A 35: Precision Spectroscopy of atoms and ions

Time: Thursday 16:15–18:15 Location: S Fobau Physik

A 35.1 Thu 16:15 S Fobau Physik

Axion-induced Lamb-shift in atomic and muonic hydrogen —

•Alina Golub, Selym Villalba-Chávez, and Carsten Müller — Institut für Theoretische Physik I, Heinrich-Heine-Universität Düsseldorf, Deutschland

Vacuum polarization effects due to hypothetical axion-like particles, which are predicted in some extensions of the standard model, are considered. The self-energy operator of the electromagnetic field is determined with an accuracy of second-order in the axion-diphoton coupling. The result is utilized for establishing the axion-modified Coulomb potential of a static pointlike charge. In connection, the plausible distortion of the Lamb-shift in hydrogenlike atoms is established and the scopes for searching axion-like particles in high-precision atomic spectroscopy are investigated. Particularly, we show that these hypothetical degrees of freedom are ruled out as plausible candidates for explaining the proton radius anomaly in muonic hydrogen [1].

[1] Axion-modified photon propagator, Coulomb potential, and Lamb-shift; S. Villalba-Chavez, A. Golub, C. Müller accepted for publication in Phys. Rev. D [arXiv:1806.10940v1]

A 35.2 Thu 16:15 S Fobau Physik

Coherent Control of Thermal Atoms with Photonic Crystal Cavities —

•Hadiseh Alaeian, Ralf Ritter, Artur Skljarow, Harald Kübler, Tilman Pfau, and Robert Löw — 5.Physikalisches Institut and Center for Integrated Quantum Science and Technology, Universität Stuttgart, Pfaffenwaldring 57, D-70569 Stuttgart, Germany

Unless proper modifications are employed, the atom-photon interaction is an inefficient process in free space. Historically, optical and superconducting cavities have been used successfully to increase the atom-photon interaction probability for the optical and microwave photons, respectively. With recent advancements in nanofabrication, integrated Nano-photonic devices have been used to enhance the quantum optical phenomena in several solid-state based platforms like quantum dots and vacancy centers. In this work, we present our recent theoretical and experimental efforts on the integration of high-Q cavities with thermal atoms beyond the perturbative limit. In particular, we discuss about an optimized cavity in a Si_3N_4 photonic crystal supporting a high-Q mode with small volume at 780nm, i.e. 5S→5P of rubidium. Through a detailed Monte-Carlo calculation incorporating all the device effects, including the Purcell and Casimir-Polder, we demonstrate the feasibility of reaching a strong atom-light coupling down to a single photon.

A 35.3 Thu 16:15 S Fobau Physik

A fresh computational approach to atomic structures, processes and cascades —

•Stephan Fritzsche — Helmholtz Institute, Jena, Germany — Friedrich-Schiller University Jena

The recent years have seen an increasing demand for accurate atomic computations. Apart from the traditional fields of astro- and plasma physics, accurate atomic data are needed today in various emerging areas, such as laser spectroscopy, quantum optics and metrology, x-ray lithography, or even in material science, to name just a few. – In this contribution, I present a new (Julia) code for modelling atomic properties and processes. To this end, a high-level toolbox has been designed (and already implemented to a sizable extent) for dealing more efficiently with complex systems. Here, I shall introduce these tools and explain by simple examples how they help provide accurate theoretical predictions and may serve for (requests from) the spectroscopy of atoms and multiply-charged ion and in various fields elsewhere.

A 35.4 Thu 16:15 S Fobau Physik

Two-loop QED diagrams for the bound-electron *g* factor: radiative corrections to the magnetic loop —

•Vincent Debierre, Bastian Sikora, Halil Cakir, Natalia S. Oreshkina, Zoltán Harman, and Christoph H. Keitel — Max Planck Institute for Nuclear Physics, Saupfercheckweg 1, 69117 Heidelberg

The g factor of bound electrons in light and medium-light hydrogen-like ions (e.g. C, Si) has been measured with an accuracy of a few parts in 10^{11} [S. Sturm *et al.*, Nature **506**, 467 (2014)]. Experiments such as ALPHATRAP and HITRAP aim at reaching this accuracy with heavy, few-electron ions, motivating the evaluation of two-loop radiative corrections.

