A 33: Poster Session II

Time: Wednesday 16:15–18:15 Location: Redoutensaal

A 33.1 Wed 16:15 Redoutensaal

Laser spectroscopy of the 1001 nm transition in atomic dysprosium — •Lena Maske, Dominik Studer, Niels Petersen, Florian Mühlbauer, Klaus Wendt, and Patrick Windpassinger — QUANTUM, Institut für Physik, Johannes Gutenberg-Universität Mainz, Staudingerweg 7, 55128 Mainz, Germany

High precision spectroscopy of ultra-narrow transitions in cold quantum gases is a promising tool for tests of fundamental physics [1]. Furthermore, ultra-narrow transitions in atoms and molecules are extremely useful for applications in quantum simulation and quantum state manipulation. When considering magnetic quantum gases or very complex electronic systems, a good candidate for an ultra-narrow resonance is the 1001 nm $4f^{10}6s^2\ {}^5I_8 \rightarrow 4f^9\,({}^6H^0)\,5d6s^2\ {}^7I_9^0$ ground state transition in atomic dysprosium. Theoretical calculations predicted the exceptionally small linewidth of 53 Hz [2].

We present the first laser spectroscopy of the possibly ultra-narrow 1001 nm line in atomic dysprosium. Using resonance ionization spectroscopy with pulsed Ti:sapphire lasers at a hot cavity laser ion source, we were able to observe the transition and confirm the level energy listed in the NIST database. In addition, we show our progress towards precision spectroscopy of the 1001 nm transition with a continuous wave ECDL in cold dysprosium atoms to measure the linewidth and the isotope shift.

[1] V.A. Dzuba et al., Physical Review A81, 052515 (2010)

[2] C. Delaunay et al., Physical Review D96, 093001 (2017)

A 33.2 Wed 16:15 Redoutensaal

Observation of the motional Stark effect in low magnetic fields — •Manuel Kaiser[1], Jens Grimmel[1], Lara Torralbo-Campo[1], Florian Karlewski[1], Nils Schopohl[2], and József Fortágh[1] — [1]Center for Quantum Science, Physikalisches Institut, Universität Tübingen, Germany — [2]Center for Quantum Science, Institut für Theoretische Physik, Universität Tübingen, Germany

The motional Stark effect (MSE) originates from a Lorentz force acting in opposite directions on the ionic core and the electrons of an atom moving in a magnetic field. This introduces a coupling between the internal dynamics and the center-of-mass motion of the atom which is therefore no longer a constant of motion. Approximately the MSE can be seen as a Stark effect resulting from an electric field in the frame of a moving atom. We measured this motional Stark shift on ^{87}Rb Rydberg atoms moving in low magnetic fields employing a velocity selective spectroscopy method in a vapor cell. For an atom velocity of 400 m/s, a principal quantum number of n = 100, and a magnetic field of 100 G the shifts are on the order of 10 MHz. Our experimental results are supported by numerical calculations based on a diagonalization of the effective Hamiltonian governing the valence electron of ^{87}Rb in the presence of crossed electric and magnetic fields. Furthermore we present our investigations on the velocity associated with the pseudomomentum as a constant of motion, that is supported by our experimental findings.

A 33.3 Wed 16:15 Redoutensaal

Two-loop corrections to the bound electron g factor: contribution of light-by-light scattering — •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

We report on the computation of a specific set of two-loop corrections to the bound-electron g factor. Diagrams belonging to this set involve the scattering of the external magnetic field in the Coulomb field of the ionic nucleus, which represents the lowest nonvanishing order of the so-called magnetic loop. We have looked at the electric loop (EL)+magnetic loop (ML) diagram and the self-energy(SE)+magnetic loop diagrams. We restrict ourselves to the $1S$ ground state, and our approach, which treats the binding of the electron to the nucleus at all orders, is hence valid for highly charged, high-Z ions.

We announce full results on the EL-ML diagram, and partial results on the vertex (analytical and subsequent numerical results for the zero-potential term) and the non-vertex (full contribution from the energy-type (or reducible) correction) SE-ML diagrams. The numerical values obtained so far indicate corrections to the g factor of order up to 10^{-8} for the largest contribution (electric loop+magnetic loop), in the case of $_{82}$Pb, values that could be observed in principle in upcoming experiments such as ALPHATRAP and HITRAP.

A 33.4 Wed 16:15 Redoutensaal

Accurate theoretical lifetimes data in the prospects of high precision experiments — •Moazzam Bilal[1,2], Andrey Volotka[1], Randolf Beerwerth[1,2], and Stephan Fritzsche[1,2] — [1]Helmholtz-Institut Jena, Germany — [2]Friedrich-Schiller-Universität, Jena, Germany

We present a detailed investigation of the magnetic dipole (M1) line strengths between the fine-structure levels of the ground configurations in B-, F-, Al- and Cl-like Ar, Fe, Mo and W ions. Systematically improved (enlarged) multiconfiguration Dirac-Hartree-Fock (MCDHF) wave functions are employed for the evaluations of the Coulomb type inter-electronic interactions. Relativistic configuration interaction method is used to evaluate the Breit type inter-electronic interactions. The QED corrections are incorporated by correcting the transition operator of the atomic magnetic moment for the anomalous magnetic moment of the electron (EAMM). One electron QED correction going beyond EAMM approximation is also implemented. The M1 transition rates are reported using the calculated line strengths and available accurate transition energies. Finally, the lifetimes in millisecond to piceseconds range are calculated including the contributions from the transition rate from the E2 transition channel. The discrepancy with available experiments is discussed and a benchmark dataset of theoretical lifetimes is provided in the prospects of future experiments. [1] A. Lapierre et al 2005 *Phys. Rev. Lett.* **95**, 183001. [2] G. Brenner et al 2007 *Phys. Rev. A* **75**, 032504. [3] P. Jönsson, et al 2013 *Comput. Phys. Commun.* **184** 2197.

A 33.5 Wed 16:15 Redoutensaal

Experimental setup for quantum logic inspired cooling and readout techniques for a single (anti-)proton — •Johannes Mielke[1], Teresa Meiners[1], Malte Niemann[1], Juan M. Cornejo[1], Anna-Greta Paschke[1,2], Matthias Borchert[1,3], Jonathan Morgner[1], Amado Bautista-Salvador[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

We discuss techniques tailored for quantum logic inspired cooling and manipulation of a single (anti-)proton in a Penning trap system. Inside the trap a double-well potential is engineered for co-trapping a beryllium ion, which enables for the use of quantum logic spectroscopy inspired sympathetic cooling and readout techniques [1, 2]. These should allow for preparation at sub-Doppler temperatures and a readout of the (anti-)proton's spin-state in less than a second. Within the BASE collaboration [3] these methods could be applied to precision measurements of the (anti-)proton's g-factor, thus contributing to a precise test of CPT invariance with baryons.

Here, we present recent progress made in the setup of the Penning trap apparatus, laser systems, and imaging optics for cooling, manipulation, and detection of the trapped beryllium ion.

