A 10: Poster I - Precisions Spectroscopy

Zeit: Dienstag 16:30–18:30 Raum: Poster B

A 10.1 Di 16:30 Poster B

Low–lying level structure of atomic nobelium and lawrencium: A challenge for ab–initio theory — •S. Fritzsche[1], C. Z. Dong[2], G. Gaigalas[3], and M. Sewtz[4] — [1]Universität Kassel, D–34132 Kassel, Germany — [2]Northwest Normal University, Lanzhou 730070, China — [3]Vilnius Research Institute of Theoretical Physics and Astronomy, — [4]LMU München, D-85748 Garching, Germany

Studies on the transuranium elements have attracted a lot of interest during the last two decades, both by experiment and theory. Beside the challenge of identifying new elements, these investigations aim for a better understanding of the electronic structure in strong fields as well as for insights into the chemical binding in Nature.

In this contribution, we report on relativistic multiconfiguration Dirac–Fock calculations for the low–lying excitation spectrum of atomic nobelium ($Z = 102$) and lawrencium ($Z = 103$). For these elements, there are strong effects of relativity, electron correlations, and bound–state relaxation (for atomic transitions) which must be treated coherently within the same framework [1]. Based on detailed computations for the low–lying resonances, and including the analysis of the absorption rates, two fermium resonances at 25099.8 cm^{-1} and 25111.8 cm^{-1} could be identified recently [2] and have raised the hope that such resonances will be observed also for other heavy elements [3] in the near future using resonance ionization spectroscopy (RIS).

[1] S. Fritzsche, J. Electr. Spec. Rel. Phenon. **114–116**, 1155 (2001).
[2] M. Sewtz et al., Phys. Rev. Lett. **90**, 163002 (2003).
[3] S. Fritzsche, Eur. Phys. J. **D33**, 15 (2005).

A 10.2 Di 16:30 Poster B

Towards Direct Frequency Comb Spectroscopy using Quantum Logic — •Börge Hemmerling, Lukas An der Lan, and Piet O. Schmidt — Institut für Experimentalphysik, Universität Innsbruck, Austria

Modern physics theories allow for a variation of fundamental constants, such as the fine-structure constant. Searches for such a variation on a cosmological timescale are based on the interpretation of quasar absorption spectra. The sensitivity of these tests is limited by the availability of accurate laboratory spectrocopic data of atoms with a complex level structure [1]. A major difficulty in obtaining more precise data is the need for many different laser systems for probing, cooling and initial state preparation.

We report on the progress towards a flexible spectroscopy setup in which we plan to apply direct frequency comb spectroscopy to a cloud of spectroscopy ions trapped in a linear Paul trap that are sympathetically cooled via Mg^+ ions. The appropriately tailored spectrum of the frequency comb is used for initial state preparation and spectroscopy. This allows us to study several different ion species that have resisted precision spectroscopy in the past.

[1] J. C. Berengut, V. A. Dzuba, V. V. Flambaum, M. V. Marchenko and J. K. Webb, arXiv:physics/0408017 (2006)

A 10.3 Di 16:30 Poster B

Die MAXEBIS als Testionenquelle für HITRAP und das Ladungsbrüten — •Holger Zimmermann[1], Oliver Kester[2], Jochen Pfister[3], Alexey Sokolov[2], Danyal Winters[2] und Hendrik Ernst[2] — [1]LMU München, Schellingstraße 4, 80799 München — [2]GSI Darmstadt, Planckstraße 1, 64291 Darmstadt — [3]Universität Frankfurt, Max-von-Laue-Straße 1, 60438 Frankfurt

Die Frankfurt MAXEBIS wurde an der GSI wieder in Betrieb genommen, um hochgeladenen Ionen für offline-Tests der HITRAP Niederenergiesektion zu liefern. Die MAXEBIS dient dabei vor allem als Testinjektor für die HITRAP-Kühler-Penningfalle. Außerdem dient die MAXEBIS Experimenten zum Ladungsbrüten extern erzeugter, einfach geladener Ionen, was vor allem Experimenten mit hochgeladenen Ionen exotischer Nukliden zu Gute kommt. Durch transversalen und longitudinalen Einschluss von Ionen in einem Elektronenstrahl eignet sich die EBIS zur Erzeugung hoher Ladungszustände. Zu den Tests wurden einfach geladene Barium-Ionen aus einer Oberflächenquelle und Ar-Ionen aus einer Sputterquelle in die MAXEBIS eingeschossen und zu höheren Ladungszuständen ionisiert und wieder extrahiert. Der experimentelle Aufbau und erste Messergebnisse werden vorgestellt.

