A 20: Poster: Precision spectroscopy of atoms and ions (with Q)

Time: Tuesday 16:00–18:30 Location: Empore Lichthof

A 20.1 Tue 16:00 Empore Lichthof

The ARTEMIS Experiment: Precision Spectroscopy of Highly Charged Ions in a Penning Trap — •Manuel Vogel[1,2], Gerhard Birkl[1], David von Lindenfels[2,3], Alexander Martin[1], Wolfgang Quint[2,3], and Marco Wiesel[1] — [1]Institut für Angewandte Physik, TU Darmstadt, 64289 Darmstadt — [2]GSI Helmholtzzentrum für Schwerionenforschung, 64291 Darmstadt — [3]Physikalisches Institut, Ruprecht Karls-Universität Heidelberg, 69120 Heidelberg

We present the concept and setup of the ARTEMIS experiment located at the HITRAP facility at GSI, Germany. It is dedicated to laser-microwave double-resonance spectroscopy of confined and cooled highly-charged ions with high precision. Such spectroscopy allows a simultaneous determination of electronic and nuclear magnetic moments with respective relative accuracies on the ppb and ppm level. In single- and few-electron highly charged ions this opens the possibility to resolve QED contributions to the electron g-factor due to the bound state. At the same time, nuclear magnetic moments can be measured in absence of electronic shielding and corresponding models can be tested for the first time.

A 20.2 Tue 16:00 Empore Lichthof

Parity violation effects in superconductors — •Nikolay A. Belov[1] and Zoltán Harman[1,2] — [1]Max Planck Institute for Nuclear Physics, Saupfercheckweg 1, 69117 Heidelberg, Germany — [2]ExtreMe Matter Institute (EMMI), Planckstraße 1, 64291 Darmstadt, Germany

Parity violation effects in a circular superconducting Josephson junction has been investigated in the eighties. That time it appeared that this phenomenon was not significant enough to be experimentally observable.

In our work we show, that this rate can be increased in the case of a circular Josephson junction of an unconventional superconductor. Furthermore, this phenomenon can be more significant in the case of the ferromagnetic p-wave unconventional superconductor, since the effect is stronger for polarized pairs.

A 20.3 Tue 16:00 Empore Lichthof

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

We present the theoretical and experimental basis for a highly-sensitive spectroscopy technique, based on the detection of motional excitation through photon recoil. In the experiment we trap an ion crystal consisting of two ions, the spectroscopy ion and the logic ion for cooling and detection. Spectroscopy is performed by first cooling the axial modes of the ion crystal to the motional ground state. Scattering of photons on the spectroscopy ion results in recoil kicks, which populate excited motional states. We present a theoretical model of the motional state evolution of this system.

The population of the motional mode can be detected through application of a red sideband pulse on the logic ion, which changes the internal state of the ion if the system is in an excited motional state. This detection techniques suffers from an incomplete transfer of population, since the Rabi frequency is a function of the initial motional state. We present theoretical and experimental results on the investigation of adiabatic passage techniques for state independent population transfer, which increases the signal to noise ratio of the spectroscopy signal.

A 20.4 Tue 16:00 Empore Lichthof

Single Ra^+ ion spectroscopy - towards a measurement of Atomic Parity Violation — •Mayerlin Nunez Portela, A. Mohanti, E.A. Dijck, H. Bekker, O. Boell, J. van den Berg, G.S. Giri, K. Jungmann, C.J.G. Onderwater, B. Santra, R.G.E. Timmermans, O.O. Versolato, L.W. Wansbeek, L. Willmann, and H.W. Wilschut — KVI, University of Groningen, Groningen , The Netherlands

The sensitivity of the Atomic Parity Violation (APV) signal grows faster than the third power of the atomic number Z. Ra^+ (Z=88)is heaviest alkaline earth ion available. A single trapped Ra^+ ion opens a very promising path for a measurement atomic parity violation. One of the experimental challenges is the localization of the ion within a fraction of an optical wavelength. For this the current experiments are focused on trapping and laser cooling of Ba^+ ions as a precursor for Ra^+. Ba^+ ions are trapped and laser cooled in a precision hyperbolic Paul trap. Work towards single Ba^+ ion localization and detection is in progress. Recently the hyperfine structure of the $6d_2D_{3/2}$ states and the isotope shift of the $6d_2D_{3/2}$-$7p_2P_{1/2}$ transition in the isotopes $^{209-214}Ra^+$ has been measured [1]in online laser spectroscopy experiments at the KVI AGOR/TRIμP facility. These results are essential for the interpretation of an APV measurement in Ra^+. [1] G.S. Giri et al., Phys. Rev. A 84, 020503(R) (2011)

