A 18: Precision spectroscopy of atoms and ions IV (with Q)

Time: Tuesday 14:00–16:00 Location: B 305

Invited Talk A 18.1 Tue 14:00 B 305

Der g-Faktor des gebundenen Elektrons - Test des Standardmodells und Zugang zu fundamentalen Konstanten — •Sven Sturm[1], Florian Köhler[1,2], Anke Wagner[1], Zoltan Harman[1], Jacek Zatorski[1], Wolfgang Quint[2], Günter Werth[3], Christoph H. Keitel[1] und Klaus Blaum[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg — [2]GSI Helmholtzzentrum, Darmstadt — [3]Johannes-Gutenberg Universität Mainz

Der g-Faktor des in hochgeladenen Ionen gebundenen Elektrons ist eine einmalige Möglichkeit um die Grenzen der Gültigkeit des Standardmodells in extrem starken Feldern zu untersuchen. In Penningfallen kann der g-Faktor bis auf 10 signifikante Stellen bestimmt werden, so dass es möglich wird auch Beiträge der Quantenelektrodynamik (QED) in höherer Ordnung zu überprüfen. Entsprechend stellt die Messung des g-Faktors von $^{28}Si^{13+}$ den zur Zeit empfindlichsten Test der QED in großen Feldern da. Darüber hinaus eröffnet der Vergleich von Theorie und Experiment einen Zugang zur Bestimmung fundamentaler Konstanten. Durch die Entwicklung neuartiger Detektionstechniken ist es jüngst möglich geworden, die Masse des Elektrons mit einer Genauigkeit zu bestimmen, die den aktuellen Literaturwert deutlich überschreitet. Das Experiment sowie Ergebnisse werden präsentiert.

A 18.2 Tue 14:30 B 305

Messung von Isotopieverschiebung und Hyperfeinstruktur von Uranisotopen mittels hochauflösender Resonanzionisationsspektroskopie — •Amin Hakimi[1], Thomas Fischbach[1], Nicolas Tolazzi[1], Norbert Trautmann[2] und Klaus Wendt[1] — [1]Institut für Physik, Johannes-Gutenberg-Universität Mainz — [2]Institut für Kernchemie, Johannes-Gutenberg-Universität Mainz

Uran ist das schwerste der natürlich vorkommenden Aktiniden. Mit seiner Grundzustandskonfiguration $5f^36d7s^2$ eröffnet es mannigfaltige Kopplungsmöglichkeiten. Dadurch wird es zu einem sehr interessanten System zur Untersuchung atomarer Effekte, z.B. der JJ-Kopplung. Mittels hochauflösender Resonanzionisationsspektroskopie steht eine präzise und sensitive Nachweismethode zu Verfügung, da an Stelle von Fluoreszenzphotonen resonant erzeugte Photoionen empfindlich nachgewiesen werden. Die Methode wurde mit einem neu entwickelten, durch kommerzielle Diodenlaser betreibbaren Anregungsschema auf die Isotope $^{233-236,238}U$ angewandt. Für zwei gebundene sowie einen autoionisierenden Zustand wurden die Isotopieverschiebungen bestimmt, sowie in den Isotopen ^{235}U und ^{233}U mit einem Kernspin von $\frac{7}{2}$ bzw. $\frac{5}{2}$ die Hyperfeinstruktur aufgelöst. Die A- und B-Faktoren der Hyperfeinstruktur wurden dabei für zwei gebundene Zustände bestimmt. Die Ergebnisse zu Hyperfeinstruktur und Isotopieverschiebung sowie die experimentelle Messstrategie werden vorgestellt.

A 18.3 Tue 14:45 B 305

Hyperfine splitting in lithium-like bismuth — Matthias Lochmann[1], Zoran Andelkovic[2], Benjamin Botermann[3], Michael Bussmann[4], Andreas Dax[5], Nadja Frömmgen[1], Michael Hammen[1], Volker Hannen[6], Raphael Jöhren[6], Christopher Geppert[1,2], Thomas Kühl[2], Yuri Litvinov[2], Jonas Vollbrecht[6], Wilfried Nörtershäuser[3], Thomas Stöhlker[2,7], Richard Thompson[8], Andrey Volotka[9], Christian Weinheimer[6], Weiqiang Wen[10], Elisa Will[1], Danyal Winters[2], and •Rodolfo Sánchez[2] — [1]Universität Mainz — [2]GSI Helmholtzzentrum, Darmstadt — [3]Technische Universität Darmstadt — [4]Helmholtzzentrum Dresden-Rossendorf — [5]CERN, Genf — [6]Universität Münster — [7]Universität Heidelberg — [8]Imperial College, London — [9]Technische Universität Dresden — [10]IMP Lanzhou

High-precision measurements of the hyperfine splitting values on Li- and H-like bismuth ions, combined with precise atomic structure calculations allow us to test QED-effects in the regime of the strongest magnetic fields that are available in the laboratory. Performing laser spectroscopy at the experimental storage ring (ESR) at GSI Darmstadt, we have now succeeded in measuring the hyperfine splitting in Li-like bismuth. Probing this transition has not been easy because of its extremely low fluorescence rate. Details about this challenging experiment will be given and the achieved experimental accuracy will be presented.