We calculate a specific set of two-loop corrections to the bound-electron g factor in the hydrogen-like ground state. Diagrams belonging to this set include the magnetic loop as a subprocess and vanish in the free-loop approximation [V.A. Yerokhin and Z. Harman, Phys. Rev. A **88**, 042502 (2013)]. At the lowest nonvanishing order, they involve the scattering of the external magnetic field in the Coulomb field of then ionic nucleus. We computed the electric-loop-magnetic-loop diagram, the magnetic-loop-after-loop diagram, and the self-energy-magnetic-loop diagrams, while also shedding light on some other diagrams, which feature a self-energy loop inside the magnetic loop. Our approach treats the binding of the electron to the nucleus nonperturbatively.

The computed corrections to the g factor are of order up to 10^{-7} in the case of ^{82}Pb. These corrections will be relevant to the projected determination of the fine-structure constant from g-factor measurements.

A 35.5 Thu 16:15 S Fobau Physik

Collinear laser spectroscopy with ion trap accuracy - Future perspectives for atomic and nuclear physics —

•Kristian König, Phillip Imgram, Jörg Krämer, Tim Ratajczyk, and Wilfried Nörtershäuser — Institut für Kernphysik, TU Darmstadt

At the newly constructed collinear laser spectroscopy apparatus COALA at TU Darmstadt an unprecedented accuracy in the determination of rest-frame transition frequencies was recently demonstrated with stable Ba^+ ions. To our knowledge, this measurement represents the most-precise collinear laser spectroscopic experiment realized so far and can compete with modern ion trap measurements on dipole-allowed transitions. We will present the results and the future potential for precise and accurate measurements of atomic and nuclear properties at this setup. Required techniques like optical pumping and probing deep-UV transitions as well as a frequency-comb based laser stabilization have already been demonstrated with In^+ ions, paving the way for collinear spectroscopy on helium-like light ions, which is of great interest from a nuclear structure perspective.

A 35.6 Thu 16:15 S Fobau Physik

Scheme to generate and filter photon pairs from atoms in a hollow-core fibre —

•Mark Zentile, Ioannis Caltzidis, Harald Kübler, Robert Löw, and Tilman Pfau — 5. Physikalisches Institut and Center for Integrated Quantum Science and Technology IQST, Universität Stuttgart

Single photon sources are essential for quantum optics. It has been shown that a heralded source with high-spectral brightness can be achieved using four-wave mixing (4WM) in a thermal-atomic vapour [1]. These systems are particularly useful the photons are to be interfaced with other atomic systems, e.g. quantum memories [2]. However, the schemes used so far require expensive high-power lasers (∼ 1W) to pump the 4WM process. The aim of this project is to develop a source of heralded single photons with a much higher efficiency, thereby allowing the use of a single diode laser as the pump. We will achieve this by using an alkali-vapour contained in a hollow-core micro-structured fibre and exploit the higher efficiency expected [3]. A challenge of this scheme will be to split the photon pairs. Since the wavelengths of the light emerging from the fibre are close to each other, and the beams are overlapped, many common techniques (such as using interference filters and/or spatial filtering) will not work. However, we have identified a scheme using an atomic vapour as a beam splitter for the photon pairs.

[1] MacRae, A. et al., Phys. Rev. Lett. 109, 033601 (2012)
[2] Sprague, M. R. Et al., Nature Photon. 8, 287 (2014)
[3] Londero, P. et al., Phys. Rev. Lett. 103, 043602 (2009)

A 35.7 Thu 16:15 S Fobau Physik

Realistic atomic clock simulations with single to hundreds of atoms —

•Marius Schulte[1], Víctor J. Martínez-Lahuerta[1], Piet O. Schmidt[2,3], and Klemens Hammerer[1] — [1]Institute for Theoretical Physics and Institute for Gravitational Physics (Albert-Einstein-Institute), Leibniz University Hannover — [2]Physikalisch-Technische Bundesanstalt, 38116 Braunschweig — [3]Institute for Quan-

tum Optics, Leibniz University Hannover

Recently, optical atomic clocks have shown great success in achieving systematic fractional frequency uncertainties on the order of 10^{-18} using few hundreds of uncorrelated reference atoms. However the extent to which entanglement can improve such atomic clocks in practice, including realistic local oscillator noise, preparation errors and dead time, has so far been little researched. To answer this question we investigate numerically the long-term stability of optical atomic clocks with entangled atoms. We tackle in particular the exact dynamics of symmetrical systems containing single to few hundred atoms, which lie beyond the validity of Gaussian approximations.

