A 39: Precision spectroscopy of atoms and ions IV (with Q)

Time: Thursday 10:30–12:30 Location: BEBEL SR140/142

A 39.1 Thu 10:30 BEBEL SR140/142

Highly-sensitive image-current detection systems for BASE — •Christian Smorra[1], Kurt Alan Franke[1,2], Andreas Mooser[3], Hiroki Nagahama[1,4], Georg Ludwig Schneider[1,3], 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 BASE collaboration aims for a ppb measurement of the antiproton magnetic moment by using the so-called double Penning-trap technique. Key components for this measurement are superconducting single-particle image-current detection systems for the determination of the antiproton's motional eigenfrequencies. BASE focused on improving the state-of-the-art detection systems in order to achieve a better signal-to-noise ratio for the axial detection systems and shorter resistive cooling time constants for the cyclotron detectors. Benefits are a higher spin-state detection fidelity, shorter measurement times, faster cooling cycles and lower effective particle temperatures.

The talk gives an overview on the design and characterization of our recenty developed detection systems. Compared to previously used detectors, a factor of five higher signal-to-noise ratio was achieved and the cyclotron cooling times were significantly reduced.

A 39.2 Thu 10:45 BEBEL SR140/142

Kryogene Detektionselektronik für das ALPHATRAP Experiment — •Andreas Weigel[1,2], Marko Turkalj Oreskovic[1,2], Christian Roux[1], Robert Wolf[1], Sven Sturm[1] und Klaus Blaum[1,2] — [1]Max-Planck-Institut für Kernphysik, 69117 Heidelberg, Germany — [2]Fakultät für Physik, Universität Heidelberg, 69120 Heidelberg, Germany

Das ALPHATRAP-Projekt ist ein neues g-Faktor Penningfallenexperiment, das sich derzeit am Max-Planck-Institut für Kernphysik Heidelberg in der Aufbauphase befindet. Es ist der Nachfolger des Mainzer g-Faktor-Experiments, mit dem kürzlich der bisher empfindlichste Test der Quantenelektrodynamik an wasserstoffähnlichem ^{28}Si durchgeführt wurde. Ziel von ALPHATRAP sind g-Faktor-Messungen an den schwersten hochgeladenen Ionen, bis hin zu wasserstoffähnlichem Blei, bei einer gleichzeitig verbesserten Messgenauigkeit. Dies soll dazu beitragen, die Grenzen der Gültigkeit der QED gebundener Zustände noch weiter auszuloten.

Die Bestimmung des g-Faktors basiert auf der nichtdestruktiven Bestimmung des Quantenzustandes des Elektronenspins mittels des kontinuierlichen Stern-Gerlach Effektes in einer magnetischen Flasche. Dazu muss die Axialfrequenz des Ions über die Detektion von Spiegelströmen, die das Teilchen in den Fallenelektroden induziert, gemessen werden. Diese Ströme liegen typischerweise im Bereich von einigen fA, weshalb es einer sehr rauscharmen kryogenen Detektionselektronik bedarf. Design und Test der kryogenen Detektionselektronik werden vorgestellt.

A 39.3 Thu 11:00 BEBEL SR140/142

Development of cryogenic components for the ALPHATRAP experiment — •Marko Turkalj Oreskovic, Andreas Weigel, Christian Roux, Robert Wolf, Sven Sturm, and Klaus Blaum — Max-Planck-Institut für Kernphysik, Heidelberg

At the Max-Planck-Institute for Nuclear Physics, Heidelberg, a Penning trap experiment for the determination of the g-factor of the bound electron in heavy highly-charged ions is under construction.

ALPHATRAP will be connected to an EBIT via a room temperature beam-line. Since trapping of highly-charged ions requires extremely good vacuum, in excess of 10-15 mbar, the external flow of the background gas from the room-temperature beam-line has to be reduced significantly. Therefore, a cryogenic vacuum valve was developed, which enables adequate storage times. The valve can reduce the rest-gas pressure by a factor of at least 400, is manually actuated, and operates at cryogenic temperatures as well as in strong magnetic fields.

Furthermore, for the image-current detection electronics a cryogenic electromechanical switch and a variable capacitor are developed. Advantages compared to solid state devices are negligible leakage currents for the switch being in open position and negligible dielectric losses. The switch is designed as a single pole single throw switch and has a residual resistance of only 11 mOhm.

The designs and first test results of the devices will be presented.

A 39.4 Thu 11:15 BEBEL SR140/142

Systematic laser-spectroscopic investigations of the La spectrum — •Tobias Binder[1], Bettina Gamper[1], Jerzey Dembczynski[2], and Laurentius Windholz[1] — [1]Institut für Experimentalphysk, TU Graz, Petersgasse 16, A-8010 Graz, Österreich — [2]Chair of Quantum Engineering and Metrology, TU Poznan, Pl-60-965 Poznan, Polan

While performing laser excitation of transitions within the spectrum of Lanthanum atoms, we quite often realized that excitation is possible even at wavelengths for that no emission lines are known. Thus we made a continuous laser scan over a wide spectral range: from 5833 to 5650 Å. Within this region we found, using optogalvanic detection, several hundreds of transitions, most of them up to now unknown combinations between already known energy levels. Moreover, several lines could not be interpreted and did lead to the discovery of new, up to now unknown energy levels. In several cases we had to correct existing levels in their J-value. The final goal of the investigations is a semi-empirical interpretation of the La levels in order to find their designations and wave-function compositions.