A 20.5 Tue 16:00 Empore Lichthof

Structure of highly charged ions: towards a determination of the variation of the fine-structure constant — •Natalia S. Oreshkina[1], Zoltán Harman[1,2], and Christoph H. Keitel[1] — [1]Max Planck Institute for Nuclear Physics, Saupfercheckweg 1, 69117 Heidelberg, Germany — [2]ExtreMe Matter Institute (EMMI), Planckstrasse 1, 64291 Darmstadt, Germany

The possibility of the time-variation of the fine structure constant α, as one of the fundamental constants, has a great interest for modern science. Specifically, a varying α has been proposed as a way of solving puzzles in cosmology and astrophysics. Transitions in highly charged ions can have an extremely high sensitivity to α variation and can be observed in laboratory by high-precision spectroscopy. We present a set of ionic optical transitions which may be utilized to observe a frequency shift due to α variation.

A 20.6 Tue 16:00 Empore Lichthof

Spezifikation der Energieunschärfe gekühlter und gepulster Ionenstrahlen mittels Laserspektroskopie am TRIGA-Mainz — •S. Kaufmann[1], T. Beyer[2], K. Blaum[2], Ch. E. Düllmann[1,3,4], K. Eberhardt[1,4], M. Eibach[2,5], N. Frömmgen[1], Ch. Geppert[1,4,6], C. Gorges[1], M. Hammen[1,6], A. Krieger[1,4,6], S. Nagy[2], W. Nörtershäuser[1,4,6], D. Renisch[1], E. Will[1] und Die TRIGA-SPEC-Kollaboration[1] — [1]Institut für Kernchemie, Universität Mainz — [2]MPIK Heidelberg — [3]GSI Darmstadt — [4]HIM Mainz — [5]Fakultät für Physik und Astronomie, Universität Heidelberg — [6]TU Darmstadt

Der Aufbau zur kollinearen Laserspektroskopie am Forschungsreaktor TRIGA Mainz dient zur Untersuchung radioaktiver Isotope und als Prototyp für das LASPEC-Experiment an FAIR [1]. Zur Akkumulation und Kühlung der Ionen ist ein gasgefüllter Radiofrequenz-Quadrupol (RFQ) in der gemeinsamen Strahlstrecke implementiert. Die Energie und die Energieverteilung der daraus extrahierten Ionen ist sowohl für den Einschuss in die nachfolgende Penningfalle (TRIGA-TRAP) als auch für die kollineare Laserspektroskopie (TRIGA-LASER) von großer Bedeutung und kann mittels Laserspektroskopie sehr genau ermittelt werden. Geplant ist die Untersuchung der Abhängigkeit dieser Größen von den Parametern des RFQ. Der Status des Projektes und erste Ergebnisse werden vorgestellt. Unter anderem wird die benötigte Laserstabilisierung auf eine Absolutfrequenz und eine verbesserte Datenaufnahme mittels eines FPGA-basierten Sequencers diskutiert.

[1] D. Rodriguez et al., Eur. Phys. J. Special Topics 183, 1-123 (2010)

A 20.7 Tue 16:00 Empore Lichthof

High resolution fluorescence spectroscopy of Kα transitions in highly charged iron ions at a synchrotron — •Jan Rudolph[1,2], René Steinbrügge[1], Sven Bernitt[1], and José R. Crespo López-Urrutia[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg, Germany — [2]Institut für Atom- und Molekühlphysik, Gießen, Germany

Most prominent features in active galactic nuclei X-ray spectra originate from photoexcited iron K_α transitions. An experimental approach to study these processes needs a high X-ray photon flux near 6.7 keV and a target of highly charged iron ions. For this experiment we used the Heidelberg transportable electron beam ion trap FLASH-EBIT to produce a dense ion target. To resonantly photo excite K_α transitions in this ion cloud and detect fluorescence the PETRA III photon source was used. A double crystal monochromator at beam line P01 provided $10^{12}\gamma\ s^{-1}$ with a resolution of 0.1 eV. By scanning the monochromator energy from 6.4 to 6.7 keV several electric dipole allowed K_α transitions in $Fe^{17+\cdots 24+}$ ions were detected. Absolute line energies with an accuracy of a few ppm had been measured. Even the natural line width of the fluorescence lines were determined. This method of measuring absolute line energies combining an EBIT with a highly resolved and focused X-ray beam at a synchrotron overcomes classical methods like crystal spectrometer measurements. We achieve higher statistics in a much shorter period of time. The complexity of the measurement setup is reduced compared to classical spectroscopy as well as the susceptibility to disturbances in the experimental surroundings.

