Q 6: Precision Spectroscopy of Atoms and Ions I (joint session A/Q)

Time: Monday 11:00–13:00 Location: HS PC

Invited Talk Q 6.1 Mon 11:00 HS PC

Towards an optical atomic clock based on Ni^{12+} — •Malte Wehrheim[1], Lukas J. Spiess[1], Shuying Chen[1], Alexander Wilzewski[1], Piet O. Schmidt[1,3], and José R. Crespo Lopez-Urrutia[2] — [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

Highly charged ion (HCI) optical clocks offer reduced susceptibility to systematic shifts due to the high binding energies of the remaining electrons. Our experimental setup allows the co-trapping of individual HCI with Be^+ for sympathetic cooling and quantum logic readout. In the past, this approach allowed us to measure absolute frequencies of optical transitions in HCI with uncertainties in the low 10^{-16} range limited by the ions* short excited-state lifetime of around 10 ms [1].

In this work, we present the progress towards an improved HCI clock based on Ni^{12+}, with expected systematic uncertainties at the low 10^{-18} level and reduced instability due to its long excited-state lifetime of ∼20 seconds, enabling long interrogation times. We report on the initial transition search [2] and the first spectroscopy of the dipole-forbidden clock transition, paving the way for a new generation of high accuracy optical clocks.

[1] S. A. King, L. J. Spiess, et al., Nature 611, 43 (2022)
[2] S. Chen, et al., Phys. Rev. Appl. 22, 054059 (2024)

Q 6.2 Mon 11:30 HS PC

A Cryogenic Permanent Magnet Penning Trap for Sympathetic Laser Cooling at μTEx — •Philipp Justus[1,2], Anton Gramberg[1,2], Stefan Dickopf[1], Annabelle Kaiser[1], Ankush Kaushik[1], Marius Müller[1], Stefan Ulmer[3,4], Andreas Mooser[1], and Klaus Blaum[1] — [1]Max-Planck-Institut für Kernphysik Heidelberg, Germany — [2]Ruprecht-Karls Universität Heidelberg, Germany — [3]Heinrich-Heine Universität Düsseldorf, Germany — [4]RIKEN, Wako, Japan

Penning traps, being versatile tools for various high-precision measurements in atomic and nuclear physics, are used for nuclear magnetic moment measurements at the μTEx experiment in Heidelberg. The experiment aims to measure the $^3He^{2+}$ nuclear magnetic moment with a relative uncertainty on the 10^{-9} level which relies on sympathetic laser cooling with $^9Be^+$ [1-3]. To test and implement sympathetic laser cooling a new experimental setup has been developed. It consists of a five-electrode Penning trap with a permanent magnet system providing a homogeneous magnetic field of $B \sim 240$ mT and cooled to $T \sim 4$ K using a pulse tube cooler. The characterization of Doppler cooling at the $^2S_{1/2} \rightarrow {}^2P_{3/2}$ transition of $^9Be^+$ will employ electronic and photonic detection mechanisms integrated into the system. The entire experiment is designed for quick adjustments and flexible modifications to the setup. In the talk I will present the current status of the design of the experiment.

[1] Mooser et al., J. Phys.: Conf. Ser. 1138 012004 (2018) [2] Schneider et al., Nature 606, 2022 [3] Dickopf et al., Nature 632, 2024

Q 6.3 Mon 11:45 HS PC

Two-Photon Spectroscopy of Xenon — •Felix Waldherr[1], Simon Stellmer[2], Skyler Degenkolb[1], and panEDM Collaboration[3] — [1]Universität Heidelberg, Germany — [2]Rheinische Friedrich-Wilhelms-Universität Bonn, Germany — [3]Institut Laue-Langevin, Grenoble, France

Precision spectroscopy of xenon is relevant for a variety of applications, including searches for the neutron electric dipole moment and magnetometry. However, spectroscopy has been challenging due to the inaccessibility of suitable UV laser systems. We present a spectroscopy setup capable of performing two-photon spectroscopy of xenon, focusing on the $5p^6(^1S_0) \rightarrow 5p^5(^2P_{3/2})6p\ ^2[5/2]_2$ transition at 256 nm. Building on earlier measurements of this transition, the setup incorporates the use of coincidence detection of emitted IR and UV fluorescence photons, which is expected to enhance the signal-to-noise ratio.

Q 6.4 Mon 12:00 HS PC

Spectroscopy of a narrow cooling transition in zinc — •Vedang Sumbre, Lukas Möller, David Röser, and Simon Stellmer — Physikalisches Institut, Universität Bonn, Nussallee 12, 53115 Bonn

Zinc has emerged as a strong candidate for a highly precise optical clock, due to its small sensitivity to black body radiation. We perform Doppler-free spectroscopy of the 307.6 nm 1S0 -> 3P1 transition on a thermal vapor of zinc atoms, and measure the isotope shifts of this transition for all the stable isotopes of Zinc.