[1] D. J. Heinzen *et al.*, PRA **42**, 2977 (1990)

[2] D. J. Wineland *et al.*, J. Res. NIST **103**, 259-328 (1998)

[3] C. Smorra *et al.*, EPJ-ST **224**, 3055 (2015)

A 33.6 Wed 16:15 Redoutensaal

Molecular Beam for Quantum Logic Spectroscopy of Single Molecular Ions — •Jan C. Heip[1], Fabian Wolf[1], and Piet O. Schmidt[1,2] — [1]Physikalisch-Technische Bundesanstalt, Braunschweig, Germany — [2]IQO, Leibniz Universität, Hannover, Germany

The internal structure of molecules offers rich possibilities for tests of fundamental physics. For example, transitions involving vibrational levels are sensitive to possible variations in the electron-to-proton mass ratio. The additional degrees of freedom (rotational and vibrational) cause obstacles in controlling the quantum states of molecules required for precision spectroscopy. Recent developments in state detection of molecular ions using state-dependent optical dipole forces [1] and state preparation via Raman transitions induced by far-detuned, infrared lasers [2] or frequency combs implements a toolbox which brings high precision optical spectroscopy for molecules within reach. An interesting candidate for a test of possible m_e/m_p variations is $^{16}\mathrm{O}_2^+$ [3]. We are currently setting up a new experimental apparatus consisting of a RF Paul trap and a molecular beam to perform experiments on O_2^+. A Multi-channel plate equipped with a phosphor screen is used to characterize the spatial and temporal properties of the gas pulses from the molecular beam. First studies on the photo-ionization spectrum of $^{16}\mathrm{O}_2^+$ using a pulsed dye laser are carried out and progress towards quantum logic spectroscopy of these molecular ions will be presented.

[1] Wolf et. al., Nature 530, 457 (2016)
[2] Chou et. al., Nature 545, 203 (2017)
[3] Kajita, Phys. Rev. A 95, 023418 (2017)

A 33.7 Wed 16:15 Redoutensaal

Optical quenching of metastable helium atoms via the 4^1P state — •Vivien Behrendt, Jonas Grzesiak, Simon Hofsäss, Frank Stienkemeier, and Katrin Dulitz — Albert-Ludwigs-Universität Freiburg

Our experiments are aimed at studying quantum-state-selected reactive Penning collisions between metastable helium atoms and ultracold lithium atoms. As a first step towards this goal, it is necessary to distinguish between the contributions of the He(2^1S) and the He(2^3S) state to the reaction. In this contribution, we will present a novel scheme for the quenching of the metastable singlet state using optical pumping to the 4^1P state at 397 nm and subsequent decay to the electronic ground state. We will present the experimental setup and preliminary results which illustrate that this scheme offers several experimental advantages compared to previous approaches.

A 33.8 Wed 16:15 Redoutensaal

Extrapolation of spectral lines of highly charged technetium ions in the EUV range — Leticia Täubert[1], Julia I. Jäger[1], •Chintan Shah[1], Klaus Werner[2], and José Ramón Crespo López-Urrutia[1] — [1]Max-Plank-Institut für Kernphysik, Heidelberg, Germany — [2]Eberhard Karls Universität, Tübingen, Germany

Astronomical observations of elements heavier than iron in stars give insights into their stellar evolution. To interpret spectroscopic observations, accurate atomic data of highly charged trans-iron ions are required. The trans-iron element technetium (Z=43) is of special interest since it is the lightest element with no stable isotopes. The spectroscopic measurement of such element poses a technical challenge due to its radioactive nature. Here, we examined its neighboring elements ruthenium (Z=44) and molybdenum (Z=42) on the premise that their atomic structures are same as of technetium. We produced Ru^{14+} and Ru^{15+} using an electron beam ion trap and measured the extreme ultraviolet spectra using flat-field grazing incidence spectrometer. We then identified spectral lines using the Flexible Atomic Code [3]. The NIST spectral line database was used to acquire the corresponding molybdenum spectra. These data enabled the extrapolation of the spectral lines of highly charged technetium.

[1] K. Werner et al., ApJL, 753, L7 (2012)
[2] K. Werner et al., A&A, 574, A29 (2015)
[3] M. Gu, CJP, 86, 5 (2008).

A 33.9 Wed 16:15 Redoutensaal

Evaluating the performance of cascaded atomic clocks — •Marius Schulte[1], Piet O. Schmidt[2,3], and Klemens Hammerer[1] — [1]Institut für theoretische Physik und Institut für Gravitationsphysik (Albert Einstein Institut), Leibniz Universität Hannover, Appelstrasse 2, 30167 Hannover, Germany — [2]Physikalisch-Technische Bundesanstalt, 38116 Braunschweig, Germany — [3]Institut für Quantenoptik, Leibniz Universität Hannover, 30167 Hannover, Germany

A fundamental challenge for optical clocks is given by the noise properties of their local oscillator. Increasing the interaction time with the atomic reference allows to make more precise estimates on the frequency error and better corrections in the clock operation, however this is only true as long as the phase between local oscillator and reference can be uniquely measured. In this way atomic clocks with e.g. Ramsey interrogation have maximal interrogation times which are set by the noise strength of the local oscillator and limit their long term stability [1]. Cascaded clocks with multiple atomic ensembles were proposed to overcome this limitation [2]. Here we perform numerical analysis of such protocols, finding optimised servo controllers as well as reviewing the maximal interrogation times and long term stability.

[1] Leroux, I. D., et al., On-line estimation of local oscillator noise and optimisation of servo parameters in atomic clocks, Metrologia 54.3 (2017) [2] Borregaard, J. and Sørensen, A. S., Efficient atomic clocks operated with several atomic ensembles, Phys. Rev. Lett. 111, 090802 (2013)

A 33.10 Wed 16:15 Redoutensaal

Hyperfine structure in heavy muonic atoms — •Niklas Michel, Natalia S. Oreshkina, and Christoph H. Keitel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

We consider bound states between an atomic nucleus and a muon, so called muonic atoms. Especially for high charge numbers, the surrounding atomic electrons do not influence the muon and the system is essentially hydrogenlike. Just as in normal atoms, there is fine and hyperfine splitting, but the significance of the various contributions differs dramatically. In particular, nuclear structure effects are much bigger, and vacuum polarization effects are very important. We calculate the level structure in heavy muonic atoms, taking several QED and nuclear structure effects into account in first-order perturbation theory and beyond. Thereby, precise values of the hyperfine structure of muonic atoms are obtained [1] and the dependence of transition energies in muonic atoms on nuclear parameters is investigated.

[1]: Phys. Rev. A 96, 032510 (2017)

A 33.11 Wed 16:15 Redoutensaal

Towards Quantum Logic Spectroscopy of Highly Charged Ar^{13+} — •Peter Micke[1,2], Steven A. King[1], Tobias Leopold[1], Lisa Schmöger[1,2], Maria Schwarz[1,2], José R. Crespo López-Urrutia[2], and Piet O. Schmidt[1,3] — [1]QUEST-Institut, Physikalisch-Technische Bundesanstalt, Braunschweig, Germany — [2]Max-Planck-Institut für Kernphysik, Heidelberg, Germany — [3]Leibniz Universität Hannover, Germany

Precision spectroscopy of electric dipole-forbidden optical transitions in highly charged ions (HCIs) has applications in the study of fundamental physics and the development of new optical atomic clocks with extremely low systematic uncertainties. However, precision spectroscopy on HCIs is challenging since they are usually produced at megakelvin temperatures and do not offer strong cycling transitions for laser cooling. We are currently commissioning an experiment aiming at high-precision quantum logic spectroscopy (QLS) on HCIs, using Ar^{13+} as the first test species. Produced in the PTB electron beam ion trap (EBIT), one of the novel 0.86 T Heidelberg Compact EBITs, the HCIs will be extracted and decelerated through a beamline, injected into a linear Paul trap and sympathetically cooled by laser-cooled Be^+ ions. A cryogenic system is operated with a pulse-tube cryocooler, mechanically decoupled from the Paul trap and located in a separate room together with the PTB-EBIT, and provides a trap temperature of below 5 K for long-term storage of HCIs. Ground state cooling of the logic ion Be^+ has been achieved as a prerequisite for state preparation and readout via QLS.