A 20.8 Tue 16:00 Empore Lichthof

Ion Coulomb crystals for precision spectroscopy and dynamical studies — •Heather L. Partner, Karsten Pyka, Jonas Keller, Tobias Burgermeister, and Tanja E. Mehlstäubler — Physikalisch-Technische Bundesanstalt, Braunschweig

We present our experimental setup, in which we trap and store Coulomb crystals of $^{172}Yb^+$ and $^{115}In^+$ ions. We provide technical details of the chip-based segmented linear Paul trap which we developed for metrological applications. It is specifically designed for minimizing excess micromotion, includes a protected spectroscopy segment and provides three dimensional laser access. This well-controlled environment allows to create and perform spectroscopy on 1D, 2D, and 3D Coulomb crystals. Using these crystals, we create topological defects and study the dynamics in laser cooled coupled ion systems.

A 20.9 Tue 16:00 Empore Lichthof

Spectroscopy of a narrow-line optical pumping transition in atomic dysprosium — •Holger Kadau, Thomas Maier, Matthias Schmitt, Michaela Nickel, Axel Griesmaier, and Tilman Pfau — 5. Physikalisches Institut, Universität Stuttgart, Pfaffenwaldring 57, 70569 Stuttgart, Germany

Dysprosium is a rare-earth element with a complex energy level structure with several possible cooling and optical pumping transitions. We have prepared samples of dysprosium atoms at $\sim$1 mK in a magneto-optical trap by laser cooling on a broad transition at 421 nm. One possibility to laser cool the atoms further is to use a narrow-line optical transition at 626 nm and reach conditions suitable for forced evaporative cooling in an optical dipole trap.

One alternative to forced evaporative cooling is lossless demagnetization cooling [1]. It requires an atomic sample with inelastic dipolar scattering in its lowest energetic state, a controllable magnetic field and an optical pumping transition. We present a suitable candidate for such optical pumping at a wavelength of 684 nm. We assign the positions of the so far unknown fermionic hyperfine shifts of the transition. We measured the transition linewidth and give an upper limit for the branching ratio between decay to the groundstate and other states. Our measurements show that this transition is usable for optical pumping and demagnetization cooling.

[1] M. Fattori *et al.*, Nat. Phys. **2**, 126401 (2006)

A 20.10 Tue 16:00 Empore Lichthof

Lifetime and natural line width determination of Kα transitions in highly charged iron ions — •Jan K. Rudolph[1,2], René Steinbrügge[1], and José R. Crespo López-Urrutia[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg, Germany — [2]Institut für Atom- und Molekühlphysik, Gießen, Germany

Resonance spectroscopy measurements have been performed on photoexcited highly charged iron ions in the X-ray regime near 6.7 keV photon energy. The transportable Heidelberg electron beam ion trap FLASH-EBIT was used to produce and store $Fe^{22+\cdots 24+}$ ions. The beamline P01 with its double-crystal monochromator at the PETRA III facility served as X-ray source. The energy resolution of the monochromator was 0.1 eV sufficient to determine natural line widths with good accuracy. While scanning the monochromator energy, ions were continuously extracted from the trap, separated by their charge-to-mass ratio and detected with a position sensitive detector. Thus, by simultaneously measuring the photoionization yield and the line width of all the signals, the Auger and radiative decay rates could be determined independently of geometric factors.

