end, the main Penning trap ("CavityTrap") not only should provide a highly harmonic trapping potential but also needs to support efficient millimeter wave spin control drives at the Larmor frequency and axial sideband, while efficiently rejecting photons at the cyclotron frequency. To achieve this, both the mode structure and the in-coupling of the microwaves into the cavity have to be designed appropriately. Additionally, the CavityTrap should allow for the separation of the singly charged helium ion and the positron that are trapped together. Numerical simulations are used to design the CavityTrap geometry in order to simultaneously fulfill the requirements for the microwave cavity structure and also optimize the electrostatic potential of the Penning trap. I will show the current status of the Lsym CavityTrap design.