A 33.12 Wed 16:15 Redoutensaal

The g-factor of highly charged ions — •Halil Cakir, Bastian Sikora, Vincent Debierre, Natalia S. Oreshkina, Jan S. Breidenbach, Christoph H. Keitel, and Zoltán Harman — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany

The determination of the g-factor of highly charged ions allows us to test QED effects in strong fields. There are already very precise measurements of the g-factor of light ions [1] and measurements for heavy highly charged ions are on the way [2]. However, in many cases, theoretical calculations of the g-factor of ions are not on the same level of precision yet. For heavier ions in particular, expansions in the nuclear coupling strength $Z\alpha$ are not feasible.

A combination of experimental and theoretical values of the g-factor of ions recently allowed a significant improvement of the electron mass [3]. A similar interplay of experiment and theory for very heavy ions is expected to improve the value of the fine-structure constant [4]. In this context, we present recent theoretical calculations of the g-factor for H- and Li-like ions. – [1] A. Wagner *et al.*, Phys. Rev. Lett. **110**, 033003 (2013); [2] S. Sturm *et al.*, Atoms **5**, 4 (2017); [3] S. Sturm *et al.*, Nature **506**, 467 (2014); [4] V. M. Shabaev et al., Phys. Rev. Lett. **96**, 253002 (2006).

A 33.13 Wed 16:15 Redoutensaal

The ALPHATRAP g-Factor Experiment — •Ioanna Arapoglou[1,2], Alexander Egl[1,2], Martin Höcker[1], Sandro Kraemer[1,2], Tim Sailer[1,2], Andreas Weigel[1,2], Robert Wolf[1], Sven Sturm[1], and Klaus Blaum[1] — [1]Max Planck Institute for Nuclear Physics, Heidelberg — [2]Faculty of Physics and Astronomy, University of Heidelberg

ALPHATRAP is a high-precision Penning-trap experiment which aims for the most stringent test of bound-state quantum electrodynamics (BS-QED) in the strong field regime. These fields are provided by heavy highly charged ions (HCI), such as hydrogen-like ^{208}Pb^{81+}, where the electron is exposed to the strong binding potential of the nucleus. The heavy HCI are externally produced and delivered via a beamline to the cryogenic double Penning-trap system, which enables a measurement of the bound electron's g-factor. For the external ion production, the setup is equipped with an external non-cryogenic compact room temperature Electron Beam Ion Trap (EBIT) and a laser ionization source. Additionally, part of the beamline will be connecting the Heidelberg-EBIT to the Penning-trap setup. Currently, experiments are performed at ALPHATRAP with ^{40}Ar^{13+} ion, in preparation for the first g-factor measurement. For further reduction of energy related systematic shifts, sympathetic laser cooling using ^{9}Be^{+} will be implemented which is expected to improve the precision of the measurement besides permitting two-ion Coulomb crystallization. The ALPHATRAP setup as well as the current status of the experiment and the first results with trapped highly charged ions will be discussed.

A 33.14 Wed 16:15 Redoutensaal

Electronic level structure investigations in Th^{+} and nuclear properties of ^{229m}Th — •David-Marcel Meier, Johannes Thielking, Przemyslaw Glowacki, Maksim V. Okhapkin, and Ekkehard Peik — Physikalisch-Technische Bundesanstalt, Bundesallee 100, D-38116 Braunschweig

The ^{229}Th isotope possesses a unique, low-energy nuclear isomeric state at about 7.8(5) eV. This fact has stimulated the development of novel ideas in the borderland between atomic and nuclear physics, for example the use as an optical nuclear clock. Since the required precise information on the isomer energy is not yet available, it is intensely searched for using different experimental approaches. For the excitation of the nuclear isomer via electronic bridge or NEET processes, we investigate two-photon laser excitation of high-lying electronic levels in Th^{+}. We recently expanded our search range to higher energies and measured more than 100 previously unknown energy levels with $J = 1/2$, 3/2 and 5/2 in the range from 7.8 eV to 9.8 eV. We also present the recent progress of the hyperfine structure measurement of ^{229m}Th^{2+} ions and the determination of ^{229m}Th nuclear properties.

A 33.15 Wed 16:15 Redoutensaal

Towards an excition scheme for giant dipole states of Rydberg excitons in Cu2O — •Thomas Stielow, Markus Kurz, and Stefan Scheel — Universität Rostock, Institut für Physik, Albert-Einstein-Straße 23, 18059 Rostock, Germany

An exotic species of Rydberg atoms in crossed eletric and magnetic fields are so-called giant-dipole atoms [1]. They are characterized by an electron-ionic core separation in the range of several micrometers, leading to huge permanent dipole moments of several hundred thousand Debye. So far, these states stay out of reach for observation. Recently, the possible formation of giant dipole states by Rydberg excitons in Cu_2O has been proposed [2]. Excitons observe much stronger couplings to external fields, bringing giant dipole states into the reach of current experiments performed on Cu_2O. We discuss different possible excitation paths leading to giant dipole excitons based on the latest descriptions of excitonic giant dipole states.

[1] O. Dippel, P. Schmelcher, and L. S. Cederbaum, Phys. Rev. A, **49**, 4415 (1994).

[2] M. Kurz, P. Grünwald, and S. Scheel, Phys. Rev. B **95**,245205 (2017).

A 33.16 Wed 16:15 Redoutensaal

Networks of Atomic Spectra — •Julian Heiss[1], David Wellnitz[1], Armin Kekić[1,2], Sebastian Lackner[3], Andreas Spitz[3], Michael Gertz[3], and Matthias Weidemüller[1,4] — [1]Physikalisches Institut, Universität Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg, Germany — [2]École Normale Supérieure, Paris, France — [3]Institut für Informatik, Im Neuenheimer Feld 205, 69120 Heidelberg, Germany — [4]Shanghai Branch, University of Science and Technology of China, Shanghai 201315, China

We demonstrate a network-inspired approach for treating atomic spectroscopy data of hydrogen, helium and iron. Nodes of the network represent states, while links represent transitions between them. We find that the node community structure coincides with state labels derived from the quantum mechanical treatment of atoms. Using state-of-the-art methods for link prediction we are able to predict unknown atomic transitions.

A 33.17 Wed 16:15 Redoutensaal

On the status of experiments with hydrogen-like ions at the Heidelberg electron beam ion trap — •Hendrik Bekker and José R. Crespo López-Urrutia — Max-Planck-Insitüt für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

The strong enhancement of bound-state quantum-electrodynamic (QED) and relativistic effects combined with the relatively simple structure of heavy hydrogen-like ions make them highly suitable for studies of fundamental physics. For example, the value of fundamental constants can be extracted from g-factor measurements [1]. Also, the ground-state hyperfine splitting (HFS) can be within laser range, allowing for precision spectroscopic studies of variation of fundamental constants [2]. By also investigating the HFS in Li-like systems, QED can be tested in the strongest electric field available at present for experimental study [3]. At the Heidelberg electron beam ion trap (HD-EBIT), preparations for high energy operation are underway. Planned measurements include investigations of the HFS of Pr^{58+}. Furthermore, the HD-EBIT will function as an ion source for the Penning trap experiments PENTATRAP and ALPHATRAP.