A 20.11 Tue 16:00 Empore Lichthof

Spectroscopy of hole transitions in Ir^{17+} — •Hendrik Bekker[1], Alexander Windberger[1], Christian Beilmann[2], Renee Klawitter[3], Piet O. Schmidt[4,5], Oscar O. Versolato[1], and José R. Crespo López-Urrutia[1] — [1]Max-Planck-Institut für Kernphysik — [2]Karlsruhe institut für Technologie — [3]Tri University Meson Facility — [4]Physikalisch-Technische Bundesanstalt — [5]Leibniz Universität Hannover

Astronomical observations hint at a spatial gradient of the fine structure constant α [1]. Since the Earth moves along this spatial gradient, a temporal variation in α, $\dot{\alpha}$, should be observable in the lab. Current estimates for the variation are $\dot{\alpha}/\alpha < 10^{-19}$/year. For a lab measurement of $\dot{\alpha}$ to be feasible in the foreseeable future, two accurate optical clocks with different sensitivities to $\dot{\alpha}$ are required. An optical clock with high sensitivity to $\dot{\alpha}$ can be found by looking at hole transitions in highly charged ions. It has been calculated that due to level crossings the hole transitions in Ir^{17+} are within optical range, while at the same time this system has one of the highest sensitivities to $\dot{\alpha}$ [2]. In our electron beam ion trap, Ir^{17+} ions are prepared and collisionally excited. A grating spectroscope is employed to study the level structure at an aimed accuracy of 1 ppm. Theory cannot predict the electronic structure as accurately as needed. Knowledge of the level structure is therefore an essential prerequisite for future laser spectroscopy experiments in the cryogenic Paul trap CryPTEx.

[1] J.K. Webb *et al., Phys. Rev. Lett.* **107**, 191101 (2011).
[2] J.C. Berengut *et al., Phys. Rev. Lett.* **106**, 210802 (2011).

A 20.12 Tue 16:00 Empore Lichthof

A cryogenic Paul trap for highly charged ions — •Maria Schwarz[1,2], Oscar O. Versolato[1], Alexander Windberger[1], Lisa Schmöger[1], Sita Eberle[1], Piet O. Schmidt[2], and José R. Crespo López-Urrutia[1] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg — [2]Quest, Physikalisch-Technische Bundesanstalt, Bundesallee 100, 38116 Braunschweig

A linear cryogenic Paul trap experiment (CryPTEx) has been set up in-line with an electron beam ion trap. It will provide long storage times for highly charged ions (HCIs) due to the extremely low background pressure within a 4 K enclosure. First experiments on the storage of HCIs in this trap are presently under way. Since HCIs generally do not allow for direct laser cooling, one needs to apply sympathetic cooling. The trapped HCIs will be coupled by Coulomb-interaction to a low-temperature bath of laser-cooled ions what ultimately should allow to resolve the natural linewidth of forbidden transitions. Our final goal is the application of quantum logic spectroscopy, where a singly charged ion species (Be^+) is responsible for the sympathetic cooling and state detection of the HCI. For the purpose of these high precision measurements, a second cryogenic Paul trap is currently being designed at MPIK in collaboration with the PTB. The design of this trap is based on CryPTEx but will focus on extremely precise and stable trapping conditions.

A 20.13 Tue 16:00 Empore Lichthof

A Radium Ion Optical Clock — •Elwin A. Dijck, M. Nuñez Portela, O. Böll, S. Hoekstra, K. Jungmann, A. Mohanty, C.J.G. Onderwater, R.G.E. Timmermans, L. Willmann, and H.W. Wilschut — KVI, University of Groningen, Groningen, The Netherlands

Single-ion based optical clocks are currently the best candidates for a future time and frequency standard with their stability exceeding that of the current ^{133}Cs standard. In particular, the 7s $^2S_{1/2}$ (F=2, mF=0)-6d $^2D_{3/2}$ (F=0, mF=0) at 828 nm transition in $^{223}Ra^+$ could be exploited as a robust atomic clock operating at a fractional frequency uncertainty of 10^{-17} since it exhibits no linear Zeeman and electric quadrupole shifts[1]. Laser spectroscopy of trapped $^{209-214}Ra^+$ yielded the hyperfine structure of the 6d $^2D_{3/2}$ state and isotope shift of the 6d $^2D_{3/2}$-7p $^2P_{1/2}$ transition, providing input for the design of a Ra^+ clock. Application include the direct comparison of the clock frequencies via an optical fiber networks and an optical frequency comb to determine frequency shifts in the gravitational field, and the implementation in an improved earth-bound positioning system. The comparison of different ions species is of fundamental interest because of their specific dependence on possible changes of fundamental constants, e.g. the fine structure constant. The Ra^+ clock transition is much more sensitive to $d\alpha/dt$ than e.g. the Al^+ clock, and the shift would have the opposite sign than that of Hg^+. [1] O.O. Versolato et al., Physical Review A 83 (4), 043829. [2] G.S. Giri et al., Phys. Rev. A 84, 020503(R) (2011)

