# A 25: Precision spectroscopy of atoms and ions V (with Q)

Time: Wednesday 11:00–12:30 Location: B 302

A 25.1 Wed 11:00 B 302

**The Baryon Antibaryon Symmetry Experiment BASE** — •Christian Smorra[1], Kurt Franke[2], Georg Schneider[3], Klaus Blaum[2,4], Andreas Mooser[3,5], Wolfgang Quint[4,6], Jochen Walz[3,5], Yasunori Yamazaki[1], and Stefan Ulmer[1] — [1]RIKEN Advanced Science Institute, Hirosawa, Wako, Saitama 351-0198, Japan — [2]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, D-69117 Heidelberg, Germany — [3]Institut für Physik, Johannes-Gutenberg-Universität Mainz, D-55099 Mainz, Germany — [4]Ruprecht-Karls-Universität Heidelberg, D-69047 Heidelberg, Germany — [5]Helmholtz Institut Mainz, D-55099 Mainz, Germany — [6]GSI-Helmholtzzentrum für Schwerionenforschung, D-64291 Darmstadt, Germany

The Baryon Antibaryon Symmetry Experiment (BASE) planned at the Antiproton Decelerator (AD) at CERN is dedicated to compare fundamental properties of proton and antiproton with high precision. Such matter/antimatter comparisons are sensitive tests of the CPT theorem. As one of these quantities, the g-factors of both particles are currently only compared with a moderate precision of $\delta g/g = 3\times10^{-3}$, limited by the antiproton value. Recently, we succeeded in measuring the proton g-factor with a relative precision of $8.9 \times 10^{-6}$ using the continuous Stern-Gerlach effect on a single proton in a cryogenic Penning trap. Using the same method on a single antiproton, we aim for a 100-fold improved CPT test with baryons. By applying the so-called double-trap technique, BASE ultimately aims for a relative precision of $10^{-9}$ or better, resulting at least in a factor of one million improved CPT test. In this talk, the BASE experiment will be presented.

A 25.2 Wed 11:15 B 302

**BASE : Single Particle Detector Systems** — •Kurt Franke[1], Christian Smorra[2], Georg Schneider[3], Klaus Blaum[1,4], Andreas Mooser[3,5], Wolfgang Quint[3,6], Jochen Walz[3,5], Yasunori Yamazaki[2], and Stefan Ulmer[2] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, D-69117 Heidelberg, Germany — [2]RIKEN Advanced Science Institute, Hirosawa, Wako, Saitama 351-0198, Japan — [3]Institut für Physik, Johannes-Gutenberg-Universität Mainz, D-55099 Mainz, Germany — [4]Ruprecht-Karls-Universität Heidelberg, D-69047 Heidelberg, Germany — [5]Helmholtz Institut Mainz, D-55099 Mainz, Germany — [6]GSI-Helmholtzzentrum für Schwerionenforschung, D-64291 Darmstadt, Germany

The BASE experiment planned at the Antiproton Decelerator (AD) at CERN aims at a high-precision measurement of the magnetic moment of the antiproton. The heart of the apparatus consists of a stack of four cylindrical Penning traps. These traps will be used for catching and storing of antiprotons from the AD, and for the magnetic moment measurement, which will be carried out by application of the continuous Stern-Gerlach effect. Six cryogenic single particle detection systems, each consisting of a high-Q resonator and a low-noise amplifier, are planned and currently under construction. These detection circuits will be used for precision measurements of the particle*s eigenfrequencies, giving direct access to the particle*s fundamental properties. In this talk, an overview of the detection systems and status of the construction and characterization will be presented.

A 25.3 Wed 11:30 B 302

**Highly charged ions for mass determinations of short-lived isotopes** — Martin C. Simon[1], Dieter Frekers[2], •Vanessa V. Simon[1,3,4], José R. Crespo López-Urrutia[4], and Jens Dilling[1] — [1]TRIUMF, Vancouver, Canada — [2]Westfälische Wilhelms-Universität, Münster, Germany — [3]Ruprecht-Karls-Universität Heidelberg, Germany — [4]Max-Planck-Institut für Kernphysik, Heidelberg, Germany

TRIUMF*s Ion Trap for Atomic and Nuclear science (TITAN) is the only high precision Penning trap mass measurement setup coupled to a rare isotope facility using charge breeding of short-lived nuclides for accurate mass determinations [1,2].

Experiments on isotopes with half-lives as low as 65 ms, such as 74-Rb [3], and in charge states as high as 22+ have been carried out. Results on Ge and Ga relevant to neutrino-detector flux calibrations will be reported. Future plans include a new electron beam ion source for re-acceleration applications [4].

