A 9: Precision Spectroscopy II

Time: Monday 17:00–19:00 Location: N 3

A 9.1 Mon 17:00 N 3

Laser spectroscopy of the heaviest elements — •Sebastian Raeder[1], Dieter Ackermann[2,3], Hartmut Backe[4], Michael Block[1,2,4], Bradley Cheal[6], Premaditya Chhetri[2,5], Christian Droese[2], Christoph E. Düllmann[1,2,4], Julia Even[7], Rafael Ferrer[8], Francesca Giacoppo[1,2], Stefan Götz[1,2,4], Fritz Peter Hessberger[2,5], Oliver Kaleja[2], Jadambaa Khuyagbaatar[1,2], Peter Kunz[9], Mustapha Laatiaoui[1,2], Felix Lautenschläger[2,5], Werner Lauth[4], Lotte Lens[2,4], Nathalie Lecesne[3], Andrew K. Mistry[1,2], Enrique Minaya Ramirez[10], Thomas Walther[5], Alexander Yakushev[1,2], and Zhiyuan Zhang[11] — [1]Helmholtz-Institut Mainz — [2]GSI, Darmstadt — [3]GANIL, Caen — [4]Universität Mainz — [5]TU Darmstadt — [6]University of Liverpool — [7]KVI-CART, Groningen — [8]KU-Leuven — [9]TRIUMF, Vancouver — [10]IPN Orsay — [11]IMP Lanzhou

Laser spectroscopy of the heaviest elements with $Z>100$ enables studying the influence of relativistic and QED effects on the atomic shell structure, but is hampered by the low production rates available. Applying the sensitive Radiation Detected Resonance Ionization Spectroscopy technique at the SHIP velocity filter in GSI, we identified optical transitions in the element nobelium (Z=102) for the first time. Besides the identification of a strong optical ground-state transition, the hyperfine structure splitting in the isotope ^{253}No was measured along with the isotope shifts in $^{252-254}$No. These results will be discussed and the prospects for first attempts in extending laser spectroscopy to the next of the heaviest elements, lawrencium, will be given.

A 9.2 Mon 17:15 N 3

Precision spectroscopy of Ba^+ isotopes in a Paul trap — •Nivedya Valappol, Elwin Dijck, Amita Mohanty, Klaus Jungmann, Lorenz Willmann, and Aswin Hofsteenge — Van Swinderen Institute, University of Groningen, The Netherlands

We perform precision spectroscopy on Ba^+ ions and precisely determine the $6s^2S_{1/2}$ - $6p^2P_{1/2}$, $6p^2P_{1/2}$ - $5d^2D_{3/2}$, $6s^2S_{1/2}$ - $5d^2D_{5/2}$ transition frequencies. We have achieved more than 100 times improved values using single trapped ion and frequency comb and I_2 line locked laser system. We have reached 10^{-11} relative accuracy, where these values test precisely the atomic wave functions. This is important input for a measurement of atomic parity violation in the alkaline earth atoms.

A 9.3 Mon 17:30 N 3

High-resolution In-source Laser Spectroscopy of Hyperfine Structures and Isotope Shifts on ^{163,165,166m}Ho Isotopes for the ECHo Project — •Reinhard Heinke[1], Tom Kieck[1], Tobias Kron[1], Sebastian Raeder[2], Marcel Trümper[1], Carsten Weichhold[1], and Klaus Wendt[1] — [1]Johannes Gutenberg-Universität, Mainz — [2]Helmholtz-Institut Mainz

The ECHo project aims for a measurement of the electron neutrino mass by precise analysis of the electron capture decay spectrum of ^{163}Ho. As part of this project, ^{163}Ho ions are implanted into metallic microcalorimeters, applying the highly selective laser resonance ionization technique at the RISIKO mass separator at Mainz University. In order to fully exploit the opportunities of isotope selective ionization, suppressing the interfering contamination of radioactive ^{166m}Ho even further, detailed knowledge of the hyperfine structure of the atomic transitions is mandatory. Therefore, high resolution laser spectroscopic investigations were performed on ^{163,165,166m}Ho isotopes, using a pulsed frequency doubled injection-locked high repetition rate titanium:sapphire laser system in combination with a newly developed dedicated ion source with perpendicular atom - laser beam interaction geometry in a radiofrequency quadrupole structure. First results on atomic and nuclear structure parameters are presented, including first-time optical measurements on ^{166m}Ho.