A 20.14 Tue 16:00 Empore Lichthof

Laser Systems for the Preparation of Cold Highly Charged Ions — •Sita Eberle[1], Oscar O. Versolato[1], Matthias Kohnen[2], Alexander Windberger[1], Maria Schwarz[1], Piet

O. Schmidt[2], Joachim Ullrich[1,2], and José R. Crespo Lopez-Urrutia[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg, Deutschland — [2]Physikalisch-Technische Bundesanstalt, Braunschweig, Deutschland

Highly charged ions (HCIs) are of particular interest for metrology as well as for studying fundamental physics. Narrow optical transitions would provide for new frequency standards with low sensitivity to external fields. Stringent tests of bound-state QED as well as parity violation benefit from strong enhancement effects. For these purposes we have designed a cryogenic Paul trap that enables the trapping and sympathetic laser cooling of HCIs for precision spectroscopy. The coolant of choice is the Be+ ion which requires a Doppler-cooling laser system operating at 313nm wavelength that we constructed in collaboration with PTB. A separate system was developed for the photo-ionization of Be+ ions at 235nm wavelength that can deliver up to several 10mW of UV. It is based on frequency quadrupling an amplified diode laser system operating at 940nm with up to 1500mW output power. Thermal lensing issues limit the first second harmonic generation (SHG) stage, based on resonance enhanced doubling in a bow-tie cavity using an AR-coated PPKTP crystal. The second SHG system also relies on resonance enhanced doubling in a bow-tie cavity employing a Brewstercut BBO crystal.

A 20.15 Tue 16:00 Empore Lichthof

Search for the permanent electric dipole moment of ^{129}Xe — •Olivier Grasdijk[4], Werner Heil[1], Sergei Karpuk[1], Anja Scharth[1], Yuri Sobolev[1], Kathlynne Tullney[1], Fabian Allmendinger[2], Ulrich Schmidt[2], Martin Burghoff[3], Wolfgang Kilian[3], Allard Schnabel[3], Frank Seifert[3], Lutz Trahms[3], Klaus Jungmann[4], and Lorenz Willmann[4] — [1]Institut für Physik, Universität Mainz — [2]Physikalisches Institut, Universität Heidelberg — [3]PTB Berlin — [4]KVI, University of Groningen

Permanent electric dipole moments (EDMs) violate parity and time reversal symmetry at the same time. Assuming CPT invariance a non-zero EDM would also violate CP symmetry, which could provide an explanation for the observed matter-antimatter asymmetry in the universe. An EDM at the present limit of experimental sensitivity would provides unambiguous evidence for physics beyond the Standard Model. Our approach is to observe the coherent spin-precession of co-located ^{3}He/^{129}Xe polarized samples over extended periods of 1 day, typically. Based on results of measurements on Lorentz-invariance [1], we intend to reach a measurement sensitivity that will improve the present upper limit $d_{Xe} = 3{\cdot}10^{-27}$ecm significantly. Phase I of this experiment will be performed in the magnetically shielded room BMSR-2 of the PTB Berlin using very sensitive SQUID gradiometers as magnetic flux detectors and electric fields of 2 kV/cm. The experimental setup, in particular the implementation of the electric field, and current status of work will be presented. [1] C.Gemmel et al., Eur. Phys. J D 47, 303 (2010; C.Gemmel et al., Phys. Rev D 82, 111901(R)(2010).

A 20.16 Tue 16:00 Empore Lichthof

A low-energy beamline for injection of highly charged ions into a cryogenic Paul trap — Lisa Schmöger[1], •Maria Schwarz[1,2], Oscar O. Versolato[1], Alexander Windberger[1], Thomas M. Baumann[1], Joachim Ullrich[2], and José R. Crespo López-Urrutia[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg, Germany — [2]Physikalisch-Technische Bundesanstalt, Braunschweig

