A 21: Precision spectroscopy of atoms and ions III (with Q)

Time: Tuesday 14:00–15:45 Location: BEBEL SR140/142

A 21.1 Tue 14:00 BEBEL SR140/142

The Baryon-Antibaryon Symmetry Experiment (BASE) — •Kurt Franke[1,2], Christian Smorra[2], Andreas Mooser[3], Hiroki Nagahama[2,4], Georg Schneider[2,3], Klaus Blaum[1], Yasuyuki Matsuda[4], Christian Ospelkaus[5], Wolfgang Quint[6], Jochen Walz[3], Yasunori Yamazaki[7], and Stefan Ulmer[2] — [1]MPI-K, Heidelberg, Germany — [2]RIKEN Ulmer IRU, Japan — [3]Universität Mainz, Germany — [4]University of Tokyo, Japan — [5]Universität Hannover, Germany — [6]GSI Darmstadt, Germany — [7]RIKEN APL, Japan

BASE is a multinational collaboration currently building an apparatus at the Antiproton Decelerator (AD) of CERN to make comparison measurements of antiproton and proton magnetic g-factors. Such comparisons are interesting because any measured asymmetry would hint at physics beyond the Standard Model.

The experiment consists of measuring the cyclotron and Larmor frequencies, ν_c and ν_L, of a single trapped (anti)proton, with the g-factor given by $2\nu_L/\nu_c$. Determination of ν_c is by measurement of the three motional eigenfrequencies in the *precision trap,* a Penning trap with highly homogeneous magnetic field. The measurement of ν_L requires tracing out the spin flip resonance curve which further requires a second Penning trap—the so-called *analysis trap*—to measure the spin state. These two Penning traps form the heart of the experiment. Additional subsystems include systems for trapping and storing antiprotons, cryogenics, and low-noise electronics. We will present an overview of the BASE project and the current status.

A 21.2 Tue 14:15 BEBEL SR140/142

The BASE Penning trap system — •Georg Ludwig Schneider[1,3], Christian Smorra[1], Kurt Alan Franke[1,2], Andreas Mooser[3], Hiroki Nagahama[1,4], Klaus Blaum[2], Yasuyuki Matsuda[4], Christian Ospelkaus[5], Wolfgang Quint[6], Jochen Walz[3], Yasunori Yamazaki[7], and Stefan Ulmer[1] — [1]RIKEN Ulmer IRU, Japan — [2]MPI-K Heidelberg, Germany — [3]University of Mainz, Germany — [4]Tokyo University, Japan — [5]University of Hannover, Germany — [6]GSI Darmstadt, Germany — [7]RIKEN APL, Japan

The Baryon Antibaryon Symmetry Experiment (BASE) at CERN aims to measure the g-factor of the antiproton with a precision of one part per billion. This will provide a stringent test of CPT symmetry with baryons.

A single antiproton stored in a cryogenic Penning trap system is used to perform this measurement. The g-factor will be determined by measuring the frequency ratio $\nu_\mathrm{L}/\nu_\mathrm{c}$, where ν_L is the spin precession frequency and ν_c the cyclotron frequency. To achieve this goal an advanced Penning trap system, consisting of four traps was developed. Analysis and precision trap are used to observe single spin flips and obtain the desired frequencies. Cooling and reservoir trap on the other hand allow efficient particle cooling and long-term storage of an antiproton reservoir.

The talk will give an overview on the design, characterization and implementation of this trapping system into the BASE apparatus.

A 21.3 Tue 14:30 BEBEL SR140/142

News from the Muonic Helium Lamb-Shift Experiment — •Marc Diepold and The CREMA Collaboration — Max-Planck-Institute of Quantum Optics, Garching

Our ongoing experiment located at Paul-Scherrer-Institute (Switzerland) recently succeeded to measure the $2S_{1/2} - 2P_{3/2}$ transition in the muonic Helium-4-ion, and will continue to measure the remaining $2S - 2P$ transitions in $\mu 4He^+$ and $\mu 3He^+$ later this summer.

Due to its sensitivity to finite size effects, the Lamb-shift in muonic atoms is an excellent tool to determine nuclear rms charge radii, important input parameters in both nuclear models and atomic theory.

With our result, we will be able to provide a ten times more accurate value for the absolute nuclear charge radius of the alpha particle, together with the respective 3He, 6He and 8He values that can be extracted via already measured isotope shifts.

Furthermore, our data sheds interesting new light on the so-called "proton size puzzle", created by the 7-sigma discrepancy between the muonic hydrogen value of the proton radius and other experiments.

A 21.4 Tue 14:45 BEBEL SR140/142

Charakterisierung des Penningfallen-Massenspektrometers PENTATRAP — •Alexander Rischka[1], Hendrik Bekker[1], Christine Böhm[1,2], José Crespo López-Urrutia[1], Andreas Dörr[1], Sergey Eliseev[1], Mikhail Goncharov[1], Yuri N. Novikov[3], Julia Repp[1], Christian Roux[1], Sven Sturm[1], and Klaus Blaum[1] — [1]Max-Planck-Institut für Kernphysik, 69117 Heidelberg, Germany — [2]ExtreMe Matter Institute EMMI, Helmholtz Gemeinschaft, 64291 Darmstadt, Germany — [3]Petersburg Nuclear Physics Institute, 188300 Gatchina, Russia

