MS 5 Präzisions-MS kurzlebiger Nuklide 1

Zeit: Mittwoch 14:00–16:15 Raum: H1

Gruppenbericht

MS 5.1 Mi 14:00 H1

New atomic masses related to fundamental physics measured with SMILETRAP — •Szilard Nagy[1], Tomas Fritioff[1], Markus Suhonen[1], Andreas Solders[1], Ingmar Bergström[2], and Reinhold Schuch[1] — [1]AlbaNova University Center, Atomic Physics, S-106 91 Stockholm, Sweden — [2]Manne Siegbahn Laboratory (MSL),Frescativägen 24, S-104 05 Stockholm, Sweden

Some recent improvements of the SMILETRAP Penning trap mass spectrometer together with a number of interesting high precision mass measurements will be presented which are relevant to several of today's fundamental physics problems. The masses of the hydrogen- and lithium-like ^{40}Ca ions have been determined recently, these values being indispensable when evaluating g-factor measurements of the bound electron. The uncertainty in the mass was improved by one order of magnitude compared to available literature values. A new mass value for ^{7}Li has been obtained with an unprecedented relative uncertainty of $6.3{\times}10^{-10}$. A large deviation of 1.1 μu (160ppb) compared to the literature value has been observed. The mass difference between ^{3}He and ^{3}H is the Q-value of the tritium β-decay which is of importance in the search for a finite rest mass of the electron antineutrino. By adding an accurate measurement of the mass of ^{3}He^{1+} to previous mass measurements of ^{3}H^{1+} and ^{3}He^{2+}, we have improved our previous Q-value by a factor of 2. The current Q-value determined by Smiletrap mass measurements is the most accurate and more importantly, it is based on the correct atomic mass values.

MS 5.2 Mi 14:30 H1

High-accuracy mass measurements of short-lived nuclides with ISOLTRAP — •K. Blaum[1,2], S. Baruah[3], P. Delahaye[4], M. Dworschak[5], S. George[1,2], C. Guénaut[6], U. Hager[7], F. Herfurth[1], A. Herlert[4], A. Kellerbauer[4], H.-J. Kluge[1], M. Marie-Jeanne[4], S. Schwarz[8], L. Schweikhard[3], and C. Yazidjian[1,4] — [1]GSI, 64291 Darmstadt, Germany — [2]Inst. f. Physik, Universität Mainz, 55099 Mainz, Germany — [3]Inst. f. Physik, Universität Greifswald, 17487 Greifswald, Germany — [4]CERN, Physics Department, 1211 Geneva 23, Switzerland — [5]Physiaklisches Institut, Universität Würzburg, 97074 Würzburg Germany — [6]CSNSM-IN2P3-CNRS, 91405 Orsay-Campus, France — [7]University of Jyväskylä, Department of Physics, 40014 Jyväskylä, Finland — [8]NSCL, Michigan State University, East Lansing, MI 48824-1321, USA

The Penning trap mass spectrometer ISOLTRAP at ISOLDE/CERN is devoted to accurate mass measurements of short-lived nuclides. Recent mass measurements with a relative mass uncertainty in the order of 10^{-8} provide new data for tests of nuclear and astrophysical models. The results for the mass determination of neutron-rich Zn, Sn, and Cd isotopes will be presented. In addition, an overview of new technical developments at ISOLTRAP will be given. Examples are a new ion detector for higher detection efficiency as well as a temperature and pressure regulation for a minimization of magnetic field fluctuations.

MS 5.3 Mi 14:45 H1

Die Ramsey-Methode in der Präzisionsmassenspektrometrie mit Penning-Fallen — •Sebastian George[1,2], Klaus Blaum[1,2], Frank Herfurth[2], Alexander Herlert[3], Martin Kretzschmar[1], Stefan Schwarz[4], Lutz Schweikhard[5] und Chabouh Yazidjian[2,3] — [1]Institut für Physik, Johannes Gutenberg-Universität Mainz, 55099 Mainz, Germany — [2]GSI Darmstadt, 64291 Darmstadt, Germany — [3]Physics Department, CERN, 1211 Geneva 23, Switzerland — [4]NSCL, Michigan State University, East Lansing, MI 48824-1321, USA — [5]Institut für Physik der Ernst-Moritz-Arndt Universität Greifswald, 17487 Greifswald, Germany

