A 10: Highly charged ions and their applications

Time: Monday 16:15–17:45 Location: S HS 3 Physik

A 10.1 Mon 16:15 S HS 3 Physik

Commissioning of a High-Power Electron-Gun for Electron-Ion Crossed-Beams Experiments — •B. Michel Döhring[1,2], Alexander Borovik Jr[1], Benjamin Ebinger[1,2], Kurt Huber[1], Tobias Molkentin[1], Alfred Müller[1], and Stefan Schippers[1] — [1]Justus-Liebig-Universität Gießen — [2]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt (Germany)

Reliable atomic data for electron impact ionisation of ions are required for a thorough understanding and modelling of plasmas. This affects a wide range of research fields such as, e. g. astrophysics, space propulsion, EUV-lithography, and fusion research. Recently, a new electron gun has been integrated into the Gießen crossed-beams experiment which permits to extend the measurements to much higher electron energies than before. This electron gun provides a ribbon-shaped electron beam with energies ranging from 10 to 3500 eV [1,2,3]. For a high flexibility, we can choose between different operation modes. Here, we present the latest achievements in the commissioning of this gun as well as new cross-section measurements for multiply charged xenon ions.

[1] W. Shi et al., NIMB 205 (2003) 201-206.
[2] A. Borovik Jr. et al., J. Phys.: Conf. Ser. 488 (2014) 142007.
[3] B. Ebinger et al., NIMB 408 (2017) 317-322.

A 10.2 Mon 16:30 S HS 3 Physik

Statistical completion and validation of the NIST Atomic Spectral Database — •Keisuke Fujii[1] and José R. Crespo López-Urrutia[2] — [1]Kyoto University, Department of Mechanical Engineering and Science, Graduate School of Engineering, Kyoto 615-8540, Japan — [2]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

The NIST Atomic Spectral Database (ASD) [1] contains the electronic energy levels of most elements in all known degrees of ionization, and has for decades been an essential standard tool in atomic science, spectroscopy and plasma physics. However, there are substantial gaps in the data, and many energy levels of highly charged ions are still missing owing to the difficulties of measurements. In this work, we utilize a machine learning method to find structures in the atomic data compiled in the ASD database. With the extracted data structure, we predict the missing data values and provide probabilistic Bayesian uncertainty information. Furthermore, we identify some anomalies in the existing entries, which may be due to typographic mistakes or misidentifications.

[1] Kramida, A., Ralchenko, Yu., Reader, J. and NIST ASD Team (2018). NIST Atomic Spectra Database (version 5.6.1), https://physics.nist.gov/asd . National Institute of Standards and Technology, Gaithersburg, MD. DOI: https://doi.org/10.18434/T4W30F

A 10.3 Mon 16:45 S HS 3 Physik

Direct determination of ion numbers and energies by a single-pass non-destructive charge counter — •Markus Kiffer[1], Stefan Ringleb[1], Nils Stallkamp[1,2], Sugam Kumar[3], Ilya Blinov[4], Manuel Vogel[2], Stefan Stahl[5], Wolfgang Quint[2,6], Thomas Stöhlker[1,2,7], and Gerhard G. Paulus[1,7] — [1]Institut für Optik und Quantenelektronik, Friedrich-Schiller-Universität, 07743 Jena, Germany — [2]GSI Helmholtzzentrum für Schwerionenforschung GmbH, 64291 Darmstadt, Germany — [3]Inter-University Accelerator Centre, 110067 New Delhi, India — [4]Fachbereich Physik, Technische Universität Darmstadt, 64289 Darmstadt, Germany — [5]Stahl Electronics, 67582 Mettenheim, Germany — [6]Physikalisches Institut, Ruprecht Karls-Universität Heidelberg, 69120 Heidelberg, Germany — [7]Helmholtz-Institut Jena, 07743 Jena, Germany

The HILITE Penning trap will provide well-defined ion targets to investigate laser-matter interactions in both the high-intensity and high-energy regime with highly-charged ions. For ion counting we have implemented two distinct single-pass non-destructive charge counters. They measure the time-dependent image charge induced by an ion bunch. From these signals we can directly extract the kinetic energy, the number of ions and the bunch length. We will show a brief overview of the HILITE experiment and present the implemented ion counting technique with detailed characterization results. Here we will focus on the sensitivity of the device and the minimum detectable number of ions. Furthermore, we will outline actions to further increase the signal-to-noise ratio to be even sensitive to less than ten ions per bunch.

A 10.4 Mon 17:00 S HS 3 Physik

Laser beamline for laser cooling of stored relativistic heavy-ion beams at the SIS100 — •Max Horst[1,2], Daniel Albach[3,5], Gerhard Birkl[2], Michael Bussmann[3], Volker Hannen[4], Daniel Kiefer[2], Sebastian Klammes[1,2], Thomas Kühl[1], Markus Löser[3,5], Ulrich Schramm[3,5], Mathias Siebold[5], Peter Spiller[1], Thomas Stöhlker[1,6,7], Johannes Ullmann[1,4], Thomas Walther[2], Daniel Winzen[4], and Danyal Winters[1] — [1]GSI Darmstadt — [2]TU Darmstadt — [3]HZDR Dresden — [4]Uni Münster — [5]TU-Dresden — [6]HI-Jena — [7]Uni-Jena

At relativistic velocities, laser cooling is an efficient technique to minimize the momentum spread of stored heavy-ion beams in storage rings. For the future facility FAIR in Darmstadt, this cooling method will be the only one applied to the heavy-ion synchrotron SIS100. The distance from the laser lab to the accelerator, in which the laser beam will be overlapped with an ion beam, is about 25 m crossing two tunnels. For several good reasons, it is best to transport the laser light through a vacuum beamline. However, due to the required mirror setup and multiple optical components, the polarization of the light emerging from the laser beamline will be somewhat modified. To avoid unwanted effects during laser cooling, such as optical pumping, we need to control the polarization of the laser light at the interaction section. We will present the design of the laser beamline, mention some important aspects, and discuss results from recent polarization measurements using a demo setup of the laser beamline.

Invited Talk A 10.5 Mon 17:15 S HS 3 Physik

Towards testing physics beyond the Standard Model with the bound-electron g factor — •Vincent Debierre, Christoph H. Keitel, and Zoltán Harman — Max Planck Institute for Nuclear Physics, Saupfercheckweg 1, 69117 Heidelberg

We demonstrate the relevance of the g factor of bound electrons in few-electron ions to the search for physics beyond the Standard Model (SM). The contribution to the g factor from hypothetical forces beyond the SM can be calculated and, when compared to existing and potential experimental data, used to derive competitive bounds on the parameters of these forces.

A first method to implement this program consists in comparing the best available theoretical and experimental results, including data on the weighted difference of g factors of different electronic levels [V.A. Yerokhin *et al.*, Phys. Rev. Lett. **116**, 100801 (2016)]. Stringent bounds can be obtained in the future with this method, through the ongoing advancement of bound-state QED calculations at the two-loop level.

Another method makes use of the isotope shift. Inspired by a recent proposal concerning optical frequencies in ions [J.C. Berengut *et al.*, Phys. Rev. Lett. **120**, 091801 (2018)], we propose to use precision spectroscopy of the isotope shifts in the g factor of few-electron ions, to obtain bounds on a hypothetical fifth fundamental force. This method is based on experimental King plots, which are built from isotope shift data. By carefully considering subleading nuclear corrections to the g factor, our treatment allows for the precise interpretation of King plots.