[1] S. Sturm, *et al.* "High-precision measurement of the atomic mass of the electron." Nature 506.7489 (2014): 467-470

[2] S. Schiller, "Hydrogenlike HCI for tests of the time independence of fundamental constants." Phys. Rev. Lett. **98**, 180801 (2007)

[3] V. M. Shabaev, *et al.* "Towards a test of QED in investigations of the hyperfine splitting in heavy ions." Phys. Rev. Lett. **86**, 3959 (2001)

A 33.18 Wed 16:15 Redoutensaal

Analytical evaluation of energy levels for multi-electron atoms with Hartree-Fock accuracy — •Kamil D Dzikowski, Oleg D Skoromnik, Natalia S Oreshkina, and Christoph H Keitel — Max Planck Institute for Nuclear Physics, Saupfercheckweg 1, 69117 Heidelberg, Germany

We employ a complete hydrogen-like basis with an effective charge parameter to find fully analytic expressions for energy levels of multi-electron ions and atoms. The completeness of such basis allows us to write a secondary quantized representation of the exact Hamiltonian for construction of perturbation theory. To increase the convergence rate, we isolate contributions from states with closely spaced energies, by forming suitable linear combinations of the corresponding state vectors. We then use them to diagonalize the system's Hamiltonian, effectively accounting for all orders of perturbation theory within a corresponding finite basis subset. The accuracy of calculated characteristics is comparable with the one obtained via advanced numerical solutions of Hartree-Fock equations. [1] J. Phys. B 50 245007 (2017) https://doi.org/10.1088/1361-6455/aa92e6

A 33.19 Wed 16:15 Redoutensaal

Radiation pressure on a two-level atom: an exact analytical approach — •Lionel Podlecki[1], Rohan Glover[1,2], John Martin[1], and Thierry Bastin[1] — [1]Institut de Physique Nucléaire, Atomique et de Spectroscopie, CESAM, University of Liege, Bât. B15, Sart Tilman, Liège 4000, Belgium — [2]Centre for Quantum Dynamics, Griffith University, Nathan, QLD 4111, Australia

The mechanical action of light on atoms is nowadays a tool used ubiquitously in cold atom physics. In the semiclassical regime where the atomic motion is treated classically, the computation of the mean force acting on a two-level atom requires in the most general case numerical approaches. Here we show [1] that this problem can be tackled in a pure analytical way. We provide an analytical yet simple expression of the mean force that holds in the most general case where the atom is simultaneously exposed to an arbitrary number of lasers with arbitrary intensities, wave vectors, and phases. This yields a novel tool for engineering the mechanical action of light on single atoms.

[1] L. Podlecki, R. Glover, J. Martin, and T. Bastin, Radiation pressure on a two-level atom: an exact analytical approach, J. Opt. Soc. Am. B (in press); arXiv:1702.05410, (2017).

A 33.20 Wed 16:15 Redoutensaal

A new calibration standard for X-ray light sources — •Steffen Kühn[1], Sven Bernitt[2], Peter Micke[3], René Steinbrügge[4], and José Ramon Crespo López-Urrutia[1] — [1]Max-Planck-Institut für Kernphysik, 69117 Heidelberg, Germany — [2]Institut für Optik und Quantenelektronik, Friedrich-Schiller-

Universität, 07743 Jena, Germany — [3]Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig, Germany — [4]Deutsches Elektronen-Synchrotron, Notkestrasse 85, 22607 Hamburg, Germany

In the last decade X-ray laser spectroscopy has been proven to be a reliable technique to investigate atomic transitions of highly charged ions with highest precision by measuring the fluorescence of an ion cloud following the resonant excitation by a brilliant, monoenergetic photon beam provided by synchrotrons or free-electron lasers. We developed a new setup in which the highly charged ions are produced and stored in an electron beam ion trap (EBIT) that employs a novel off-axis electron gun with optical access along the beam axis. This allows an in-situ usage of the ion cloud to resonantly photoexcite well-known inner-shell atomic transitions and thus calibrate the photon beam energy with highest accuracy. Here we present first results of a calibration of the U49-2_PGM beam line at BESSY II in Berlin. The calibrated photon beam was used to investigate the absorption spectra of different molecular gases, which are crucial for the interpretation of X-ray satellite observations.

A 33.21 Wed 16:15 Redoutensaal

UV laser systems for sympathetic cooling of highly charged ions using $^{9}\mathrm{Be}^{+}$ — •Lukas Spiess[1], Lisa Schmöger[2], Julian Stark[1], Janko Nauta[1] und José R. Crespo López-Urrutia[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg, Germany — [2]Institut für Experimentalphysik, Universität Innsbruck, Austria

Precisely measuring the spectrum of cold, highly charged ions (HCIs) is of particular interest for metrology and measuring a possible variation of the fine structure constant. Since HCIs in general lack suitable optical transitions for laser cooling, at CryPTEx [1][2] HCIs are sympathetically cooled by a second laser-cooled ion species. For this purpose $^{9}\mathrm{Be}^{+}$ is chosen because it can be trapped alongside various HCIs in a linear Paul trap. The photoionization laser for creation of $^{9}\mathrm{Be}^{+}$ is based on [3]. It consists of a 940 nm diode laser which is twice frequency doubled: firstly using a PPKTP crystal and secondly a BBO crystal. The produced light at 235 nm interacts with the $2s^{1}S_{0}$ - $2p^{1}P_{1}$ transition for resonance-enhanced two photon ionization. The produced ions are then Doppler-cooled via the $^{2}S_{1/2}$ - $^{2}P_{3/2}$ transition at 313 nm. The required laser is based on [4] and is generated from fiber lasers at 1051 nm and 1550 nm. In a first stage, 626 nm light is produced by sum frequency generation in a PPLN crystal, followed by second harmonic generation in a BBO crystal to generate the needed 313 nm light.

[1] M. Schwarz et al., Rev. Sci. Instr. 83
[2] L. Schmöger et al., Science 347
[3] H.-Y. Lo et al., Appl. Phys. B 114
[4] A. C. Wilson et al., Appl. Phys. B 105

A 33.22 Wed 16:15 Redoutensaal

A cryogenic Paul trap experiment for long-time storage of highly-charged ions — •Julian Stark[1], Peter Micke[1,2], Lisa Schmöger[3], Janko Nauta[1], Steffen Kühn[1], Lukas Spiess[1], Tobias Leopold[2], Steven King[2], Piet O. Schmidt[2], and José R. Crespo López-Urrutia[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg, Germany — [2]Physikalisch-Technische Bundesanstalt, Braunschweig, Germany — [3]Institut für Experimentalphysik ,Universität Innsbruck, Austria

Forbidden transitions in highly charged ions (HCIs) are particularly interesting candidates for novel optical frequency standards and searches for physics beyond the Standard Model, such as possible drifts in the value of the fine structure constant α. For the purpose of these high precision experiments the HCIs are sympathetically cooled by simultaneously trapped Be^{+} ions in a cryogenic linear radio-frequency Paul trap [1,2,3]. We present the design of a cryogenic Paul trap setup which is based on CryPTEx [1] but focusses on long storage times of HCIs at extremely stable trapping conditions by isolating mechanical vibrations. Furthermore, a novel superconducting Paul trap resonator will enable precise localization of HCIs in low-noise trapping potentials which is needed for high precision laser spectroscopy.