A 9.4 Mon 17:45 N 3

Towards Laser Spectroscopy of Boron-8 — •Bernhard Maass[1], Peter Müller[2], Jason Clark[2], Christian Gorges[1], Simon Kaufmann[1], Kristian König[1], Jörg Krämer[1], Anthony Levand[2], Rodney Orford[2], Rodolfo Sánchez[3], Guy Savard[2], Felix Sommer[1], and Wilfried Nörtershäuser[1] — [1]IKP,TU Darmstadt, DE — [2]ANL, Chicago, IL, USA — [3]GSI Darmstadt, DE

The BOR8 experiment aims at the determination of the nuclear charge radius of boron-8 with high-resolution laser spectroscopy. ^{8}B is perhaps the best candidate of a nucleus exhibiting an extended proton wave-function or one-proton-halo. The charge radius, which is directly correlated with the extent of the proton wave function, can be extracted from the measured isotope shift along the boron isotopic chain. Atomic theory calculations of the five-electron system, which were recently carried out, pave the way for targeting neutral boron atoms, whose spectroscopic properties are well suited for such measurements. In-flight production and preparation of sufficient yields of ^{8}B ions at low energies are provided by the Argonne Tandem Linac Accelerator System (ATLAS) at Argonne National Laboratory (ANL). In a first off-line experiment, the isotope shift of the stable isotopes ^{10,11}B have been measured with resonance ionization mass spectrometry. This delivers a valuable test not only of atomic theory, but also of experimental equipment which will later be used at ANL.

This work is supported by the U.S. DOE, Office of Science, Office of Nuclear Physics, under contract DE-AC02-06CH1135, and by the Deutsche Forschungsgemeinschaft through Grant SFB 1245.

A 9.5 Mon 18:00 N 3

Atomic Parity Violation in Ytterbium and Dysprosium — •Anne Fabricant[1], Dionysios Antypas[2], Lykourgos Bougas[1], Nathan Leefer[3], Konstantin Tsigutkin[4], and Dmitry Budker[1,2,5] — [1]Johannes Gutenberg Universität-Mainz, Germany — [2]Helmholtz Institut-Mainz, Germany — [3]Nixie Labs, Mountain View, California, USA — [4]ASML, Veldhoven, The Netherlands — [5]University of California at Berkeley, USA

Atomic-parity-violation (APV) experiments enable us to probe fundamental electroweak and nuclear physics at low energies on a tabletop. Ytterbium (Yb) and dysprosium (Dy) are excellent candidates for APV measurements because of their particularly strong parity-violating effects (already confirmed experimentally for Yb) and the availability of many stable isotopes. Both systems are ideal for investigation of neutron distributions in the nucleus (the neutron skin), as well as of anapole moments arising from the weak interaction between nucleons. In addition, Dy is used to search for variation of fundamental constants. We report on the current status of our updated experimental setups in Mainz, present our latest results, and discuss future plans.

A 9.6 Mon 18:15 N 3

Nuclear transitions induced by atomic processes — Andrey V. Volotka[1], Andrey Surzhykov[2,3], Stephan Fritzsche[1,4], and •Robert A. Müller[2,3] — [1]Helmholtz-Institute Jena, Jena, Germany — [2]Physikalisch-Technische Bundesanstalt, Braunschweig, Germany — [3]Technische Universität Braunschweig, Braunschweig, Germany — [4]Friedrich-Schiller-Universität Jena, Jena, Germany