A 35.8 Thu 16:15 S Fobau Physik

Cold Atomic Hydrogen Source @ T-Rex — •Jan Haack, Merten Heppener, Stefan Schmidt, Henrik-Lukas Schumacher, Marcel Willig, Andreas Wieltsch, and Randolf Pohl — Institut f. Physik Johannes Gutenberg-Univertität, Mainz

The Triton-Radius Experiment T-Rex at JGU Mainz aims at a first measurement of the 1S-2S transition in atomic tritium [1]. Such a measurement has the potential to improve the charge radius of the triton nucleus by a factor of 400, with an experimental accuracy of only 1 kHz. This is 100x *less* precise than the current measurements of the 1S-2S transition in H and D, [2,3]. T-Rex will use a cryogenic hydrogen (later tritium) beam and select low atomic velocities by a magnetic quadrupole guide. The slowest atoms will then be stopped using a Li MOT as a cold buffer gas, and trapped in a magnetic minimum trap. We will present the state of the experiment as well as an outlook.

[1] S. Schmidt et al. J. Phys. Conf. Ser. accepted (2018), arXiv 1808.07240
[2] C. Parthey et al. Phys. Rev. Lett. 104 233001 (2010)
[3] C. Parthey et al. Phys. Rev. Lett. 107 203001 (2011)

A 35.9 Thu 16:15 S Fobau Physik

First Measurement Results of the Alphatrap *g*-factor Experiment — •Bingsheng Tu[1], Ioanna Arapoglou[1], José Ramon Crespo López-Urrutia[1], Alexander Egl[1], Martin Höcker[1], Tim Sailer[1], Timo Steinsberger[1,2], Andreas Weigel[1], Robert Wolf[1], Sven Sturm[1], and Klaus Blaum[1] — [1]Max-Planck-Institut für Kernphysik, 69117 Heidelberg — [2]Fakultät für Physik und Astronomie, Universität Heidelberg, 69120 Heidelberg

The Alphatrap experiment, situated at the Max Planck Institute for Nuclear Physics in Heidelberg, aims for stringent tests of Bound-State Quantum Electrodynamics (BS-QED) in extremely strong electromagnetic fields via high-precision measurements of the magnetic moment (g-factor) of bound electrons in highly charged ions up to hydrogenlike $^{208}Pb^{81+}$. Sub-parts-per-billion precision can be achieved in the double Penning-trap setup which consists of cryogenic 7-electrode and 5-electrode cylindrical Penning traps. The highly charged ions are created in three external ion sources: the Heidelberg EBIT, the room-temperature HC-EBIT and the laser ion source, each for different experimental motivations. Boronlike $^{40}Ar^{13+}$ has already been produced and captured in the Alphatrap setup. Furthermore, a first g-factor measurement with a relative uncertainty in the 10^{-9} range has been performed on this system, which exceeds the current calculations by two orders of magnitude. Based on the spin-state detection, laser spectroscopy of the fine structure of boronlike $^{40}Ar^{13+}$ has also been implemented by using a novel technique to detect forbidden transitions. The present status and the future plans of ALPHATRAP will be presented.

A 35.10 Thu 16:15 S Fobau Physik

Simulation of an atomic beam under magneto-optical influence — •Andreas Christian Wieltsch, Jan Haack, Stefan Schmidt, Marcel Willig, and Randolf Pohl — Johannes Gutenberg-Universität Mainz, QUANTUM, Institut für Physik & Exzellenzcluster PRISMA$^+$, Mainz, Germany

We are developing a simulation software to track the movement of atoms in a laser spectroscopy experiment. In such an experiment atoms are slowed down under magneto-optical influence. The simulation can be used for evaluating different designs of the magnetic field in the slower or optimizing positions and diameters of apertures. This software is build for the Lithium experiment at the University of Mainz.

One way to model the light-atom interaction is using rate equations which are widely used for simulating the movement of atoms in such an experiment. The problem can also be described by the Optical Bloch equations, a set of differential equations describing the transitions between the energy states more precisely. We will present the generic implementation of the simulation program using both approaches, show results of the simulation and compare both methods. Due to the generic implementation, parts of the simulation software can also be used in e.g. the T-REX experiment.