[1] M. Schwarz et al., Rev. Sci. Instrum. 83, 083115 (2012)
[2] L. Schmöger et al., Rev. Sci. Instrum. 86, 103111 (2015)
[3] L. Schmöger et al., Science 347, 6227 (2015)

A 33.23 Wed 16:15 Redoutensaal

Laboratory measurement of "Dark Matter" decay 3.5 keV X-ray line — •Chintan Shah[1], Stepan Dobrodey[1], Sven Bernitt[1,2], René Steinbrügge[1], Liyi Gu[3], Jelle Kaastra[3], and José Ramón Crespo López-Urrutia[1] — [1]Max-Plank-Institut für Kernphysik, Heidelberg, Germany — [2]Friedrich-Schiller-Universität Jena, Jena, Germany — [3]SRON Netherlands Institute for Space Research, Utrecht, Netherlands

Speculations about a possible dark matter origin of observed unidentified x-ray line feature at ∼3.5 keV from galaxy clusters have sparked an incredible interest in the scientific community and given rise to a tide of publications attempting to explain the possible cause for this line [1, 2]. Motivated by this, we have measured the K-shell X-ray spectra of highly ionized bare sulfur ions following charge exchange with gaseous molecules in an electron beam ion trap, as a source of or a contributor to this X-ray line. We produced S^{16+} and S^{15+} ions and let them capture electrons in collision with those molecules with the electron beam turned off while recording X-ray spectra. We observed a charge-exchange-induced X-ray feature at the Lyman series limit (3.47 ± 0.06 keV). The inferred X-ray energy is in full agreement with the reported astrophysical observations and supports the proposed novel scenario by Gu [2, 3].

[1] E. Bulbul et al., ApJ, 13, 789 (2014)
[2] L. Gu et al., A & A, L11, 584 (2015)
[3] C. Shah et al., ApJ, 833, 52 (2016).

A 33.24 Wed 16:15 Redoutensaal

Polarization of resonanly excited X-ray line — •Chintan Shah[1], Pedro Amaro[2], René Steinbrügge[1], Sven Bernitt[1,3], Stephan Fritzsche[3], Andrey Surzhykov[4], José Ramón Crespo López-Urrutia[1], and Stanislav Tashenov[2] — [1]Max-Plank-Institut für Kernphysik, Heidelberg, Germany — [2]Physikalisches Institut, Heidelberg, Germany — [3]Friedrich-Schiller-Universität Jena, Jena, Germany — [4]Physikalisch-Technische Bundesanstalt, Braunschweig, Germany

X-ray polarization and anisotropy due to resonant recombination were experimentally studied using an electron beam ion trap. The electron-ion collision energy was scanned over the KLL dielectronic, trielectronic and quadruelectronic recombination resonances of $\mathrm{Fe}^{18+..24+}$ and $\mathrm{Kr}^{28+..34+}$ with an excellent resolution of ∼ 6 eV. The x-ray asymmetries were measured by two detectors along and perpendicular to the beam axis. Direct polarization was also measured using Compton polarimetry [1]. We observed that most of the x-ray transitions lead to polarization including higher-order resonances. These channels influence not only the charge balance but also the polarization of the dominant K_{α} x-ray line emitted by hot plasmas [2]. We conclude that the careful inclusion of relativistic Breit interaction [3] and hitherto neglected higher-order channels [2] is necessary to construct reliable plasma models diagnostics.

[1] C. Shah et al., PRA 92, 042702 (2015)
[2] C. Shah et al., PRE 93, 061201(R) (2016)
[3] P. Amaro et al., PRA 95, 0227012 (2017).

A 33.25 Wed 16:15 Redoutensaal

Dielectronic recombination of MNN in highly charged tungsten with open f-shells — •Chintan Shah[1], Pedro Amaro[2], José Paulo Santos[2], and José Ramón Crespo López-Urrutia[1] — [1]Max-Plank-Institut für Kernphysik, Heidelberg, Germany — [2]LIBPhys-UNL, FCT-UNL, P-2829-516, Caparica, Portugal

Tungsten is selected as the coating material for tokamaks Due to its high-resistance to thermal loads. Sputtering leads to contamination of highly-charged W ions in such plasmas where it provides unwanted cooling that can prevent an effective fusion ignition. Thus, an accurate recombination rates are require to predict ionization balance of such plasma [1, 2]. By using an electron beam ion trap (EBIT), we performed measurements of dielectronic recombination following MNN mechanisms in highly charged W in the energy region of multi-electronic compound resonances with many f-holes. In order to probe MNN dielectronic resonances with energies below the ionization threshold of ions with open f-shells, as well as maintaining an ion abundance constant, the electron beam energy was scanned over the resonances with times of tens of milliseconds. Preliminary calculations based on Flexible Atomic Code are reported in order to determine the main MNN resonance channels, ion abundances as well as recombination processes via multi-electron excitations. The present results can be used to provide the experimental benchmark for the theoretical predictions and plasma models [2].

[1] Pütterich et al., Nucl. Fusion 50, 025012 (2010)
[2] S. Preval et al., Phys. Rev. A 93, 0420307(2016).

A 33.26 Wed 16:15 Redoutensaal

VUV spectroscopy of highly charged ruthenium ions of as-

trophysical interest — Julia I. Jäger[1], Leticia Täubert[1], •Chintan Shah[1], Lisa Loebling[2], Klaus Werner[2], and José Ramón Crespo López-Urrutia[1] — [1]Max-Plank-Institut für Kernphysik, Heidelberg, Germany — [2]Eberhard Karls Universität, Tübingen, Germany

The discovery of technetium in the atmospheres of red giants constituted convincing proof that s-process nucleosynthesis is indeed occurring in evolved stars. The presence of Tc in the immediate progenitor stars can be an outstanding indicator for recent nucleosynthesis. However, the main obstacle for using Tc as an indicator is the lack of experimental as well as theoretical atomic data for high ionization stages [1, 2]. Since radioactive nature of Tc imposes a technical challenge in our experiment for now, as a first step, we decided to investigate the neighboring Ru (Z=44) ions assuming their atomic structures are the same. Using electron beam ion trap, we generated Ru$^{4+..6+}$ ions and emitted vacuum ultraviolet fluorescence was measured with 3-meter normal-incidence-monochromator. Some of the VUV lines are identified by the use of Flexible Atomic Code [3]. We further plan to implement these data in non-LTE model-atmosphere simulations computing stellar spectra that can finally be compared to ultraviolet observations obtained with space-based UV telescopes.
[1] K. Werner et al., ApJL, 753, L7 (2012)
[2] K. Werner et al., A&A, 574, A29 (2015)
[3] M. Gu, CJP, 86, 5 (2008).

A 33.27 Wed 16:15 Redoutensaal

Integration of photonic structures and thermal atomic vapors — •Artur Skljarow[1], Ralf Ritter[1], Nico Gruhler[2,3], Wolfram H.P. Pernice[2,3], Harald Kübler[1], Tilman Pfau[1], and Robert Löw[1] — [1]5. Physikalisches Institut and Center for Integrated Quantum Science and Technology, Universität Stuttgart, Pfaffenwaldring 57, D-70569 Stuttgart, Germany — [2]Institute of Nanotechnology, Karlsruhe Institute of Technology, D-76344 Eggenstein-Leopoldshafen, Germany — [3]Institute of Physics, University of Münster, Heisenbergstr. 11, D-48149 Münster, Germany

The usage of atomic vapors in technological applications has become increasingly relevant over the past few years. They are utilized e.g. in atomic clocks, magnetometers, as frequency reference or to slow down and store light. Integrated devices which combine photonic structures and thermal atomic vapors on a chip could be an ideal basis for such purposes, as they provide efficient atom-light coupling on a miniaturized scale well beyond the diffraction limit.
After having investigated various types of waveguides on the D_1 line in Rubidium, now we want to use a three level ladder scheme featuring optical access to telecom photons. By this, we are able to use Si as waveguide material instead of Si_3N_4.