Das Hochpräzisions-Massenspektrometer PENTATRAP wird zurzeit am Max-Planck-Institut für Kernphysik in Betrieb genommen. Ziel des Experimentes ist es, Massenverhältnisse von mittel- bis hochgeladenen schweren Ionen mit einer relativen Genauigkeit von einigen 10^{-12} zu bestimmen. Dazu steht eine Anordnung von fünf zylindrischen Penningfallen zur Verfügung, die eine in-situ Korrektur der Hochpräzisionsmessungen sowie einen schnellen Ionentransport ermöglicht. Die hochgeladenen Ionen werden von einer DRESDEN-EBIT3 oder der Heidelberg-EBIT bereitgestellt. Geplant ist es Ende 2014 als erste Messung das Massenverhältnis von Re/Os zu messen. Diese Messung wird einen wichtigen Beitrag für Experimente zur Bestimmung der Neutrinomass leisten. Der Vortrag behandelt den aktuellen Stand von PENTATRAP, insbesondere die Charakterisierung des Fallenaufbaus.

A 21.5 Tue 15:00 BEBEL SR140/142

Long storage times for hyperpolarized 129Xe and precise measurement of its absolute polarization — •Maricel Repetto, Stefan Zimmer, Sergei Karpuk, Peter Blümler, and Werner Heil — Johannes Gutenberg Universität, Institut für Physik. Staudingerweg 7 55099, Mainz, Deutschland

Applications of hyperpolarized (HP) 129Xe in medical research and fundamental physics experiments increased significantly in recent years [1, 2]. All uses profit from high degrees of polarization (PXe) which not only needs to be generated but also preserved during transport and storage. PXe is usually determined via comparison of the NMR signals from HP Xe with the NMR signal of thermally polarized H2O or Xe [3]. All these procedures have experimental errors which are hard to eliminate [4]. We present a simple method for the measurement of absolute PXe which best resolution is 0.6 % together with wall storage times > 12 hs using a homebuilt, mobile Xe polarizer.

[1] S. Patz Eur. Jour. Of Rad. 64 (2007) 335-344. [2] K. Tullney Phys Rev. Let. 111, (2013) 100801. [3] G. Schrank. Xenon Polarizer Characterization and Biological Studies. 2009. (Page 27). [4] E.Wilms. Nuc. Ins. And Meth. in Phys Res. A 401 (1997) 491-498.

A 21.6 Tue 15:15 BEBEL SR140/142

Imaging of Relaxation Times and Microwave Field Strength in a Microfabricated Vapor Cell — •Andrew Horsley[1], Guan-Xiang Du[1], Matthieu Pellaton[2], Christoph Affolderbach[2], Gaetano Mileti[2], and Philipp Treutlein[1] — [1]Departement Physik, Universität Basel, Switzerland — [2]Laboratoire Temps-Fréquence, Institut de Physique, Université de Neuchâtel, Switzerland

We present a new characterisation technique for atomic vapor cells [1], combining time-domain measurements with absorption imaging to obtain spatially resolved information on decay times, atomic diffusion and coherent dynamics. The technique is used to characterise a 5 mm diameter, 2 mm thick microfabricated Rb vapor cell, with N_2 buffer gas, placed inside a microwave cavity. Time-domain Franzen and Ramsey measurements are used to produce high-resolution images of the population (T_1) and coherence (T_2) lifetimes in the cell, while Rabi measurements yield images of the σ_-, π and σ_+ components of the applied microwave magnetic field. We observe a 'skin' of reduced T_1 and T_2 times around the edge of the cell due to the depolarisation of Rb after collisions with the silicon cell walls. Our observations suggest that these collisions are far from being 100% depolarising. Our technique is useful for vapor cell characterisation in atomic clocks, atomic sensors, and quantum information experiments.

[1] A. Horsley et al., *Imaging of Relaxation Times and Microwave Field Strength in a Microfabricated Vapor Cell*, accepted to PRA. Arxiv: 1306.1387

A 21.7 Tue 15:30 BEBEL SR140/142

Spin effects and the Pauli principle in semiclassical electron dynamics — FRANK GROSSMANN[1], •MAX BUCHHOLZ[1], ELI POLLAK[2], and MATHIAS NEST[3] — [1]Institut für Theoretische Physik, Technische Universität Dresden, 01062 Dresden, Germany — [2]Chemical Physics Department, Weizmann Institute of Science, 76100, Rehovoth, Israel — [3]Theoretische Chemie, TU München, Lichtenbergstr. 4, 85747 Garching, Germany

We investigate the scattering of two electrons with different semiclassical methods, most importantly Heller's Thawed Gaussian Wavepacket Dynamics [1] and the Herman-Kluk propagator [2].

It has already been shown that fermionic dynamics can be treated semiclassically by including repulsive Pauli potentials or by using antisymmetric trial states [3]. In contrast, we only take initial states with the correct symmetry and unmodified potentials. Propagating either symmetrized or antisymmetrized initial state, we compare the time evolution of the distance between the electrons both from full quantum as well as from semiclassical calculations. The objective is to find out whether the Pauli principle is obeyed by the dynamics under these standard semiclassical propagators, i.e. the fact that two electrons with parallel spins must be in orthogonal states.

[1] E. J. Heller, J. Chem. Phys. 62, 1544 (1975)
[2] M. F. Herman and E. Kluk, Chem. Phys. 91, 27 (1984)
[3] H. Feldmeier, J. Schnack, Rev. Mod. Phys. 72, 655 (2000)