[1] J. Dilling, et al. Int. J. Mass Spectrosc. **251**, 198 (2006).
[2] M. Froese, et al., Hyperfine Interact. **173**, 85 (2006)
[3] S. Ettenauer et al., Phys. Rev. Lett. **107**, 272501 (2011)
[4] M. C. Simon, et al., Rev. Sci. Instrum. **83**, 02A912 (2012)

A 25.4 Wed 11:45 B 302

**Pair production processes by nuclear decay and in muonic atoms** — •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

The pair production process by $\gamma$-emission of nuclei has been investigated so far both theoretically and experimentally. But, in all works only the production of a free electron and positron was considered. The case when an electron is "born" in a bound state of atom has been neglected as a relatively small effect. We investigate this bound-free pair conversion process for different multipolarities of nuclear $\gamma$ decay. We use a relativistic description of the electron and positron wave functions as it is necessary for heavy elements. It appears that the contribution of this bound-free process for bare heavy ions at low $\gamma$-energies close to $2m_ec^2$ gives a contribution comparable to or stronger than the free-free process and that it may be the dominant electromagnetic decay channel in case of E0 nuclear transitions.

We also investigate the similar bound-free pair production process in electromagnetic muonic transitions in muonic atoms. In this case, all matrix elements can be calculated exactly. Photon energies have the same order as the $\gamma$-energies in the nuclear case, so one expects a similar dominance of the bound-free process over the free-free process at low transition energies (for transitions between excited muonic states). Our calculations have confirmed this behaviour.

A 25.5 Wed 12:00 B 302

**Quantum Logic Enabled Test of Discrete Symmetries** — •Timko Dubielzig[1], Malte Niemann[1], Anna-Greta Paschke[1], Martina Carsjens[1,2], Matthias Kohnen[2,1], and Christian Ospelkaus[1,2] — [1]Institut für Quantenoptik and Centre for Quantum Engineering and Space Time Research (QUEST), Leibniz Universität Hannover — [2]PTB Braunschweig

Much progress has been made recently towards a CPT test with baryons based on the (anti-)proton's magnetic moment [1, 2]. A big challenge in any such experiment is the spin state measurement for single (anti-)protons, which has not been realized yet at the single-shot level, as would be desirable for an accurate and competitive g-factor CPT test. We describe concepts and simulations for an experiment which will implement single-shot fast readout using quantum logic operations according to the proposal by Heinzen and Wineland [3]. We discuss trapping geometries, concepts for single (anti-)proton rf sideband control, and for ground state cooling of the atomic quantum logic ion at fields exceeding 1 Tesla in a miniaturized Penning trap.

[1] S.Ulmer et al., Phys. Rev. Let. **106**, 253001 (2011)
[2] N. Guise et al., Phys. Rev. Let. **104**, 143001 (2010)
[3] Heinzen and Wineland, PRA **42**, 2977 (1990)

A 25.6 Wed 12:15 B 302

**Upgrade des optischen Nachweises des TRIGA-LASER Experiments und Charakterisierung gebunchter Ionenstrahlen** — •C. Gorges[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], M. Hammen[1,6], S. Kaufmann[1], 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]MPI-K Heidelberg — [3]GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt — [4]HIM Mainz — [5]Fakultät für Physik und Astronomie,Universität Heidelberg — [6]TU Darmstadt

Ziel des TRIGA-SPEC Experimentes am Forschungsreaktor TRIGA Mainz ist es, Massenspektrometrie und kollineare Laserspektroskopie an kurzlebigen Isotopen durchzuführen, die durch die neutroneninduzierte Spaltung von $^{235}$U, $^{239}$Pu oder $^{249}$Cf produziert und in einer online Ionenquelle ionisiert werden[1]. Zum Kühlen und Akkumulieren der Ionen wird ein gasgefüllter RF-Quadrupol (RFQ) eingesetzt. In der Laserspektroskopie ist die Optimierung des Signal/Rausch-Verhältnisses essentiell. Die Weiterentwicklung der optischen Nachweisregion bewirkt eine Erhöhung der Signalrate und eine Unterdrückung des Laser-Streulichtuntergrunds. Durch zeitaufgelöste Mes-

sungen des Restgasleuchtens in der optischen Nachweisregion wird die zeitliche Struktur der Ionenpakete charakterisiert und der RFQ-Betrieb für online Laserspektroskopie optimiert. Erste Ergebnisse zum optischen Nachweises und zur Bunchstruktur werden präsentiert.

[1] Ketelaer et al., Nucl. Instr. Meth. A 594, 162 (2008)