[1] R. Ritter, et al., *Appl. Phys. Lett.* **107**, 041101 (2015)
[2] R. Ritter et al., *New Journal of Physics* **18**, 103031 (2016)

A 33.28 Wed 16:15 Redoutensaal

Development of a HHG frequency comb for XUV metrology of Highly Charged Ions — •Janko Nauta[1], Alexander Ackermann[1], Julian Stark[1], Steffen Kühn[1], Andrii Borodin[1], Peter Micke[2], Lisa Schmöger[3], Thomas Pfeifer[1], and José Crespo López Urrutia[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg, Germany — [2]Physikalisch-Technische Bundesanstalt, Braunschweig, Germany — [3]Institut für Experimentalphysik ,Universität Innsbruck, Austria

Recent theoretical studies have shown that forbidden optical transitions in highly charged ions (HCI) are the most sensitive systems for probing the variation of the fine structure constant α [1]. Moreover, they have been proposed as novel frequency standards due to their low polarizability and insensitivity to black body radiation [2].

We plan to perform high resolution spectroscopy of cold HCI [2] in the extreme ultraviolet region (XUV), where transitions, from dipole-allowed (E1) to highly forbidden, also take place. To this end, we are developing an enhancement cavity to amplify femtosecond pulses from a phase-stabilized infrared frequency comb at 100 MHz. High-order harmonics will be generated in the tight focus of the cavity, and can be used for direct frequency comb spectroscopy of HCI to determine absolute transition energies.
[1] J. Berengut et al., Phys. Rev. Lett. 109, 070802 (2012)
[2] A. Derevianko et al., Phys. Rev. Lett. 109, 180801 (2012)
[3] L. Schmöger et al., Science 347, 6227 (2015)

A 33.29 Wed 16:15 Redoutensaal

Ionenfalle mit transparenten Elektroden — •Kai Krimmel[1,2], Sebastian Wolf[2], Johannes Heinrich[3], Ron Folman[4], Mark Keil[4], Dmitry Budker[1,2,5,6] und Ferdinand Schmidt-Kaler[1,2] — [1]Helmholtz-Institut Mainz, Mainz 55128, Germany — [2]QUANTUM, Institut für Physik, JGU Mainz, Mainz 55128, Germany — [3]Laboratoire Kastler Brossel, UPMC-Sorbonne Universites, CNRS, ENS-PSL Research University, College de France — [4]Department of Physics, Ben-Gurion University of the Negev, Be'er Sheva 84105, Israel — [5]Department of Physics, University of California at Berkeley, Berkeley, CA 94720, USA — [6]Nuclear Science Division, Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA

Wir präsentieren eine lineare segmentierte Ionenfalle aus transparenten Chips, die eine Beobachtung von Fluoreszenzlicht durch die Falle erlauben. Die Falle ist aus einem Quartzglas-Substrat mit ITO und goldbeschichteten Elektroden hergestellt und soll für die Speicherung großer Kristalle aus Be+-Ionen und eine sympathetische Kühlung von zusätzlichen eingeschossenen Fremdionen dienen. Wir stellen den Aufbau und erste Messungen zur Charakterisierung der Falle dar und diskutieren zukünftige Anwendungsfälle wie z.B. die Kühlung von Anti-Wasserstoff-Ionen (P. Pérez et al., "The GBAR antimatter gravity experiment") oder eine Speicherung und Kühlung von geladenen Teilchen sehr unterschiedlicher Ladungs-zu-Masse-Verhältnissen (N. Leefer et al., "Investigation of two-frequency Paul traps for antihydrogen production").

A 33.30 Wed 16:15 Redoutensaal

Gamma spectroscopy to measure the ^{229}Th isomer energy using a 2-dimensional array of metallic magnetic microcalorimeters — •J. Geist[1], D. Hengstler[1], M. Krantz[1], R. Pons[1], P. Schneider[1], C. Schötz[1], S. Kempf[1], L. Gastaldo[1], A. Fleischmann[1], C. Enss[1], G.A. Kazakov[2], S.P. Stellmer[2], T. Schumm[2], and J. Bussmann[1] — [1]Heidelberg University — [2]Vienna University of Technology

The isotope ^{229}Th has a nuclear isomer state with the lowest presently known excitation energy, which possibly allows to connect the fields of nuclear and atomic physic with a potential application in a nuclear clock. In order to verify and improve the accuracy of the currently most accepted energy value, (7.8 ± 0.5) eV, we want to resolve the 29.18 keV doublet in the γ-spectrum following the α-decay of ^{233}U, corresponding to the decay into the ground and isomer state, to measure the isomer transition energy without additional theoretical input parameters.

We developed the detector array maXs-30 consisting of 8x8 metallic magnetic calorimeters with an expected energy resolution below 6 eV, providing a large detection area of 16 mm^2 to face the low rate of the 29.18 keV transitions.

In first measurements we observed the 29.18 keV transitions as a single peak with an instrumental resolution of 33 eV.A strong background contribution due to β-radiation from accumulated decay products in the ^{233}U-source was discovered. We present results of the latest measurements with an adjusted maXs-30 detector, new generation SQUIDs and an updated setup in the cryostat.

A 33.31 Wed 16:15 Redoutensaal

Modelling high-harmonic generation in solids beyond the single active electron — •Helena Drüeke and Dieter Bauer — Institute of Physics, University of Rostock, 18051 Rostock, Germany

Laser-driven electrons in linear chains of ions constitute the simplest models for the study of high-harmonic generation (HHG) in solids. The importance of band structure, finite-size or surface effects, and electron-electron interaction can be systematically investigated using such models.

On the poster, we illustrate our implementation of a time-dependent Kohn-Sham solver for the study of solid slabs in intense laser fields. In particular, we present HHG spectra, discuss their cut-offs, and analyze the role of electron-electron interaction and topological surface effects [1,2].

[1] Kenneth K. Hansen, Tobias Deffge, Dieter Bauer, *High-order harmonic generation in solid slabs beyond the single-active-electron approximation*, Phys. Rev. A 96, 053418 (2017).
[2] Dieter Bauer, Kenneth K. Hansen, *High-harmonic generation in solids with and without topological edge states*, (submitted) arXiv:1711.05783.

A 33.32 Wed 16:15 Redoutensaal

The Electron Capture in ^{163}Ho experiment — •Clemens Hassel and THE ECHo COLLABORATION — Kirchhoff-Institute of Physics, Heidelberg University, Germany.

Direct determination of the electron neutrino (m_{ν_e}) and anti-neutrino mass ($m_{\bar{\nu}_e}$) can be obtained by the analysis of electron capture and beta spectra respectively. In the last years experiments analysing the ^{3}H beta spectrum reached a limit on $m_{\bar{\nu}_e}$ of 2 eV. The upper limit on m_{ν_e} is still two orders of magnitudes higher at about 225 eV. The Electron Capture in ^{163}Ho experiment, ECHo, is designed to investigate m_{ν_e} in the sub-eV region and reach the same sensitivity as foreseen for $m_{\bar{\nu}_e}$ in new ^{3}H-based experiments. In ECHo, high sensitivity on a finite m_{ν_e} will be reached by the analysis of the endpoint region in high statistics and high resolution calorimetrically measured ^{163}Ho spectra. To perform this experiment, high purity ^{163}Ho source will be enclosed in a large number of low temperature metallic magnetic micro-calorimeters which are readout using the microwave multiplexing technique. This approach allows for a very good energy resolution of below $\Delta E_{\mathrm{FWHM}} < 5$ eV and for a fast time resolution well below 1 μs. Thanks to the modular approach, the ECHo experiment is designed to be stepwise up-graded. The first on-going phase, ECHo-1k, is characterized by a ^{163}Ho activity of about 1 kBq enclosed in about 100 pixels. The statistics of 10^{10} events in the ^{163}Ho spectrum will allow to improve the limit on m_{ν_e} by more than one order of magnitude. In this talk, the present status of the ECHo-1k experiment will be discussed as well as the plans for the next phase, ECHo-100k.