Die Masse und die damit direkt verbundenen atomaren und nuklearen Bindungsenergien gehören zu den fundamentalen Eigenschaften eines Atoms bzw. Atomkerns. Mit Experimenten wie dem Penningfallen-Massenspektrometer ISOLTRAP an ISOLDE/CERN werden radioaktive Isotope mit Lebensdauern bis unter 1 s und relativen Massengenauigkeiten bis kleiner als 10^{-8} vermessen. Analog zur Magnetresonanzmethode wird die Breite der gemessenen Resonanzkurve verringert, wenn die Ionenanregung in der Penningfalle mit zeitlich getrennten hochfrequenten Feldern anstelle einer kontinuierlichen Anregung erfolgt. Hierbei konnte gezeigt werden, dass die Unsicherheit bei der Bestimmung der Resonanzfrequenz mittels der Ramsey-Methode um etwa einen Faktor vier reduziert werden kann. Sowohl die theoretische Beschreibung der Bahnbewegung der gespeicherten Ionen als auch die experimentellen Ergebnisse werden präsentiert.

MS 5.4 Mi 15:00 H1

Optimization of the cyclotron frequency determination forhigh-accuracy mass measurements on short-lived radionuclides — •Michael Dworschak[1], Klaus Blaum[2,3], Sebastian George[2,3], Alexander Herlert[4], and Chabouh Yazidjian[2,4] — [1]Bayerische Julius-Maximilians-Universität, 97070Würzburg, Germany — [2]GSI Darmstadt, 64291 Darmstadt,Germany — [3]Institut für Physik, JohannesGutenberg-Universität Mainz, 55099 Mainz, Germany — [4]Physics Department, CERN, 1211 Geneva 23, Switzerland

The mass is a fundamental property of a nuclide. Its measurement contributes to a variety of fundamental studies including tests of the Standard Model and the weak interaction. The limits of mass measurements of exotic nuclei have been extended considerably by improving and developing the Penning trap mass spectrometer ISOLTRAP at the ISOLDE facility at CERN. The mass resolving power of ISOLTRAP reaches 10^{7} and the uncertainty of the resulting mass values has been pushed down to $8\cdot10^{-9}$. The mass is determined by measuring the cyclotron frequency of the stored ion. To reduce the measurement uncertainty a number of improvements in ion detection and data taking have been developed. One of them is analyzing the weights of the individual frequency points of the resonance curve from which the cyclotron frequency is determined. By measuring only selected frequency points the uncertainty could be reduced by a factor of two. In addition, it was essential to implement a temperature stabilization system at the level of a few mK for the trap setup, in order to minimize magnetic field fluctuations.

MS 5.5 Mi 15:15 H1

Development of a valve at cryogenic temperatures for Penningtrap experiments — •Dennis Neidherr[1], Klaus Blaum[1,2], Rafael Ferrer[1], Frank Herfurth[2], Christine Weber[1,2], and the HITRAP collaboration[2] — [1]Institut für Physik , Johannes Gutenberg-UniversitätMainz, 55099 Mainz, Germany — [2]GSI Darmstadt, 64291 Darmstadt, Germany

The HITRAP facility will be the first setup that provides ions up to U^{92+} [1] at cryogenic temperatures. For this purpose the ions will be decelerated in several steps and at the end cooled down to a temperature of about 4 K in a separate Penning trap via resistive cooling. The vacuum in this cooler trap needs to be below 10^{-13} mbar to be able to store U^{92+} for at least 10 s. In order to separate the trap volume from the adjacent beam lines, valves have to be installed. Such a valve will be opened only to allow the passage of an ion bunch. Promising concepts are based on piezo driven motors or magnetically actuated ball valves [2]. These concepts and first results of prototype testing will be presented.