A 35.11 Thu 16:15 S Fobau Physik

Two-loop self-energy corrections to the bound-electron *g*-factor — •Bastian Sikora[1], Vladimir A. Yerokhin[2], Natalia S. Oreshkina[1], Halil Cakir[1], Chrisoph 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

We present the status of our ongoing calculations of the two-loop self-energy correction to the bound-electron g-factor. This correction currently gives rise to the largest uncertainty of theoretical g-factor predictions. We have obtained full results for the loop-after-loop diagrams, and partial results for the nested and overlapping loop diagrams, in which we treat the Coulomb interaction in intermediate states to zero and first order.

Our results will be highly relevant for planned g-factor measurements with high-Z ions in the near future as well as for an independent determination of the fine-structure constant α from the bound-electron g-factor.– [1] B. Sikora, V. A. Yerokhin, N. S. Oreshkina *et al.*, arXiv:1804.05733v1 [physics.atom-ph] (2018).

A 35.12 Thu 16:15 S Fobau Physik

Approaching sympathetic cooling of trapped ^{229}Th^{3+} ions — •Gregor Zitzer, Johannes Thielking, David-Marcel Meier, Maksim Okhapkin, and Ekkehard Peik — Physikalisch-Technische Bundesanstalt, Braunschweig, Germany

With only a few eV above its nuclear ground state the isomer of ^{229}Th is accessible for direct laser excitation. The isomeric transition may be used as a frequency reference for a new type of optical clocks which is exceptionally insensitive to field-induced frequency shifts.

For the realization of an optical nuclear clock with laser-cooled trapped ions the charge state 3+ of ^{229}Th is preferred, due to its relatively simple and convenient electronic level structure. Direct laser cooling of $^{229}Th^{3+}$ and $^{232}Th^{3+}$ has been demonstrated [1,2].

Due to limitations in the reachable laser cooling power we plan to investigate sympathetic cooling of $^{229}Th^{3+}$ with $^{88}Sr^{+}$ for experiments with large Coulomb crystals and a future clock operation. In a new setup $^{229}Th^{3+}$ and $^{88}Sr^{+}$ will be trapped in a linear radiofrequency ion trap. It is planed to extract the $^{229}Th^{3+}$ ions generated by a ^{233}U source via α-decay [3] and guide them to a segmented linear Paul trap. In this trap the laser cooled $^{88}Sr^{+}$ ions will surround the $^{229}Th^{3+}$ forming a prolate spheroid. Here the concept, design and current status of the experiment on $^{229}Th^{3+}$ will be shown.

[1] C. J. Campbell et al., Phys. Rev. Lett. 102, 233004 (2009)
[2] C. J. Campbell et al., Phys. Rev. Lett. 106, 223001 (2011)
[3] L. v. d. Wense, On the direct detection of ^{229m}Th, Springer International Publ., DOI: 10.1007/978-3-319-70461-6 (2018)

A 35.13 Thu 16:15 S Fobau Physik

Compact Collinear Laser Spectroscopy Setup for Educational Usage — •Philipp Bollinger, Tim Ratajczyk, and Wilfried Nörtershäuser — Institut für Kernphysik, Technische Universität Darmstadt

Collinear laser spectroscopy is widely used to perform highly precise measurements of atomic spectra to extract nuclear properties, namely charge radii, magnetic dipole and electric quadrupole moments [Neugart et al. J. Phys. G. 44 064002 (2017)]. It has also been used to test QED calculation of higher ions [Nörtershäuser et al. PRL 115, 033002 (2015)] and was applied on relativistic beams to test special relativity [Botermann et al. PRL 114, 239902 (2015)] and strong-field bound state QED in heavy ions [Ullmann et al. Nat. Comm. 8, 15484 (2017)]. To give students the possibility to get experienced with this technique, a compact setup for collinear laser spectroscopy is being prepared at TU Darmstadt to be used in the advanced lab classes. The setup uses a specially designed 90° dipole bender to superimpose laser and ion beam which will be tested for its usability in laser spectroscopy. An optical detection region with photomultipliers and a mass spectrometer allow further investigations. We will present the layout and current status of the project.