Electron beam ion traps (EBITs)are efficient tools for highly charged ion (HCI) production and studies. However, due to the high ion temperature inside of an EBIT (on the order of MK), laser spectroscopy on HCIs is severely constrained by Doppler broadening [1]. A novel cryogenic Paul trap (CryPTEx) operating at the MPIK [2] will allow for sympathetic cooling of HCIs by 9 orders of magnitude, down to the mK regime, and thus for resolving the natural linewidth of forbidden optical transitions in HCI. A compact beamline for transport, deceleration and transfer of HCIs from Hyper-EBIT into CryPTEx has been designed, built and commissioned at MPIK. Simulations have been performed to optimize the ion optics. The new beamline guides HCIs extracted from an EBIT into CryPTEx in both pulsed and continuous modes. Deceleration and time-focussing of the ion bunches are performed by a drift cavity which also reduces the initial energy spread of the ions. The setup allows for efficient HCI transfer and injection of slow HCIs into the Paul trap.

[1] V. Mäckel et al., Phys. Rev. Lett. **107**, 143002 (2011)
[2] M. Schwarz et al., Rev. Sci. Instrum. **83**, 083115 (2012)

A 20.17 Tue 16:00 Empore Lichthof

X-ray measurements of highly charged ions with a microcalorimeter — Sebastian Georgi[1], Sönke Schäfer[2], Thomas M. Baumann[1], Andreas Fleischmann[2], Christian Enss[2], Joachim Ullrich[3], and •José R. Crespo López-Urrutia[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg — [2]Ruprecht-Karls-Universität, Heidelberg — [3]Physikalisch-Technische Bundesanstalt, Braunschweig

A metallic magnetic microcalorimeter for photons in the spectral region 100-15000 eV was commissioned at the Heidelberg Electron Beam Ion Trap facility. It consists of eight absorber pixels made of erbium-doped gold held at 30 mK. Their temperature change due to the absorption of a single X-ray photon is used to determine its energy: Each absorber is thermally linked to a paramagnetic sensor in which a magnetization change is precisely measured by a superconducting interference device. A nested focusing X-ray mirror system is used for increased detection efficiency. We investigated the dielectronic recombination resonances of He-like and Li-like iron ions, and directly excited M-shell transitions of tungsten ions, achieving a resolution of 9,eV. The iron results were compared with multi-configuration Dirac-Fock calculations; those of the 4f$\rightarrow$3d transitions of Ni-like to Ti-like, and of 5f$\rightarrow$3d transitions of Ni-like to Cr-like tungsten ions, with Flexible Atomic Code [1] calculations of our own and with data from [2,3].

[1] M. F. Gu, Can. J. Phys. **86** (2008) 675
[2] P. Neill et al., Can. J. Phys., **82** (2004) 931
[3] J. Clementson et al., Phys. Scripta **81** (2010) 015301

A 20.18 Tue 16:00 Empore Lichthof

High prectision x-ray measurements with a metallic magnetic microcalorimeter at the MPIK Hyper-EBIT — •Sebastian Georgi[1], Sönke Schäfer[2], Thomas M. Baumann[1], Andreas Fleischmann[2], Joachim Ullrich[1], Christian Enss[2], and José R. Crespo López-Urrutia[1] — [1]Max Planck Institute for Nuclear Physics, Heidelberg, Germany — [2]Kirchhoff-Institute for Physics, Heidelberg, Germany

A metallic magnetic microcalorimeter for photons in the spectral region between 100 eV and 15 keV was commissioned at the Heidelberg Electron Beam Ion Trap facility. It is cooled to 30mK and consists of eight absorber pixels (250 μm x 250 μm sensitive area each) made of 5 μm thick gold (5N). Each absorber is thermally linked to a paramagnetic sensor made of erbium doped gold, so that the temperature increase due to the absorption of a photon result in a magnetization change of the sensor which can be precisely measured by a SQUID magnetometer. We investigated the dielectronic recombination resonances of He-like and Li-like iron ions, and also directly exited M-shell transitions of tungsten ions. The recorded iron spectra were compared with results from theoretical multi-configuration Dirac-Fock calculations. The measured energies of seven 4f$\rightarrow$3d and five 5f$\rightarrow$3d transitions of Ni- to Ti-like tungsten ions were compared to calculations carried out with the Flexible Atomic Code [1] and with results from [2,3].