A 39.5 Thu 11:30 BEBEL SR140/142

EUV spectroscopy of Re, Os, Ir, and Pt near the $4f-5s$ level crossing — •Hendrik Bekker[1], Oscar O. Versolato[2], Alexander Windberger[1], Ruben Schupp[1], Zoltan Harman[1], Natalya Oreshkina[1], Piet O. Schmidt[2,3], Joachim Ullrich[2], and José R. Crespo López-Urrutia[1] — [1]Max-Planck-Institut für Kernphysik — [2]Physikalisch-Technische Bundesanstalt — [3]Leibniz Universität Hannover

Understanding the electronic level structure of the $4f-5s$ crossing in highly charged ions is a challenging goal for both atomic theory and experiment. Complex electron correlations make calculations cumbersome, producing results with an accuracy which is not sufficient for unambiguous identification of the plethora of observed transitions. We employ an electron beam ion trap to prepare Re, Os, Ir, and Pt ions in charge states 13+ to 20+. Transitions in the extreme-ultra-violet (EUV) range are studied with a grating spectrometer. The first identification step is to determine the charge state to which the transitions belong. For that we apply two independent methods, yielding agreeing values. We then tentatively match observed transitions to atomic theory predictions. The results provide a benchmark for atomic theory in the area of highly correlated systems. A better understanding of the Ir^{17+} level structure is required for future laser spectroscopy studies of a possible variation of the fine-structure constant. Photon excitation measurements on the thus far observed transitions are planned at BESSY II.

A 39.6 Thu 11:45 BEBEL SR140/142

New even and odd energy levels of the La atom — Bettina Gamper[1], Tobias Binder[1], Feyza Güzelcimen[2], Gönül Basar[2], Sophie Kröger[3], and •Laurentius Windholz[1] — [1]Institut für Experimentalphysk, TU Graz, Petersgasse 16, A-8010 Graz, Österreich — [2]Istanbul University, Faculty of Science, Physics Department, Tr-34134 Vezneciler, Istanbul, Turkey — [3]Hochschule für Technik und Wissenschaft Berlin, Fachbereich 1, Wilhelminenhofstr. 75A, D-12459 Berlin, Deutschland

The investigation of structures in the optogalvanic spectrum of La, which can not be interpreted as transitions between known energy levels, may lead to the discovery of up to now unknown energy levels. Usually, the lowering of the fluorescence intensity of a strong La line marks the lower level of the excited transition, and the new upper level energy can be calculated using the centre of gravity excitation wave number. However, to be sure that the level really exists, some additional excitations from other known lower levels are necessary. Levels found in Graz, performing excitation in the wavelength range 690-560 nm, are confirmed in Istanbul by means of a Ti:Sa laser system (720-950 nm).

A 39.7 Thu 12:00 BEBEL SR140/142

Metallic Magnetic Calorimeters for High-Resolution X-ray Spectroscopy — •D. Hengstler[1], C. Schötz[1], M. Krantz[1], J. Geist[1], S. Kempf[1], L. Gastaldo[1], A. Fleischmann[1], C. Enss[1], R. Märtin[2], G. Weber[2], T. Gassner[2], and Th. Stöhlker[2] — [1]Kirchhoff-Institut, Uni Heidelberg — [2]Helmholtz-Institut, Jena

We are presently commissioning maXs, an 8x8 detector array of metallic magnetic calorimeters for high resolution X-ray spectroscopy. The detector is operated at T = 20 mK and is attached to the tip of a 400 mm long and 80 mm wide cold finger of a cryogen-free ^{3}He/^{4}He-dilution refrigerator. Metallic magnetic calorimeters are particle detectors that convert the energy of a single incoming photon into a temperature rise, leading to a change of magnetization in an attached paramagnetic temperature sensor that is inductively read out by a SQUID magnetometer. Three different arrays, maXs-20, maXs-30 and maXs-200, optimized for X-rays with energies up to 20, 30 and 200 keV respectively, will be available. The cryogenic platform will also allow to operate polar-maXs, a novel high resolution Compton polarimeter which comprises active low-Z Compton scatterer surrounded by a belt of about 60 maXs-type detector pixels with high stopping power. In the ongoing commissioning phase single channel maXs-20 detectors achieved an energy resolution of 1.6 eV (FWHM) for 6 keV photons, which is unsurpassed by any other micro-calorimeter. The combination with the fast signal rise-time, the large dynamic range and the excellent linearity up to tens of keV of photon energy, will make maXs to a powerful spectrometer for a number of challenging experiments.

A 39.8 Thu 12:15 BEBEL SR140/142

An absolute, high-precision ^{3}He / Cs combined magnetometer — •Hans-Christian Koch[1,2], Antoine Weis[1], and Werner Heil[2] — [1]Université de Fribourg, Département de Physique, Chemin du musée 3, 1700 Fribourg (Switzerland) — [2]Johannes Gutenberg Universität Mainz, Institut für Physik, Staudingerweg 7, 55128 Mainz (Germany)

Many experiments in fundamental science, such as the search for the neutron electric dipole moment (nEDM) at PSI, Switzerland, demand precise measurement and control of an applied magnetic field. Here, we report on a combined ^{3}He-Cs magnetometer for absolute measurement of a μT magnetic field with a precision of better than 10^{-6}. The measurement principle relies on detection of the precession frequency of polarized ^{3}He atoms by optically pumped double-resonance Mx-Cesium magnetometers. Measurements at the magnetically shielded room of PTB, Berlin, have been conducted to investigate the performance and intrinsic sensitivity of the combined device.