A 35.14 Thu 16:15 S Fobau Physik

Low emittance laser ablation ion beam source — •Tim Lellinger[1], Tim Ratajczyk[1], Victor Varentsov[2,3], and Wilfried Nörtershäuser[1] — [1]Institut für Kernphysik, TU Darmstadt — [2]Facility for Antiproton and Ion Research in Europe (FAIR GmbH) — [3]Institute for Theoretical and Experimental Physics, Moscow, Russia

Laser ablation provides access to the production of a wide range of ion beams for various researches and applications. When the laser ablation occurs in a vacuum the high temperature and large angular divergence of the produced plasma plume do not allow the production of high quality ion beams. This can be avoided if the laser ablation is performed in the presence of a He buffer gas, where the ablated ions are stopped and cooled due to collisions with He atoms and then transported by the gas flow through a miniature nozzle into an RF-only funnel. After that the ions are effectively extracted into high vacuum conditions under a combined action of gas dynamic and electric fields. We present the design and first test measurements of such an ion beam source having two RF funnels. This ion source will be able to produce low emittance ion beams in both continuous and pulsed operation mode.

A 35.15 Thu 16:15 S Fobau Physik

Negative Ions Studies in the Frankfurt Low Energy Storage Ring (FLSR) — •Oliver Forstner[1,2,3], Jan Müller[4], Markus Schöffler[4], Lothar Schmidt[4], Thomas Stöhlker[1,2,3], and Kurt Stiebing[4] — [1]Friedrich-Schiller-Universität Jena, Jena — [2]Helmholtz-Institut Jena, Jena — [3]GSI Helmholtzzentrum, Darmstadt — [4]Goethe Universität, Frankfurt

In order to allow for studies of the electronic structure of negative atomic and molecular ions by laser photodetachment, a commercial rf charge exchange ion source for negative ions (Alphatross, National Electrostatic Corporation [1]) has been installed at the injection terminal of the Frankfurt Low Energy Storage Ring (FLSR) facility [2]. First tests with negative ions stored in FLSR at 20 keV have successfully been conducted. So far, the storage times of 50 nA He^-, 260 nA O^- and 110 nA OH^- have been measured. They are in good agreement with the theoretical predicted storage times based on the residual gas pressure ($p_{FLSR} \approx 1{,}0$ - $2{,}0\text{x}10^{-10}$ mbar, corrected for H_2 as residual gas). Also, the measured lifetime of the metastable He^- of about 300 μs is in good agreement with previous measurements [3].

In a next step photodetachment of the stored ions with tunable laser beams in the VIS and NIR range will be performed.

[1] http://www.pelletron.com/products/rf-charge-exchange/ [2] K.E. Stiebing, V. Alexandrov, R. Dörner et al., Nucl. Instr. and Meth. A614, 10 (2010). [3] U.V. Pedersen, M. Hyde, S.P. Møller, T. Andersen, Phys. Rev. A64, 012503 (2001)

A 35.16 Thu 16:15 S Fobau Physik

Laser spectroscopic characterization of the nuclear clock isomer ^{229m}Th — •Johannes Thielking[1], Maksim V. Okhapkin[1], Przemysław Głowacki[1], David-Marcel Meier[1], Lars von der Wense[2], Benedict Seiferle[2], Christoph E. Düllmann[3,4,5], Peter G. Thirolf[2], and Ekkehard Peik[1] — [1]Physikalisch-Technische Bundesanstalt, 38116 Braunschweig, Germany — [2]Ludwig-Maximilians-Universität München, 85748 Garching, Germany — [3]GSI Helmholtzzentrum für Schwerionenforschung GmbH, 64291 Darmstadt, Germany — [4]Helmholtz-Institut Mainz, 55099 Mainz, Germany — [5]Johannes Gutenberg-Universität, 55099 Mainz, Germany

An optical clock based on the transition between ground state and low-lying isomer in the nucleus ^{229}Th would be highly immune to field-induced frequency shifts and a sensitive probe of temporal variations of fundamental constants [1]. We recently performed the first measurement of the nuclear magnetic dipole and electric quadrupole moments and the mean square charge radius of the isomer [2]. This was achieved via high-resolution laser spectroscopy of the hyperfine structure of trapped $^{229}Th^{2+}$ ions, loaded from the α decay of ^{233}U. We are now preparing an experiment to investigate the excitation of the nucleus via electronic bridge and NEET processes [3,4] in the energy range from 7.2 to 10.2 eV, using two-step laser excitation in Th^{2+}.

[1] E. Peik, Chr. Tamm, Europhys. Lett. 61, 181 (2003).
[2] J. Thielking et al., Nature 556, 321-325 (2018).
[3] S. G. Porsev et al., Phys. Rev. Lett. 105, 185501 (2010).
[4] F.F. Karpeshin et al., Nucl. Phys. A, 654, 579 (1999).