A 33.33 Wed 16:15 Redoutensaal

Towards High Precision Spectroscopy of μLi and μBe — •Marcel Willig, Jan Haack, Julian Krauth, Stefan Schmidt, and Randolf Pohl — Johannes Gutenberg-Universität Mainz, QUANTUM, Institut für Physik & Exzellenzcluster PRISMA, Mainz, Germany

Laser spectroscopy of muonic atoms proved to be a useful tool for measuring the rms charge radii of the lightest nuclei. The values gained with this method are orders of magnitude more precise than by electron scattering alone. This increased precision gave rise to the proton radius puzzle, a 5.6σ difference between the rms charge radius of muonic hydrogen and the respective CODATA value [1].

Further measurements have been performed on Deuterium [2], ^{3}He and ^{4}He. The next logical steps are muonic Li and Be. Spectroscopy of these atoms will improve the radii by an order of magnitude, only limited by the current accuracy of the calculated nuclear polarizability.

We summarize the results on H, D, He and present our ideas towards high precision spectroscopy of μLi and μBe. In addition we have performed a first study of the feasibility of stopping muons in a large Be ion crystal, which will also be presented.

[1] R. Pohl et al., Nature 466.7303, 213-216 (2010)
[2] R. Pohl et al., Science 353.6300, 669-673 (2016)

A 33.34 Wed 16:15 Redoutensaal

Commissioning of a new electron beam ion source as charge breeder for rare isotope beams — •Christian Warnecke[1], Michael Blessenohl[1], Stepan Dobrodey[1], Karl M. Rosner[1], Zachary Hockenbery[1], Renate Hubele[1], Thomas Baumann[2], José R. Crespo López-Urrutia[1], and Jens Dilling[3] — [1]Max-Planck-Institut für Kernphysik, Heidelberg, Germany — [2]European XFEL, Hamburg, Germany — [3]TRIUMF, Vancouver, Canada

Canada's national particle accelerator Centre TRIUMF is currently upgrading its facilities with the Advanced Rare IsotopE Laboratory (ARIEL) to deliver two additional rare isotope beams simultaneously to TRIUMF's user end stations. A new electron beam ion source (EBIS) is included in the ARIEL facility to boost the charge states of the short-lived rare isotopes to charge-to-mass ratios of $4 < A/q < 6$. For rare isotopes with half-lives down to 65 milliseconds and low abundancies of down to 10^6 per bunch, the whole process of injection, charge breeding and extraction has to be as efficient as possible. Furthermore the bunch repetition rates of around 100 Hz need a highly optimized setup. We present first injection-extraction measurements within the commissioning phase including characteristics of the electron gun with electron beam currents up to 1 A.

A 33.35 Wed 16:15 Redoutensaal

Towards laser spectroscopy of atomic tritium — •Jan Haack, Julian Krauth, Stefan Schmidt, Marcel Willig, Rishi Horn, and Randolf Pohl — Johannes Gutenberg-Universität Mainz, QUANTUM, Institut für Physik und Exzellenzcluster PRISMA, Mainz, Germany

We are currently setting up a new experiment for trapping of atomic tritium in a magnetic bottle and perform laser spectroscopy on it. This is compelling because with precise measurement of the 1S-2S transition the uncertainty of the triton charge radius can be improved by a factor of 400, making it comparable with its mirror nucleus ^{3}He who's charge radius has been improved recently using muonic helium. Comparison will e.g. allow high precision studies of 3-nucleon-forces. In our experiment tritium is trapped by using a magnetic octupole guide as a velocity selector, a ^{6}Li-MOT as a cold buffer gas and a magnetic bottle as storage. In a first stage the setup will be tested using atomic hydrogen. Additionally the planned setup can be used as a general storage device for hydrogen-like atoms in the future. We will present the design and concept of our upcoming experiment.

A 33.36 Wed 16:15 Redoutensaal

Excitation of hydrogen-like ions by twisted light: The effect of multipole mixing on the alignment of excited states — •Sabrina A.-L. Schulz[1,2], Robert A. Müller[1,2], Anton Preshkov[3], and Andrey Surzhykov[1,2] — [1]Physikalisch-Technische Bundesanstalt, Braunschweig, Germany — [2]Technische Universität Braunschweig, Germany — [3]Helmholtz-Institut Jena, Germany

During the last years twisted or vortex light beams have attracted considerable attention both in experiment and theory. These beams carry a non-zero projection of orbital angular momentum (OAM) onto their propagation direction and have a helical phase front [1]. Owing to these specific features the interaction of twisted light with ions and atoms may lead to a modification of the conventional (plane-wave) selection rules of radiative transitions. Such OAM-modified selection rules were recently observed experimentally by Schmiegelow and colleagues [2]. In this contribution, we theoretically investigate how these OAM-modified selection rules affect the magnetic sublevel population of photoexcited hydrogen-like ions. Particular emphasis is paid to radiative transitions, which can occur via several multipole channels. For example, we discuss the $1s_{1/2} \rightarrow 2p_{3/2}$ transition, which can proceed via the electric dipole (E1) and magnetic quadrupole (M2) channels. We show how the relative strength of these multipole transitions can be influenced by twisted light and how this can be seen in the magnetic sublevel population.

[1] H. M. Scholz-Marggraf, *et al.* Phys. Rev. A 90, 013425 (2014)
[2] C. T. Schmiegelow, *et al.* Nature Communications 7 12998 (2016)

A 33.37 Wed 16:15 Redoutensaal

Integrated and Time-Resolved Measurements of Collisional Energy Transfer in Rubidium P-States — •Ralf Albrecht[1], Johannes Schmidt[1,2], Robert Löw[1], and Harald Kübler[1] — [1]Integrated Quantum Science and Technology, Universität Stuttgart, 5. Physikalisches Institut — [2]Institut für Großflächige Mikroelektronik

Buffer gases are often used as collisional partners in spectroscopy gases e.g. to effectively average out the Doppler effect by redistributing velocity classes and therefore extend the time of light-matter interactions. We want to determine collisional cross-sections of excited 5P-states in rubidium. Thus, fluorescence spectra are acquired to observe quenching collisions by evaluating fluorescence intensities of different optical transitions. In addition, measurements at various atomic densities and thermal velocities are taken to extract information of the temperature dependence of collisional decay rates. Furthermore, a setup for pulsed saturation spectroscopy was built to measure time-resolved decay rates of optically excited rubidium. This allow us to measure quenching collisions with nanosecond resolution. The results are compared with that from our fluorescence measurements.

A 33.38 Wed 16:15 Redoutensaal

Laserspectroscopy experiments at CRYRING@ESR — •Konstantin Mohr[1], Aineah Barasa[1], Tim Ratajzyk[1], Wilfried Nörtershäuser[1], Zoran Andelkovic[2], Rodolfo Sanchez[2], Volker Hannen[3], Axel Buss[3], and Christian Weinheimer[3] — [1]Institut für Kernphysik, TU Darmstadt — [2]GSI Helmholtzzentrum — [3]Institut für Kernphysik, WWU Münster

CRYRING is a storage ring at the GSI Helmholtzzentrum that provides ion-beams with energies in range of 300keV/u up to 14MeV/u for the heaviest ion-species like ^{238}U^{92+}. In 2017 a first ion-beam of H_2^+-ions was established. During the beam-time in November 2017 cooling, acceleration and bunching was successfully tested. In October 2018, first experiments on stored ion-beams are scheduled.