A 18.4 Tue 15:00 B 305

Absolute energy determination of He-like Krypton Kα transitions — •René Steinbrügge[1], Sascha Epp[2], Jan Rudolph[1,3], Christian Beilmann[1], Hendrik Bekker[1], Sven Bernitt[1], Sita Eberle[1], Oscar Versolato[1], Hasan Yavas[4], Hans-Christian Wille[4], and José R. Crespo López-Urrutia[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg — [2]Max Planck Advanced Study Group, CFEL, Hamburg — [3]Institut für Atom- und Molekülphysik, Gießen — [4]DESY, Hamburg, Germany

Helium-like ions serve as an important testing ground for investigations of many-body relativistic and QED effects, which scale with the fourth power of the atomic number Z. We have carried out absolute energy measurement of the $1s^2 - 1s2p$ transitions in He-like krypton (Z=36) ions. They were produced and trapped at conditions below the electron-impact excitation threshold using the transportable electron beam ion trap FLASH-EBIT [1,2], and excited with X-ray photons at the beamline P01 at PETRA III. The transition energies were measured by scanning the photon energy with the double-crystal monochromator, and detecting fluorescence photons. For absolute energy determinations, we compared measurements at different crystal orientations and calibrations using absorption edges as references. The energy measurements have achieved unprecedented uncertainties well below 5 ppm at 13keV.

[1] S. W. Epp et al., Phys. Rev. Lett. **98**, 183001 (2007)
[2] S. Bernitt et al., Nature **492**, 225 (2012)

A 18.5 Tue 15:15 B 305

First imaging of cold ion clouds in SpecTrap - ion dynamics in the Penning trap — •Stefan Schmidt[1,2,3], Tobias Murböck[2,4], Zoran Andelkovic[2], Manuel Vogel[2,4], Alexander Martin[2,4], Volker Hannen[6], Jonas Vollbrecht[6], Christian Weinheimer[6], Gerhard Birkl[4], Richard Thompson[5], and Wilfried Nörtershäuser[1,2,3] — [1]Institut für Kernphysik, TU Darmstadt — [2]GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt — [3]Institut für Kernchemie, Johannes Gutenberg Universität Mainz — [4]Institut für Angewandte Physik, TU Darmstadt — [5]Imperial College London, South Kensington Campus London — [6]Institut für Kernphysik, Westfälische Wilhelms-Universität Münster

Heavy Highly Charged Ions (HCI) are particularly promising candidates for high precision experiments. This includes precision spectroscopy of dipole-forbidden transitions in HCIs at low energies, which will serve as a novel test of strong-field quantum electrodynamics with an accuracy of the order of 10^{-7}.

This talk will present the current status of the SpecTrap apparatus, designed to produce a cold and dense sample of low-Z ions, HCIs and their combination. Recently, we confined singly charged Mg^+ ions in the trap and performed laser cooling inside the Penning trap. By means of optical and electronic detection methods the properties of the ion cloud such as storage time and temperature were further investigated. In future, the laser cooled ion cloud will serve as an ideal tool for sympathetic cooling of HCIs.

A 18.6 Tue 15:30 B 305

The puzzle of the La line 6520.77 Å — •Laurentius Windholz[1], Bettina Gamper[1], Przemyslaw Glawocki[2], and Jerzey Dembczynski[2] — [1]Institut für Experimentalphysik, Technische Universität Graz, Petersgasse 16, A-8010 Graz, Österreich — [2]Chair of Quantum Engineering and Metrology, Faculty of Technical Physics, Poznań University of Technology, 60 965 Poznań, Poland

The strong La line 6520.770 Å is present in a Fourier transform spectrum available to us as a blend of two lines: a weak one at 6520.735 Å and a strong one at 6520.644 Å (signal to noise ratio of 250 in the Fourier transform spectrum). The latter we could not classify using all known energy levels of the La atom (La I) and its first ion (La II). It appears as a single broadened peak (FWHM 3.5 GHz), while the FWHM of a single hyperfine (hf) structure component is 1.2 GHz.

When setting the laser wavelength to 6520.65 Å, we observed a very strong optogalvanic (OG) modulation of the discharge current, and this did lead to the observation of more than 200 lines which showed laser-induced fluorescence (LIF) signals. Trying to use upper levels of LIF lines with opposite phase (compared to OG in-phase signals) as lower levels of the excited transition did lead to the assumption that a new upper level, 35449.041 cm-1, even, J=13/2, is participating. We applied Doppler-reduced intermodulated OG spectroscopy and were able to find the hf constants A of the involved levels. The angular momentum is 13/2 due to theoretical considerations. The new upper level shows only one combination with known lower levels, located in the infrared region (14908.421 Å).

A 18.7 Tue 15:45 B 305

Few-Photon Spectroscopy of a trapped ion through sensitive recoil detection — •Yong Wan[1], Florian Gebert[1], Boerge Hemmerling[2], and Piet O. Schmidt[1] — [1]QUEST Inst. for Exp. Quantum Metrology, PTB Braunschweig and Leibniz Univ. of Hannover, Germany — [2]Department of Physics, Havard University, Cambridge, MA02138, USA

Traditional laser spectroscopy, e.g. laser-induced fluorescence, allowed us to perform precision spectroscopy with high accuracy. The signal-noise-ratio of this spectroscopy technique is rather limited by the number of photons that can be detected. We present here a highly sensitive spectroscopy technique, which is well-suited in case only a low number of photons or atoms are available. In this scheme, a spectroscopy ion is trapped simultaneously with a single logic ion, which is used for laser cooling and detection of the spectroscopy signal. Starting from the ground state of motion of a common motional mode, photon recoil from probing the spectroscopy transition is detected with high efficiency by the logic ion. We apply spectroscopy pulses synchronized with the motion of the ions in the trap to enhance the sensitivity through resonant driving. This way, we are able to detect scattering of less than 16 photons. We discuss the sensitivity of the experiment and systematic frequency shifts.

The spectroscopy technique discussed is of general interest for high precision spectroscopy and can be applied to various species of atomic and molecular ions. Furthermore, a variation of the technique might be useful for preparation of molecular ions in their internal ground state.