A 35.17 Thu 16:15 S Fobau Physik

Towards a XUV frequency comb for high resolution spectroscopy on highly charged ions — •Alexander Ackermann, Janko Nauta, Jan Hendrik Oelmann, Julian Stark, Steffen Kühn, José Crespo López-Urrutia, and Thomas Pfeifer — Max-Planck-Institute for Nuclear Physics, Heidelberg, Germany

Highly charged ions (HCI) have been proposed as a candidate for novel frequency standards [1] and for testing of the variation of the fine structure constant [2]. To carry out high resolution spectroscopy on forbidden transitions in HCIs, stable and coherent extreme ultraviolet (XUV) radiation is required. The nonlinear process of high harmonic generation in a gas target in the focus region of a femtosecond enhancement cavity located in a vacuum chamber, is used to convert a near infrared frequency comb into the XUV [3]. A home built chirped pulse amplification system, containing a prism- and grating-based pulse compressor, which enables compensation of second and third order dispersion, is employed to reach 70 W of sub-200 fs pulses at a repetition rate of 100 MHz. Pulses are characterized with a second harmonic frequency-resolved optical gating setup, based on a self developed Echelle grating spectrometer and an autocorrelator.

[1] V.A. Dzuba et al., Phys. Rev. A 86, 054502 (2012)
[2] J.C. Berengut et al., Phys. Rev. Lett. 106, 210802 (2011)
[3] J. Nauta et al., ScienceDirect 408, Pages 285-288 (2017)

A 35.18 Thu 16:15 S Fobau Physik

A proton source for precision experiments in the QLEDS project — •Nicolas Pulido[1], Johannes Mielke[1], Teresa Meiners[1], Malte Niemann[1], Juan M. Cornejo[1], Matthias Borchert[1,3], Jonathan Morgner[1,2], Amado Bautista[1,2], Stefan Ulmer[3], and Christian Ospelkaus[1,2] — [1]Institut für Quantenoptik, Leibniz Universität Hannover — [2]Physikalisch-Technische Bundesanstalt, Braunschweig — [3]Ulmer Fundamental Symmetries Laboratory, RIKEN

Penning traps are an essential tool for high precision measurements on the g-factor of protons and antiprotons to perform tests of the CPT theorem [1]. This is the goal pursued by the BASE collaboration. Here we discuss techniques for sympathetic laser cooling and detection to support these tests [2,3]. We present the design of an off-axis proton source that also allows the introduction of an on-axis antiproton beam in the Penning trap system within the BASE collaboration. The source, consisting of an electron gun and a storage trap, will be commissioned in a cryogenic test setup.

The test setup is composed of a 2-stage cryocooler and a Penning trap with permanent magnets. We discuss different methods of non-destructive ion detection for the test setup.

[1] C. Smorra *et al.*, Nature **550**, 371-374 (2017)
[2] C. Smorra *et al.*, EPJ-ST **224**, 3055 (2015)
[3] D. J. Wineland *et al.*, J. Res. NIST **103**, 259-328 (1998)

A 35.19 Thu 16:15 S Fobau Physik

Cold Atomic Hydrogen Source @ T-Rex — •Jan Haack, Merten Heppener, Stefan Schmidt, Henrik-Lukas Schumacher, Marcel Willig, Andreas Wieltsch, and Randolf Pohl — Johannes Gutenberg-Univertität Mainz, QUANTUM, Institut für Physik, Exzellenzcluster PRISMA+

The Triton-Radius Experiment T-Rex at JGU Mainz aims at a first measurement of the 1S-2S transition in atomic tritium [1]. Such a measurement has the potential to improve the charge radius of the triton nucleus by a factor of 400, with an experimental accuracy of only 1 kHz. This is 100x *less* precise than the current measurements of the 1S-2S transition in H and D, [2,3]. T-Rex will use a cryogenic hydrogen (later tritium) beam and select low atomic velocities by a magnetic quadrupole guide. The slowest atoms will then be stopped using a Li MOT as a cold buffer gas, and trapped in a magnetic minimum trap. We will present the state of the experiment as well as an outlook.