In one of these experiments, Mg will be evaporated in a standard oven and subsequently ionized in a Nielsen-type ion source. After mass separation and injection into CRYRING, ^{24}Mg^{+} ions will be used for testing whether it is possible to polarize ion-beams in a storage ring by optical pumping. Therefore a cw dye-laser drives the $3s\,^2S_{1/2} \rightarrow 3p\,^2P_{1/2}$ transition of Mg at 280,35 nm. Usage of circular polarized σ^+-light will lead to an occupation of the m_s-substate with the maximum quantum-number $m_s = 1/2$. In this case, a previously observed fluorescence signal should vanish. To prove the polarization, σ^- or π polarized light can be used for repumping. This poster will present the status of CRYRING for laser spectroscopy experiments.

This work is supported by BMBF under contract numbers 05P15RDFAA and 05P15PMFAA.

A 33.39 Wed 16:15 Redoutensaal

Transverse free-electron target for CRYRING@ESR — •B. Michel Döhring[1], Carsten Brandau[1,2], Alexander Borovik Jr[1], Benjamin Ebinger[1], Christophor Kozhuharov[2], Tobias Molkentin[1], Alfred Müller[1], and Stefan Schippers[1] — [1]Justus-Liebig-Universität Gießen — [2]GSI

The storage ring CRYRING@ESR [1] will be one of the first operational devices at the anti-proton and heavy-ion accelerator facility, FAIR, which is currently under construction in Darmstadt. A transverse free-electron target for crossed-beams in-ring experiments is currently under development. Such an electron-ion crossed-beams arrangement has never been realised at a heavy-ion-storage ring before. The electron target is based on an earlier development in Gießen [2] and consists of a multi-electrode assembly to control beam size, electron density and electron energy. According to the electron-optical simulations that we performed during the design phase of the target, the electron density will reach up to 10^9 cm^{-3} at electron energies up to 12.5 keV. The present status of the project will be presented.

[1] M. Lestinsky et al., 2016 Eur. Phys. J. ST 225 797.

[2] B. Ebinger et al., 2017 Nucl. Instrum. Meth. B 408 317.

A 33.40 Wed 16:15 Redoutensaal

Fluorescence based measurement of nuclear polarization in atomic beams. — •Abhilash Javaji[1], Mark Bissell[2], Robert Harding[3,4], Marcus Jankowski[1], Magdalena Kowalska[4], Walter Neu[1], and Philipp Wagenknecht[1] — [1]Dept. of Physics, University of Oldenburg, Oldenburg, Germany — [2]School of Physics and Astronomy, Manchester University, Manchester, United Kingdom — [3]Dept. of Physics, University of York, York, United Kingdom — [4]EP-Dept., CERN, Geneva, Switzerland

The new laser-polarization setup at ISOLDE, CERN is dedicated to versatile studies involving β-decay asymmetry and β-NMR studies with spin-polarized radioactive ion beams. The spin-polarization is achieved via the optical pumping of atomic levels with circularly polarized laser light propagating collinearly with the ion/atom beam, which is subsequently transferred to the nuclear spin through the hyperfine interaction. Finally, the spins are decoupled in a strong magnetic field and β-decay asymmetry or its destruction can be observed. The latest venture has been the development of a fluorescence based polarization checker to be used with stable isotopes. For this purpose a 2nd laser perpendicular to the magnetic field is used to probe the substates of the spin polarized stable nuclei (e.g.^{85}Rb) to determine the degree of polarization. At stronger fields, Zeeman splitting separates the magnetic sub-levels enough to be probed individually, producing fluorescence whose intensity is proportional to the population of each sub-state, thus determining the degree of nuclear polarization. The development of the setup and scheduled tests will be presented.

A 33.41 Wed 16:15 Redoutensaal

Stellar Laboratories: High-precision Atomic Physics with STIS — •Conny Glaser, Thomas Rauch, and Klaus Werner — Institut für Astronomie und Astrophysik, Eberhard Karls Universität Tübingen, Sand 1, D-72076 Tübingen, Germany

Stellar atmospheres are prime laboratories to determine atomic properties of highly ionized species. Since reliable opacities are crucial ingredients of many astrophysical simulations and a detailed comparison of iron-group oscillator strengths is still outstanding, we used the Space Telescope Imaging Spectrograph (STIS) to measure high-resolution spectra of three hot subdwarf stars that exhibit extremely high iron-group abundances. These allow us to identify even very weak spectral lines. The predicted relative strengths of the identified lines are compared with the observations to judge the quality of Kurucz's line data and to determine correction factors for abundance determinations of the respective elements.

A 33.42 Wed 16:15 Redoutensaal

He buffered Laser Ablation Ion Source for Collinear Laser Spectroscopy — •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), Darmstadt — [3]Institute for Theoretical and Experimental Physics, Moscow, Russia

In the field of laser spectroscopy the laser systems have evolved to highly precise measurement devices, covering the wavelength range from infrared to ultra violet. The ion beams from non-volatile substances on the other hand are often produced by surface ionization devices, which mostly allow for the ion beams from alkali and earth alkali metals and inhibit the study of other interesting elements (e.g. refractory elements). Conventional laser ablation ion sources expand the region of available elements, but their ion beams have large emittances. We present the current status of a combined He buffered laser ablation ion source with an electrode funnel for spatial confinement and the He gas for transportation and cooling of the ions. This ion source will combine the high variability of target materials from laser ablation with a small emittance ion beam and the possibility of bunching due to the funnel system.

A 33.43 Wed 16:15 Redoutensaal

Polarisation Dynamics of Many-body Systems Dynamically Polarised via the Cross Effect — •Federica Raimondi, Daniel Wisniewski, Alexander Karabanov, Walter Kockenberger, Igor Lesanovsky, and Juan Garrahan — University of Nottingham

Dynamic Nuclear Polarisation (DNP) provides significant signal enhancement compared to conventional thermal polarisation techniques used in typical nuclear magnetic resonance applications. Of the possible DNP mechanisms, the cross effect (CE), involving triple spin-flips between two interacting electrons and a nucleus, is most efficient at low temperatures and microwave irradiation amplitude of the first electron. In order to examine the dependence of CE polarisation dynamics on the system geometry, large-scale simulations must be carried out. This becomes impracticable using the full Liouville-von-Neumann description of the system. We have developed a new formalism that separates the dynamics of the system into fast and slow, allowing projection onto the Zeeman subspace, thereby greatly reducing the state-space of the system. Under given conditions, it is then possible to simulate the Zeeman Projected polarisation dynamics using classical kinetic Monte Carlo methods. With this approach, a system of 118 proton spins has been simulated.

A 33.44 Wed 16:15 Redoutensaal

A Detection System for Laser Spectroscopy Experiments at CRYRING@ESR — •Axel Buss[1], Volker Hannen[1], Christian Huhmann[1], Dominik Thomas[1], and Zoran Andelkovic[2] — [1]Institut für Kernphysik, Universität Münster — [2]GSI Helmholtzzentrum für Schwerionenforschung

In order to enable laser spectroscopy experiments at CRYRING, a new general purpose fluorescence detector has been developed at the University of Münster. The design allows detection from ultraviolet wavelengths to the near infrared regime. Thus, the detector can be used to observe a large variety of atomic transitions. Among others Mg- (at 280 nm) and Ca+ (at 854 nm/866 nm) ions have transitions in the wavelength regime covered by the detector.

Geant4 simulations have been performed in order to optimize the detection efficiency of fluorescence photons, while * at the same time * suppressing the detection of background photons. This is realized by an elliptical detector geometry, which selectively focuses fluorescence photons from the beam axis onto PMTs outside of the vacuum. In order to achieve a high sensitivity over the complete wavelength range, two sets of interchangable PMTs will be used, one for the UV range and one for the long wavelength part. By the time of the DPG spring meeting, construction of the detection system and integration into the CRYRING facility should be complete. The poster will present the design, construction, and status of the instrument.

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