A 10.4 Di 16:30 Poster B

Weak Interactions in Trapped Single Radium Ions — U. Dammalapati, K. Jungmann, R.G.E. Timmermans, •L. Wansbeek, and L. Willmann — Kernfysisch Versneller Instituut, University of Groningen, 9747 Groningen, Netherlands

The electroweak theory has been confirmed to great precision in high-energy accelerator experiments. One of the outstanding successful predictions of the theory was the existence of the Z^0 boson, that is mixed with the photon and mediates interactions that do not conserve parity. The mixing angle varies with scale due to the polarization of the vacuum by particle-antiparticle pairs. This has only poorly been tested. Interference of Z^0 and photon exchange between the electrons and quarks in an atom or ion results in a tiny breakdown of parity selection rules. A high-precision measurement of the electroweak mixing angle at low momentum scales is possible by monitoring quantum jumps in one single trapped Ra ion with precision laser and radiofrequency techniques combined. The proof of principle was recently given in pilot measurements at Seattle with one single Ba ion. A Ra^+ experiment can now be envisaged with a precision that, together with planned experiments at intermediate energy, can confirm the quantum structure of the electroweak theory over some five orders of magnitude in momentum scale. Such an experiment has been started at the TRIμP facility of the Kernfysisch Versneller Instituut in Groningen, where the needed radioactive Ra isotopes can be produced online. The experiment uses will use a radiofrequency trap and is possible using several all solid state lasers in an elaborate time switching scheme.

A 10.5 Di 16:30 Poster B

Hyperfine structure investigations of the odd configurations of lanthanum atom — •Jerzy Dembczynski, Boguslaw Furmann, Magdalena Elantkowska, and Jaroslaw Ruczkowski — Chair of Quantum Engineering and Metrology, Faculty of Technical Physics, Poznan University of Technology, Nieszawska 13B, 60-965 Poznan, Poland

The hyperfine structure (hfs) of lanthanum atom have been studied with the method of laser induced fluorescence (LIF) in the hollow cathode discharge.

The investigated transitions within three spectral ranges have been excited by stabilized tunable single-mode ring dye lasers (Coherent, model 699-21), operating on Rhodamine 6G and DCM in the spectral range of 570-610 nm and 617-666 nm respectively, and on Stilbene 3 in the spectral range of 410-460 nm.

The hfs magnetic dipole A and electric quadrupole B constants of more than 100 odd levels have been determined (59 of them for the first time).

The hyperfine structure of the odd levels of La I has been analyzed by simultaneous parametrization of one- and two-body interactions for the system of 61 configurations. Magnetic-dipole hyperfine interaction constants A were calculated using the fine structure eigenvectors and adjusting radial integrals in a least-squares procedure which compare the calculated A constants with the experimental values.

Moreover, the values of energy for the levels up to now unidentified and hyperfine structure A constants were predicted.

A 10.6 Di 16:30 Poster B

Correlation and QED effects on the lifetime, relativistic nuclear recoil and electronic g factor in Ar^{13+} and Ar^{14+} ions — •Z. Harman[1], R. Soria Orts[1], A. Lapierre[1], J. R. Crespo López-Urrutia[1], U. D. Jentschura[1], A. N. Artemyev[1,2], C. H. Keitel[1], V. M. Shabaev[2], H. Tawara[1], I. I. Tupitsyn[1,2], J. Ullrich[1], and A. V. Volotka[2] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg — [2]St. Petersburg State University, Oulianovskaya 1, 198504 St. Petersburg, Russia

The radiative lifetime [1] and isotope shift [2] of the $1s^2 2s^2 2p\ ^2P_{3/2} - {}^2P_{1/2}$ M1 transition and the g factor of these levels [3] in B-like argon ions has been determined with high accuracy using the Heidelberg electron beam ion trap. The lifetime corresponding to the above transition has been measured with an accuracy on the order of one per mil. Theoretical calculations predict a lifetime that is significantly lower than this high-precision experimental value. Our mass shift calculations are in excellent agreement with the experimental results and confirm the necessity to include relativistic recoil corrections when evaluating mass isotope shift contributions in medium-Z ions. The g factor of the P

states is determined with a 1.5 per mil accuracy by resolving the Zeeman components of the transition. The experimental results are in accordance with our theoretical calculations.

[1] A. Lapierre *et al.*, Phys. Rev. Lett. 95, 183001 (2005).
[2] R. Soria Orts *et al.*, Phys. Rev. Lett. 97, 103002 (2006).
[3] R. Soria Orts *et al.*, to be published

A 10.7 Di 16:30 Poster B

Resonance Laser Spectroscopy on Trapped Highly-Charged Ions using Soft X-rays from FLASH — Sascha Epp, •Jose Crespo Lopez-Urrutia, and Joachim Ullrich — Max-Planck-Institut fuer Kernphysik, Saupfercheckweg 1, D-69117 Heidelberg

Resonance laser spectroscopy, the most sensitive tool for atomic structure studies, has been severely limited due to the lack of appropriate light sources beyond the UV and especially the VUV region. With the free electron laser in Hamburg, FLASH, the soft x-ray region is now widely opened to laser spectroscopy and heavy, few-electron systems -i.e. highly charged ions (HCI) - are now accessible by this precision method. The transition between the 2S1/2 (ground) and 2P1/2 (excited) states was investigated for Li-like iron Fe23+ ions by matching soft x-rays from FLASH together with HCI provided in a transportable EBIT. The present statistical accuracy is already superior to the theoretical uncertainties and allows verifying the leading two-photon QED terms.

