Q 46: Precision Spectroscopy of Atoms and Ions IV (joint session A/Q)

Time: Wednesday 14:30–15:45 Location: KlHS Mathe

Q 46.1 Wed 14:30 KlHS Mathe

Fifth-force searches with the bound-electron *g* factor — •Zoltan Harman — Max Planck Institute for Nuclear Physics, Heidelberg, Germany

High-precision measurements of the g factor of one- and few-electron ions and its isotope shifts offer a promising avenue for probing beyond-Standard-Model (BSM) physics [1]. By calculating the potential contribution of a hypothetical new force to the g-factor of H-like, Li-like, and B-like ions, we can derive constraints on the parameters of such a force. This approach leverages the advanced theoretical calculations of QED contributions to the bound-electron g-factor [2,3].
To enhance sensitivity to new physics, we focus on the weighted difference and, especially, the isotope shift of g-factors. We have found that a recent Penning-trap measurement of the isotopic shift of the g factors in $^{20}Ne^{9+}$ and $^{22}Ne^{9+}$ to sub-parts-per-trillion precision present a compelling alternative for setting bounds on BSM interactions [4]. Moreover, combining measurements from different isotopes of H-like, Li-like and B-like ions [1] at accuracy levels projected to be accessible in the near future, experimental results would constrain the new physics coupling constant further than the best current spectroscopic data and theory. – [1] V. Debierre, C. H. Keitel, Z. Harman, Phys. Lett. B **807**, 135527 (2020); [2] J. Morgner, B. Tu, C. M. König, *et al.,* Nature **622**, 53 (2023); [3] B. Sikora, V. A. Yerokhin, C. H. Keitel, Z. Harman, arXiv:2410.10421 (2024); [4] T. Sailer, V. Debierre, Z. Harman, *et al.,* Nature **606**, 479 (2022).

Q 46.2 Wed 14:45 KlHS Mathe

Raman Transition Techniques for High-Precision Experiments in Collinear Laser Spectroscopy — •Julien Spahn, Hendrik Bodnar, Kristian König, and Wilfried Nörtershäuser — Institute for nuclear physics, TU Darmstadt, Germany

Benefitting from the drastic compression of the velocity width through an electrostatic acceleration by several 10 kV and, hence, overcoming Doppler broadening, collinear laser spectroscopy is a fast technique for precision measurements on dipole-allowed transtions. Being constantly refined, the natural linewidth of the dipole transition starts becoming a limiting factor. Raman transitions have a two orders of magnitude smaller linewidth than dipole transitions. While various applications utilizing Raman transitions have emerged over the years, techniques exploiting Raman transitions in collinear laser spectroscopy have so far been limited to hyperfine structure studies [1].
This contribution will present the results of recent measurements of the $S_{1/2} \rightarrow D_{5/2}$ clock transition $^{88}Sr^{+}$ at COALA, used to benchmark the applied collinear Raman spectroscopy. The AC-Stark shift and two-photon Rabi oscillations were investigated, and the feasibility of performing laser spectroscopical HV measurements using a "Raman velocity filter" [2] was tested. Furthermore, an approach for Doppler-free collinear Raman spectroscopy employing two subsequent Raman transitions will be presented.
This project is supported by DFG (Project-ID 461079926).
[1] TP Dinneen et al., *Physical Review A*, 43, 1991
[2] A. Neumann et al., *Physical Review A*, 101, 2020

Q 46.3 Wed 15:00 KlHS Mathe

high-resolution spectroscopy of $^{173}Yb^{+}$ — •jian jiang[1], anna viatkina[1,2], saaswath JK[1], melina filzinger[1], martin steinel[1], burghard lipphardt[1], andrey surzhykov[1,2], and nils huntemann[1] — [1]Physikalisch-Technische Bundesanstalt, Braunschweig, Germany — [2]TU Brauschweig, Braunschweig, Germany

Different isotopes of Yb^{+} have been employed in atomic clocks [1], quantum information processing [2], and new physics searches [3]. Owing to its large nuclear spin of 5/2, , $^{173}Yb^{+}$ is a particular promising candidate for advancing research in these areas compared to other isotopes [4,5,6]. However, $^{173}Yb^{+}$ is also relatively poorly investigated because of its complicated atomic structure.