[1] M. F. Gu, Can. J. Phys. 86 (2008) 675
[2] P. Neill et al., Can. J. Phys., 82 (2004) 931
[3] J. Clementson et al., Phys. Scripta 81 (2010) 015301

A 20.19 Tue 16:00 Empore Lichthof

Precision Laser Spectroscopy of the 1S-2S Transition in Positronium — Paolo Crivelli[1], David Cooke[1], Aldo Antognini[1], Klaus Kirch[1,4], •Janis Alnis[2], and Theodor W. Hänsch[2,3] — [1]ETH Zurich, Institute for Particle Physics, CH-8093 Zürich — [2]Max-Planck-Institut für Quantenoptik, 85748 Garching — [3]Ludwig-Maximilians-Universität, 80799 München — [4]Paul Scherrer Institute, Villigen, Switzerland

We aim to improve the current accuracy in the measurement of the energy interval of positronium (Ps) from its ground state (1S) to the first excited state (2S) by a factor of 5. This will provide a very stringent test of the theory describing atomic systems called bound states quantum electrodynamics (QED). Very recently a serious discrepancy of 5 sigma in the charge radius of the proton extracted from the muonic-hydrogen experiment at PSI compared to other experiments was found and has not yet been explained. This increases the importance of studying hydrogen-like and especially non-baryonic (with no quarks, e.g no protons) systems like positronium or muonium where finite-size effects due to the nucleus are absent. The proposed measurement will also result in the best determination of the positron-electron mass ratio that should be exactly one in order for the CPT symmetry to be conserved. This symmetry is a pillar of quantum field theory which is the base of our current understanding of particles and their interactions.

A 20.20 Tue 16:00 Empore Lichthof

Investigation of the structure of the solar corona by imaging spectroscopy — •Adalbert Ding[1,2] and Shadia Rifai Habbal[3] — [1]Institut für Optik und Atomare Physik, TU Berlin — [2]Institut für Technische Physik, Berlin — [3]Institute for Astronomy, University of Hawaii, Honolulu, USA

The emission of highly ionized Fe atoms in the solar corona has been investigated during the solar eclipses of 2010 (in French Polynesia)and 2012 (in Northern Australia)using wavelength selected imaging techniques. In particular, two imaging spectrometers have been used to record the solar emission spectrum along a line transversing the corona over several solar radii thereby obtaining the relative intensities of all relevant emission lines. Besides the intense Hydrogen, Helium and Calcium lines, emission from optically forbidden transitions of a number of Fe ions (Fe^{9+}: 637.4 nm, Fe^{13+}: 530.3 nm) were observed.

During the 2012 solar eclipse an improved high resolution double spectrometer was used to measure the Doppler broadening of 2 emission lines (Fe^{9+}, Fe^{13+}).

The results are compared with the 2D visible emission profiles of a number optically forbidden transitions using narrow band interference filters [1)]

The data provide information about the electron temperature distribution in different coronal structures and the excitation mechanisms of the ions.

1) S.R. Habbal et al., APJ 734, 120 (2011)

A 20.21 Tue 16:00 Empore Lichthof

A high resolution double imaging spectrometer for the investigation of ion emission in the solar corona — •Adalbert Ding[1,2] and Shadia Rifai Habbal[3] — [1]Institut für Optik und Atomare Physik, TU Berlin — [2]Institut für Technische Physik, Berlin — [3]Institute for Astronomy, University of Hawaii, Honolulu, USA

Doppler shift of emission lines can be used to obtain information about the velocity of light emitting particles in the gas phase. An easily transportable optical spectrometer has been designed and set up for such uses in solar eclipse expeditions .

An echelle grating operated under grazing incidence in high order (appr. 40^{th}) is used to significantly increase the resolution. A combination of optical cut-off filters and dichroic mirrors preselects a narrow wavelength range for order sorting. Two sets of such filters and two gratings allow the simultaneous measurement in two relevant wavelength ranges. The optical properties of the spectrometer have been chosen such that a 2 to 3 orders are simultaneously recorded with a low noise CCD-chip. This allows the deconvolution of the lines by using Fourier transform techniques.

By using an extended entrance slit it is possible to also record the intensity distribution along the slit which has been designed as a mirror. Thus it is possible to record the sun's position with respect to the slit using a separate video camera.

First results - both from natural and artificial sources - will be presented. The influence of the spectrometer parameters and the camera noise of the deconvoluted spectra will be discussed.