A 10.8 Di 16:30 Poster B

Precision Lifetime Determination of the Fe XIV $3s^2 3p\ ^2P^o_{3/2}$ Metastable Level — Guenter Brenner and •Jose Ramon Crespo López-Urrutia — Max-Planck-Insitut für Kernphysik, Heidelberg

The lifetime of the $3s^2\ 3p\ ^2P^o_{3/2}$ first excited energy level of Fe XIV (Al-like) was measured at the Heidelberg electron beam ion trap by monitoring its optical decay to the ground state by a magnetic dipole (M1) forbidden transition at λ=530.29 nm (*green coronal line*), a well known line in stellar spectra. A new trapping scheme has been applied. Possible systematic effects were investigated by studying the dependence of the decay curves on various trapping conditions with high statistical significance. The result of $16.726^{+0.020}_{-0.010}$ ms shows a clear discrepancy of about 4σ to existing theoretical predictions. The inclusion of the electron anomalous magnetic moment (EAMM) within the theoretical calculations increases this disagreement, thus pointing at other possible origins of this discrepancy.

A 10.9 Di 16:30 Poster B

Bestimmung der Absolutfrequenz einer optischen Mg Atomuhr — •Jan Friebe, Karsten Moldenhauer, Matthias Riedmann, Tanja E. Mehlstäubler, Nils Rehbein, André Pape, Alexander Voskrebenzev, Ernst M. Rasel und Wolfgang Ertmer — Institut für Quantenoptik, Leibniz Universität Hannover, Deutschland

Die Frequenz des ^{24}Mg-Interkombinationsübergangs $^1S_0 \rightarrow {}^3P_1$ wurde erstmals atominterferometrisch an einem thermischen Atomstrahl mit einem sub-kHz schmalen Diodenlaser spektroskopiert und mit Hilfe eines Faserfemtosekundenlasers mit einer transportablen Cäsiumatomuhr verglichen. Die Messung wurde in Kooperation mit der PTB durchgeführt und es konnte eine relative Genauigkeit von etwa 10^{-11} erreicht werden. Die Unsicherheit ist im Wesentlichen bestimmt durch einen verbleibenden Dopplereffekt in erster sowie zweiter Ordnung.

An kalten Mg Atomen wurde in der Vergangenheit eine spektroskopische Auflösung von bis zu 290 Hz erreicht, woraus sich eine Kurzzeitstabilität von $8 * 10^{-14}$ in 1 s ableiten lässt [1]. Diese ist durch die Restbewegung der Atome bei einer Temperatur oberhalb des Dopplerlimits von 2 mK limitiert. Da bei ^{24}Mg eine sub-Dopplerkühlung mit herkömmlichen Methoden nicht möglich ist, wurde von uns das vielversprechende Verfahren des Zweiphotonenkühlens [2] untersucht. Wir präsentieren unsere Ergebnisse, bei denen Temperaturen von deutlich unterhalb des Dopplerlimits erreicht wurden.

[1] J. Keupp et al., EPJ D 36, 289-294 (2005)
[2] W.C. Magno et al., Phys. Rev. A 67, 043407 (2003)

A 10.10 Di 16:30 Poster B

A clock laser system for Yb optical frequency standard — •U. Bressel[1], M. Okhapkin[1,2], A.Yu. Nevsky[1], and S. Schiller[1] — [1]Institut für Experimentalphysik, Heinrich-Heine-Universität Düsseldorf — [2]Institute of Laser Physics, Novosibirsk

Ytterbium is a promising candidate for a lattice optical clock [1] with a potential accuracy significantly exceeding that of the best caesium clocks. The 1S0 - 3P0 clock transition at 578 nm is dipole forbidden and has a natural linewidth of about 10 mHz, leading to a transition Q-factor about 10ˆ-16. To interrogate such a narrow transition, a reliable laser source with a sub-Hz linewidth should be developed. In our experiment the radiation at 578 nm is obtained by summing the frequencies of the Nd:YAG laser at 1064 nm and a grating-stabilized diode laser at 1267 nm in the PPLN crystal, placed in the enhancement cavity. We use the ILP-500/30 Nd:YAG laser [2] with intra-cavity frequency doubling. It is locked to a Doppler-free resonance in the molecular iodine. The enhancement cavity is locked to the Nd:YAG laser using the Pound-Drever-Hall technique. The frequency of the diode laser is locked to the cavity, thus making the cavity resonant for both IR radiations and yielding a frequency stability on the level of that of the Nd:YAG/I2 system. With 300 mW at 1064 nm and 20 mW at 1267 nm, the power at 578 nm is about 12 mW. The properties of the 578 nm radiation were characterized and work is in progress to stabilize this radiation to a high-finesse ULE cavity in order to reduce its linewidth.

[1] C.W. Hoyt et al, Phys. Rev. Lett. 95, 083003 (2005)
[2] see http://www.laser.nsc.ru/develop.htm