Q 6.5 Mon 12:15 HS PC

Magneto-optical trapping of Zinc — •Lukas Möller, David Röser, and Simon Stellmer — Physikalisches Institut, Nussallee 12, Universität Bonn, 53115 Bonn, Germany

Laser-cooling and trapping of neutral atoms is a widely used technique in contemporary atomic physics. It has been demonstrated for many elements of the periodic table and is especially well established for alkaline and alkaline-earth metals. The element zinc, an alkaline-earth-like metal, is a promising candidate for a new optical clock. Work on zinc also motivates the development of new cw-laser sources in the UV range, since its strong cooling transition lies at 213.9 nm. In this talk, I will present the work of our group towards magneto-optical trapping of Zinc, as the first step towards spectroscopy of the clock transition.

Q 6.6 Mon 12:30 HS PC

High-Resolution Dielectronic Recombination of Beryllium-like Gold Ions in the Electron Cooler of the Cryring@ESR Storage Ring — •Mirko Looshorn[1,2], Carsten Brandau[3], Mike Fogle[4], Jan Glorius[3], Elena Hanu[3,5], Volker Hannen[6], Pierre-Michel Hillenbrand[3], Claude Krantz[3], Michael Lestinsky[3], Esther Menz[3,5,7], Reinhold Schuch[8], Uwe Spillmann[3], Ken Ueberholz[6], Shuxing Wang[1,2], and Stefan Schippers[1,2] — [1]I. Physikalisches Institut, Justus-Liebig-Universität Gießen, 35392 Giessen, Germany — [2]Helmholz Forschungsakademie Hessen für FAIR (HFHF), Campus Giessen, 35392 Giessen, Germany — [3]GSI, Helmholtzzentrum für Schwerionenforschung, 64291 Darmstadt, Germany — [4]Department of Physics, Auburn University, AL 36832, USA — [5]Helmholtz-Institut Jena, 07743 Jena, Germany — [6]Institut für Kernphysik, Universität Münster, 48149 Münster, Germany — [7]Institute for Optics and Quantum Electronics, Friedrich-Schiller-Universität Jena, 07743 Jena, Germany — [8]Department of Physics, Stockholm University, 10691 Stockholm, Sweden

We report on the results of an electron-ion collision experiment with berylliumlike gold ions, which were injected into Cryring@ESR from the full chain of GSI accelerators. Measurements were carried out in the collision-energy range 0-300 eV, where the $2s2p\ (^3P_1)\ nl$ dielectronic recombination (DR) resonances with n=19-21 occur, which are associated with the $2s^2\ ^1S_0 \rightarrow 2s2p\ ^3P_1$ excitation of the Be-like ion core. We will present preliminary comparisons of our experimental DR spectra with corresponding theoretical results.

Q 6.7 Mon 12:45 HS PC

High-precision ground-state hyperfine spectroscopy on a trapped ^{9}Be ion — •Annabelle Kaiser[1], Stefan Dickopf[1], Bastian Sikora[1], Marius Müller[1], Anton Gramberg[1], Ankush Kauschik[1], Philipp Justus[1], Stefan Ulmer[2,3], Zoltan Harman[1], Vladimir Yerokhin[1], Christoph Keitel[1], Andreas Mooser[1], and Klaus Blaum[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg, Germany — [2]Heinrich-Heine Universität Düsseldorf, Germany — [3]RIKEN, Wako, Japan

Measurements of the Zeeman splitting in systems with nuclear magnetic moments can be used to infer the shielded nuclear and the bound electron g-factors, as well as the zero-field hyperfine splitting [1]. We measured the Zeeman splitting of $^9Be^{3+}$ and compare it to measurements on $^9Be^{1+}$ [2] to test the theory of the diamagnetic shielding factor [3] on the parts per billion level. Additionally, we compare our measured zero-field splitting with the value obtained in $^9Be^{1+}$ via the so-called hyperfine specific difference to cancel theoretically intractable nuclear structure contributions. The measurement results as well as future plans will be presented [4].

[1] A. Schneider et al, Nature 606, 878-883 (2022)
[2] D. J. Wineland et al, Phys. Rev. Lett. 50, 628-631 (1983)
[3] K. Pachucki and M. Puchalski, Opt. Commun. 283, 641-643 (2010)
[4] S. Dickopf et al, Nature 632, 757-761 (2024)