A 20.22 Tue 16:00 Empore Lichthof

Metallic magnetic calorimeters for high resolution x-ray spectroscopy - Latest results from maXs-20 and maXs-200 — •Mathäus Krantz[1], Sönke Schäfer[1], Christian Pies[1], Daniel Hengstler[1], Simon Uhl[1], Sebastian Heuser[1], Thomas Wolf[1], Loredana Gastaldo[1], Christian Enss[1], Andreas Fleischmann[1], Sebastian Georgi[2], Thomas M. Baumann[2], and Jose R. Crespo Lopez-Urrutia[2] — [1]Kirchhoff-Institut für Physik, Uni Heidelberg, INF 227, 69120 Heidelberg — [2]Max Planck Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Deutschland

We are developing metallic magnetic calorimeters (MMC) for high resolution x-ray spectroscopy on highly charged ions in the energy range up to 200keV. MMCs use a paramagnetic temperature sensor, readout by a SQUID, to measure the energy deposited by single x-ray photons. The recently micro-fabricated and tested prototypes include two linear 8-pixel detector arrays, maXs-20 and maXs-200, optimized for energies up to 20 keV and 200 keV, respectively. We summarize the performance of both detector prototypes. maXs-200 with its $1mm^2$ large and 200 μm thick absorbers made of electro-deposited gold has high stopping power for hard x-rays and achieves an energy resolution of 40-60 eV (FWHM). maXs-20 with its $250\mu m \times 250$ μm large and 5 μm thick absorbers has a stopping power of 98% for 6 keV photons and presently achieves an experimental line width of 3,3 eV (FWHM), with a signal rise time of 90 ns and excellent linearity. We are presently operating maXs-20 at an electron-beam-ion-trap at the MPI-K Heidelberg and will report on first atomic physics measurements.

A 20.23 Tue 16:00 Empore Lichthof

Hyperfine Structure Investigations by Modelling Emission Spectra — •Bettina Gamper and Laurentius Windholz — Institut für Experimentalphysik, Technische Universität Graz, Petersgasse 16, A-8010 Graz, Österreich

We present studies of the spectral lines of Praseodymium by modelling the emission spectrum by a sum of the hyperfine (hf) profiles of all spectral lines in a certain region. Pr has a huge amount of spectral lines, mostly in the visible region. Many transitions have nearly the same center of gravity (cg) wavelength which leads to overlapping of two or more spectral lines. To distinguish the different lines which take part in these so called blend situations we use laser-induced fluorescence (LIF) spectroscopy. We get the excitation wavelength for the investigations of a promising structure from a highly resolved Fourier transform (FT) spectrum. Our goal is to classify as many spectral lines as possible and to discover new energy levels. In the last years our group enlarged the list of the spectral lines from 12000 to 26000 and found about 300 new energy levels of the Pr atom as well as of the Pr ion. With our new program we can now summarize all classified transitions and compare them to the FT spectrum, in order to judge whether all lines contributing to the emission spectrum are known or not. The program can be adapted to every other element. An application of such a modelling could be analyzing highly resolved stellar spectra.

A 20.24 Tue 16:00 Empore Lichthof

Transportable Apparatus for a Strontium Lattice Clock — •Stefan Vogt, Sebastian Häfner, Stephan Falke, Uwe Sterr, and Christian Lisdat — Physikalisch-Technische Bundesanstalt (PTB), Bundesallee 100, 38116 Braunschweig, Germany

The best measurements of optical transition frequencies in atoms or ions are today limited by the realization of the SI second. The natural way to avoid this limitation is to directly compare frequencies in the optical regime. This will enable tests of physical theories such as possible variations of fundamental constants or tests of general relativity, or enable a new way of measuring the difference in gravitional potential between two places. Nevertheless the number of optical frequency-ratio measurements performed so far is small, because remote comparisons at that level are still difficult and so far there are no clock setups that are in fact transportable.

Here we will present the progress on a new transportable setup for an optical lattice clock working with ^{87}Sr. The system consists of a vacuum chamber and laser systems for trapping, cooling and interrogating the atoms. We will present the latest results on a Zeeman slower based on permanent magnets and field coils for the magneto-optical trap that are compatible with temperature gradients of well below one Kelvin on the vacuum chamber. This is crucial for correcting the frequency shift caused by the blackbody radiation emitted form the environment seem by the atoms. This work is supported by the Centre for Quantum Engineering and Space-Time Research (QUEST) and EU through the Space Optical Clocks (SOC2) project.