[1] S. Schmidt et al. J. Phys. Conf. Ser. accepted (2018), arXiv 1808.07240
[2] C. Parthey et al. Phys. Rev. Lett. 104 233001 (2010)
[3] C. Parthey et al. Phys. Rev. Lett. 107 203001 (2011)

A 35.20 Thu 16:15 S Fobau Physik

A detector for atomic hydrogen — •Hendrik-Lukas Schumacher, Ahmed Ouf, Jan Hack, Stefan Schmidt, and Randolf Pohl — Johannes Gutenberg-Universität Mainz, Institut für Physik, QUANTUM & Exzellenzcluster PRISMA+, Mainz, Germany

Laser spectroscopy of atomic hydrogen and deuterium has yielded the most precise values for the Rydberg constant and, for a long time, of the proton and deuteron charge radii. The biggest obstacle for improved spectroscopy is however the atom's motion and the resulting large systematic uncertainties due to Doppler and time-of-flight broadening. Trapping of atomic hydrogen would solve many of these problems.

To this end, our group plans to trap atomic hydrogen using a cloud of Li atoms in a MOT as a cold buffer gas. This would for the first time also enable high-precision spectroscopy of atomic tritium, eventually leading to a 400fold improved value for the triton charge radius.

Here we report on a simple detector for atomic hydrogen and its isotopes which is based on the heat deposited in a thin (10s of micrometers) metal wire where the 4.5 eV released in the recombination of two H atoms leads to an increase in resistivity. This detector enables measurements of the spatial profile and the flux of atoms from our cryogenic hydrogen beam.

A 35.21 Thu 16:15 S Fobau Physik

Optically transparent solid electrodes for precision Penning traps — Marco Wiesel[1,2,3], Gerhard Birkl[3], Mohammad Sadegh Ebrahimi[1,2], Zhexi Guo[1,2,4], •Kanika Kanika[1,2], Jeffrey Klimes[1,2,4], Alexander Martin[3], Wolfgang Quint[1,2], Nils Stallkamp[1,5], and Manuel Vogel[1,5] — [1]GSI Helmholtzzentrum für Schwerionenforschung GmbH, 64291 Darmstadt, Germany — [2]Physikalisches Institut, Universität Heidelberg, 69120 Heidelberg, Germany — [3]Institut für Angewandte Physik, Technische Universität Darmstadt, 64289 Darmstadt, Germany — [4]Max-Planck-Institut für Kernphysik, 69117 Heidelberg, Germany — [5]Helmholtz-Institut Jena, 07743 Jena, Germany

The concept of an electrically conducting yet optically transparent solid electrode was conceived, and subsequently materialised, tested and implemented in a cryogenic Penning trap. Dedicated to spectroscopy and imaging of confined particles under large solid angles, this trap utilises a 'half-open design' with an open endcap for easy ion ingress and a closed endcap that mainly consists of a glass window coated with a highly transparent conductive indium tin oxide layer. This closed endcap retains the desired trapping capabilities of a conventional endcap electrode and yields flexible access for optical excitation and efficient light collection from the trapping region. With its superior surface quality and its high as well as homogeneous optical transmission, the window electrode is an excellent replacement for partially transmissive electrodes that use holes, slits, metallic meshes, and the like.

A 35.22 Thu 16:15 S Fobau Physik

Atomic computations of Isotope Shift Parameters for Heavy Elements — •Randolf Beerwerth[1,2] and Stephan Fritzsche[1,2] — [1]Helmholtz Institut Jena, 07743 Jena — [2]Theoretisch-Physikalisches Institut, Friedrich-Schiller-Universität Jena, 07743 Jena

The isotope shift between two isotopes A and A' of the same element is parametrized in terms of the mass and field-shift parameters. The former arises due to the nuclear recoil, while the latter is caused by the finite extent of the nuclear charge distribution. Generally, only the lowest order in the expansion of the field shift is considered and this allows to extract differential mean squared charge radii $\delta \left\langle r^2 \right\rangle^{A,A'}$ from measured isotope shifts using a known value for the field shift factor F. The field shift factor can be computed to good precision from atomic computations without a detailed knowledge of the nuclear parameters.

We present multiconfiguration Dirac–Hartree–Fock (MCDHF) computations of isotope shift parameters for several heavy elements such as bismuth and gold that are provided to support experimental work. In addition, different strategies for evaluating the accuracy of the computed results are discussed.

Instead of describing the field shift by a single parameter F an expansion into higher-order moments can be utilized. Methods for the computation of the corresponding field shift factors are discussed and possibilities for extracting higher order nuclear moments from experimental data are presented.