[1] F. Herfurth et al., AIP conference proceedings 793 (2005) 278 - 290
[2] P. Yesley, The Road to Antihydrogen, PhD thesis, Cambridge, October 2001

MS 5.6 Mi 15:30 H1

Non-destructive detection of image currents for high-accuracy mass measurements of short-lived nuclides — •Jens Ketelaer[1], Klaus Blaum[1,2], Michael Block[2], Rafael Ferrer[1], Stefan Stahl[3], Christine Weber[1,2], and the SHIPTRAP collaboration[2] — [1]Institut für Physik, Johannes Gutenberg-Universität Mainz, 55099 Mainz, Germany — [2]GSI Darmstadt, 64291 Darmstadt, Germany — [3]Stahl-Electronics, 67582 Mettenheim, Germany

To perform high-accuracy mass measurements on some rarely produced nuclides heavier than uranium, ions of the species will be stored in a Penning trap. While moving in the trap, the ions induce an image current e.g. in the segmented ring electrode. The frequency is directly related to the charge-to-mass ratio of the nuclide of interest.

For SHIPTRAP, a new cryogenic Penning trap setup has been built [1]. This consists of a cylindrical purification trap, a hyperbolically shaped measurement trap - both at 77 K - and a superconducting coil at 4 K.

The coil and parasitary capacitances form a resonance circuit, which has to match the frequency of the ion motion. This technique is needed to determine the weak image current induced by a singly charged ion.

First tests of the characteristics of the superconducting coil and the attached electronics will be done in an off-line setup, providing similar conditions as far as temperature and pressure are concerned. The current status will be presented.

[1] C. Weber et al., Eur. Phys. J. A 25, S01, 65 (2005)

MS 5.7 Mi 15:45 H1

Technical developments for a non-destructive ion detection — •Rafael Ferrer[1], Klaus Blaum[1,2], Michael Block[2], Jens Ketelär[1], H.-Jürgen Kluge[2], Stefan Stahl[3], Christine Weber[1,2], and the SHIPTRAP Collaboration[2] — [1]Institute of Physics, Johannes Gutenberg-University, D-55099 Mainz — [2]GSI, D-64291 Darmstadt — [3]Stahl-Electronics, D-67582 Mettenheim

Accurate Penning trap mass spectrometry on radionuclides was up to now only achieved with the destructive time-of-flight ion-cyclotron-resonance (ICR) method. This detection scheme is not applicable for exotic, transuranium nuclides with extremely low production rates, as investigated with the SHIPTRAP setup behind SHIP at GSI. A sensitive and non-destructive method, like the narrow-band Fourier Transform-ICR technique, is then ideally suited for the identification and characterization of these species. Therefore a cryogenic Penning trap setup has been built. It consists of a cylindrical trap for isobaric cleaning under presence of a helium buffer gas at a pressure of 10^{-4} mbar and a hyperbolical trap for the mass determination. In the SHIPTRAP setup both traps are placed 20 cm apart from each other. In order to guarantee the required vacuum conditions of better than 10^{-9} mbar for a coherent ion motion while transient recording, they have to be separated by a pumping barrier. An overview of the current status of the setup, as well as the results of differential pumping tests at temperatures of 300 K and 80 K will be presented.

MS 5.8 Mi 16:00 H1

MATS - Measurements with an Advanced Trapping System at the future GSI facility FAIR — •Frank Herfurth[1] and Klaus Blaum[1,2] — [1]GSI Darmstadt, Planckstraße 1, 64291 Darmstadt, — [2]Institut für Physik, Johannes

The mass and its inherent connection with the nuclear binding energy is one of the fundamental properties of a nuclide. Thus, precise mass values are important for a variety of applications, ranging from nuclear-structure studies like the investigation of shell closures and the onset of deformation, the verification of nuclear mass models and mass formulas, to tests of the weak interaction and of the Standard Model. The required relative accuracy ranges from 10^{-5} to below 10^{-8} for radionuclides, which most often have half-lives well below 1 s. Substantial progress in Penning trap mass spectrometry has made this method a prime choice for precision measurements on rare isotopes. The technique is well suited to provide high accuracy and sensitivity even for short-lived nuclides. Furthermore, ion traps offer advantages when used for precision decay studies. With MATS at FAIR we aim for applying both techniques to short-lived radionuclides: High-precision mass measurements and in-trap conversion electron and alpha spectroscopy. The experimental setup of MATS is a unique combination of an electron beam ion trap for charge breeding, ion traps for beam preparation, and a high precision Penning trap system for mass measurements and decay studies. MATS will be setup in the low energy branch of the super FRS, that makes thermalized products of fragmentation reactions available with high purity.