The investigation of nuclei in isomeric (metastable) states gives important insight into their inner dynamics. Moreover the low lying nuclear excitation at a few eV in ^{229}Th has received strong interest because of its applicability for a nuclear clock [1]. For the majority of these studies the nuclear isomers are produced by neutron collisions or as products of the radioactive decay series of heavier elements. A direct photoexcitation seems possible as well but turns out to be a very difficult task due to the extremely narrow linewidths of the nuclear states. In contrast to photons, atomic electrons have a large overlap with the nucleus and, hence, are not only sensitive to nuclear properties but can also be used instead of photons to induce nuclear excitations [2]. In this contribution we will discuss different possible scenarios for the excitation of nuclei via electronic processes. We will especially concentrate on two-photon processes in highly charged ions and multi-step schemes in almost neutral systems, e.g. Th^{2+}, that can be realized using optical lasers.

[1] E. Peik and M. Okhapkin, C. R. Physique **16**, 516-523 (2015)
[2] R. A. Müller *et al.*, NIMB (2016) submitted

A 9.7 Mon 18:30 N 3

The first ionization potential of nobelium — •Premaditya Chhetri[1,2], Dieter Ackermann[2,3], Hartmut Backe[4], Michael Block[2,4,5], Bradley Cheal[6], Christian Droese[7], Christoph Emanuel Düllmann[2,4,5], Julia Even[8], Rafael

Ferrer[9], Francesca Giacoppo[2,5], Stefan Götz[2,4,5], Fritz Peter Hessberger[2,5], Oliver Kaleja[2,4], Jadambaa Khuyagbaatar[2,5], Peter Kunz[10], Mustapha Laatiaoui[2,5], Felix Lautenschläger[1,2], Werner Lauth[4], Lotte Lens[2,4], Nathalie Lecesne[3], Andrew Kishor Mistry[2,5], Sebastian Raeder[2,5], Enrique Minaya Ramirez[11], Thomas Walther[1], Alexander Yakushev[2], and Zhiyuan Zhang[12] — [1]TU Darmstadt — [2]GSI — [3]GANIL — [4]Universität Mainz — [5]Helmholtz-Institut Mainz — [6]University of Liverpool — [7]Universität Greifswald — [8]KVI-CART — [9]KU-Leuven — [10]TRIUMF — [11]IPN Orsay — [12]IMP Lanzhou

Precision measurements of optical transitions of the heaviest elements can be used to test state-of-the-art atomic calculations which include relativistic effects and electron correlations, both affecting physical and chemical properties of these elements. Only recently, the first optical spectroscopy of element nobelium (Z=102) was reported [1], making use of the sensitive Radiation Detected Resonance Ionization Spectroscopy (RADRIS) technique. Several high lying Rydberg states were observed enabling the extraction of the first ionization potential of nobelium. In this talk, a report on the recent achievements in the RADRIS measurements on nobelium will be presented.

[1] M. Laatiaoui et al., Nature 538, 495-498 (2016)

A 9.8 Mon 18:45 N 3

High-precision theory of the bound-electron *g*-factor — •Bastian Sikora[1], Nikolay A. Belov[1], Natalia S. Oreshkina[1], Vladimir A. Yerokhin[2], Christoph H. Keitel[1], and Zoltán Harman[1] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany — [2]Center for Advanced Studies, Peter the Great St. Petersburg Polytechnic University, 195251 St. Petersburg, Russia

The g-factor of bound electrons in H-like ions can be measured and calculated with high accuracy. Comparison between the theoretical and experimental values of the bound-electron g-factor allows precision tests of QED and the determination of fundamental constants such as the electron mass or the fine-structure constant α [1].

In order to achieve a high accuracy in theoretical predictions of the bound-electron g-factor in high nuclear charge states, the interaction with the nuclear potential needs to be taken into account to all orders in $Z\alpha$. We present all-order evaluations of QED contributions to the bound-electron g-factor such as two-loop corrections and the muonic vacuum polarization contribution [2]. – [1] V. A. Yerokhin, E. Berseneva, Z. Harman, *et al.*, PRL 116:100801 (2016) [2] N. A. Belov, B. Sikora, R. Weis, *et al.*, submitted; arXiv:1610.01340 (2016).