In this talk, we will first discuss our approaches to overcome challenges in laser cooling and state preparation of a single $^{173}Yb^{+}$ ion confined in a Paul trap. We will then discuss measurements we have done for the hyperfine structure of the $^2S_{1/2}$ and $^2D_{3/2}$ states and the electric quadrupole clock transition between them. We will also discuss the ongoing search for the $^2S_{1/2} \rightarrow {}^2F_{7/2}$ electric octupole clock transition.

Reference [1] PRL. 116, 063001 (2016), [2]Nature 630, 613-618 (2024), [3] PRL 125, 123002 (2020), [4] APL 119, 214002 (2021), [5] PRA 93, 052517 (2016), [6] Phys. Rev. A 96, 012516(2017)

Q 46.4 Wed 15:15 KlHS Mathe

Characterizing tungsten emissivity and temperature stability of an atomic beam source for the Project 8 Experiment — •Brunilda Mucogllava[1], Martin Fertl[1], and Marco Röllig[2] for the KAMATE-Collaboration — [1]Johannes Gutenberg University Mainz — [2]Tritium Laboratory Karlsruhe

The Project 8 experiment seeks to make a neutrino-mass measurement with a sensitivity of 40 meV/c2 using cyclotron radiation emission spectroscopy of beta decay electrons from an atomic tritium source. To enable safe initial R&D, a Hydrogen Atom Beam Source (HABS) is used at the JGU Mainz test stand, where molecular hydrogen is dissociated inside a 1 mm tungsten capillary heated radiatively to 2300 K by a tungsten filament. The efficiency of dissociation is closely tied to the capillary's surface temperature, which depends on its thermal properties. The aging of both the tungsten filament and capillary alters their surface resistivity and emissivity, affecting the achievable temperature and complicating absolute temperature measurements. To address this, a calibration setup at the Tritium Laboratory Karlsruhe (TLK) was developed to measure tungsten emissivity using a near-infrared spectrometer and a single wavelength pyrometer. This talk will present findings on tungsten emissivity modeling and HABS temperature measurements, addressing challenges in device calibration, ultra-high vacuum conditions, and temperature stability.

Q 46.5 Wed 15:30 KlHS Mathe

Absolute rate coefficients from dielectronic recombination for the astrophysically relevant ion of Ne3+ at CRYRING@ESR — •E.-O. Hanu[1,3,10], M. Lestinsky[1], E. B. Menz[1,3,4], M. Fogle[2], S. Schippers[5,6], P.-M. Hillenbrand[1,5], M. Looshorn[5,6], S. Wang[5,6], R. Schuch[7], C. Brandau[1], K. Ueberholz[8], R. S. Sidhu[9], M. Tatsch[5,6], A. Biniskos[10], and T. Stoehlker[1,3,4] — [1]GSI, Darmstadt, Germany — [2]Dep. of Physics, Auburn University, USA — [3]HI Jena, Germany — [4]Uni Jena, Germany — [5]I. Physikalisches Institut, Uni Giessen, Germany — [6]HFHF, Giessen, Germany — [7]Dep. of Physics, Stockholm University, Sweden — [8]IKP, Uni Muenster, Germany — [9]School of Physics and Astronomy, University of Edinburgh, UK — [10]Uni Frankfurt am Main, Germany

Dielectronic recombination (DR) is a resonant electron capture process, critical in astrophysical plasmas. At CRYRING@ESR, pure ion beams are stored, cooled, and exposed to a monoenergetic electron beam, enabling high-precision DR measurements at low electron-ion interaction energies. These measurements are vital for understanding cold plasma environments. Neon, among the most abundant cosmic elements, appears in spectroscopic data of various astrophysical objects. We present preliminary results from DR experiments with N-like Ne3+ ions. Ions were injected from an ECRIS, accelerated to 2.23 MeV/u, stored, and electron-cooled in CRYRING with ~6 * 10^6 ions per cycle and ~10 s beam lifetimes. DR spectra were recorded over 0 - 24 eV, revealing strong resonances, especially below 0.5 eV, where rates approach those near the series limit (~24 eV).