MS 3: Präzisionsmassenspektrometrie, Ionenfallen, FT-IZR-MS, Moleküle, Cluster III

Zeit: Montag 16:00–18:15 Raum: VMP 8 R05

Hauptvortrag MS 3.1 Mo 16:00 VMP 8 R05

Penning trap mass measurements on stable isotopes — •David Pinegar — Max-Planck Institut für Kernphysik, Heidelberg

Because single ions of long-lived nuclides can be observed indefinitely in Penning traps, there is no fundamental limit on the resolving power of Penning trap mass spectrometers. Instead, practical limitations observed on the accuracy of these experiments have included instabilities of the trap's magnetic field strength, the voltage source used to bias the ring electrode, and the frequency standard used for reference. This talk will review several different techniques used by several research groups to minimize these sources of uncertainty, allowing atomic mass ratios to be measured with uncertainties approaching, and sometimes even exceeding 1 part in 10^{11}. This precision is useful for mass measurements related to neutrino physics, such as neutrinoless double-beta decay. But due to the speaker's involvement, special emphasis will be given to work on the tritium/helium-3 mass ratio and its application to beta-spectrometer direct neutrino mass measurements.

MS 3.2 Mo 16:30 VMP 8 R05

Results from the commissioning of the double Penning trap system MLLTRAP[*] — •Veli Kolhinen, Eva Gartzke, Dietrich Habs, Jürgen Neumayr, Christian Schürmann, Jerzy Szerypo, and Peter Thirolf — Fakultät für Physik, LMU München and Maier-Leibnitz Laboratory, Am Coulombwall 1, 85748 Garching, Germany

A cylindrical double Penning trap [1] has been installed and successfully commissioned at the Maier-Leibnitz Laboratory (MLL) in Garching. This trap system has been designed to isobarically purify low energy ion beams and perform highly accurate mass measurements. Test measurements were performed by using an offline Rb surface ion source producing singly charged ^{85}Rb and ^{87}Rb ions. A mass resolving power of $139(2) \cdot 10^3$ has been reached with the purification trap for ^{85}Rb ions and a relative mass uncertainty of the order of $\delta m/m = 2.9 \cdot 10^{-8}$ with the measurement trap for ^{85}Rb ions by using ^{87}Rb as reference ions. This value does not yet include systematic uncertainties. Detailed studies of systematic uncertainties arising from magnetic field changes caused by short term temperature and pressure fluctuations in the experimental area and from the long term decay of the magnetic field strength have been performed and the result of the analysis will be presented. Mass measurements with offline actinide alpha recoil ion sources providing heavy radioactive species (e.g. ^{240}U) are in preparation.

[*] Supported by DFG under contract HA 1101/14-1 and by Maier-Leibnitz-Laboratory, Garching.

MS 3.3 Mo 16:45 VMP 8 R05

Parametrische Anregung von Ionen in einer ICR-Falle durch Axialisierung mit 2 Elektroden — •Franklin Martinez[1], Alexander Herlert[2], Gerrit Marx[1], Lutz Schweikhard[1] und Noelle Walsh[1] — [1]Institut für Physik, Ernst-Moritz-Arndt Universität, 17487 Greifswald, Deutschland — [2]Physics Department, CERN, 1211 Geneva 23, Switzerland

Die azimuthale Quadrupolanregung wird in der ICR-Massenspektrometrie vor allem in Kombination mit Puffergaskühlung verwendet, um eine Axialisierung der gespeicherten Ionen zu erreichen. Die herkömmliche Quadrupolanregung wird an 2 Paaren jeweils gegenüberliegender Ringsegmente mit entgegengesetzter Phase angelegt. Verwendet man aber zur Anregung nur ein Elektrodenpaar, so führen parametrische Resonanzeffekte bei den Frequenzen $2\nu_z$ und $\nu_p = \nu_+ - \nu_-$ unter bestimmten Umständen zu einem unbeabsichtigten Ionenverlust aus der Falle. Diese parametrischen Resonanzeffekte wurden theoretisch und experimentell untersucht. Durch eine einfache Vektordarstellung können die Multipol-Komponenten verschiedener radialer Anregungsschemata abgeleitet und somit parametrische Anteile schnell erkannt werden. Der Einfluß der Quadrupolanregung mit einer Phase konnte im Experiment am Beispiel der Axialisierung gespeicherter Clusterionen gezeigt werden.

MS 3.4 Mo 17:00 VMP 8 R05

The influence of magnetic field fluctuations on the mass uncertainty of SHIPTRAP — •Christian Droese[3], Dieter Ackkermann[2], Michael Block[1], Michael Dworschak[1], Sergey Eliseev[2], E. Haettner[4], Frank Herfurth[1], Fritz-Peter Hessberger[1], Sigurd Hofmann[1], Heinz-Jürgen Kluge[1,5], Gerrit Marx[3], M. Mazzocco[6], Yuri Novikov[1,7], W. Plass[4], Saidur Rahaman[8], Daniel Rodriguez[9], C. Scheidenberger[1,4], Lutz Schweikhard[3], Peter Thirolf[10], Gleb Vobrobyew[1,7], Christine Weber[8], Jens Ketelaer[11] und Jochen Ketter[11] — [1]GSI Helmholtzzentrum für Schwerionenforschung mbH, 64291 Darmstadt, Germany — [2]Max-Planck-Institut für Kernphysik, 69117 Heidelberg, Germany — [3]Institut für Physik, 17487 Greifswald, Germany — [4]II. Physikalisches Institut,Justus-Liebig-Universität, 35392 Gießen, Germany — [5]Ruprecht-Karls-Universität, 69120 Heidelberg, Germany — [6]University of Padova, 35122 Padova, Italy — [7]Petersburg Nuclear Physics Institute, 188300 Gatchina, St. Petersburg, Russia — [8]Department of Physics, University of Jyväskyä, 40014 Jyväskylä, Finland — [9]Universidad de Huelva, 21071 Huelva, Spain — [10]Fakultät für Physik, Ludwig-Maximilians-Universität München, 85748 Garching, Germany — [11]Institut für Physik, Johannes-Gutenberg-Universität, 55099 Mainz, Germany

Precise atomic mass measurements are essential for obtaining conclusive answers in several disciplines in physics. Particularly important are the values of masses of nuclides close to the limits of nuclear existence, commonly referred to as exotic nuclides. The masses contribute, for example, to a better understanding of astrophysical nucleosynthesis. SHIPTRAP is a high-precission mass measurement facility for heavy and superheavy ions produced in fusion-evaporation reactions at the velocity filter SHIP at GSI. The system consists of a buffer-gas cell to thermalise the incoming ions, an extraction system to separate the ions from the buffer gas, an RFQ buncher to cool and accumulate the ions and a tandem Penning-trap system for isobaric purification and high-precision mass measurements. With this setup absolut mass measurements with an uncertainty of about 10^{-8} are possible. For the detection of superheavy ions with low production rates in a penning trap system a magnetic field with lowest possible fluctuations is essential to minimize the systematical error of the results. These fluctuations can be effectively reduced by stabilizing the temperature and the pressure in the superconducting magnet. The implementation of such a system and its impact on the uncertainty for long term measurements will be presented.

MS 3.5 Mo 17:15 VMP 8 R05

Status of a non-destructive FT-ICR detection system for KATRIN — •Marta Ubieto Diaz[1], Klaus Blaum[1], Daniel Rodriguez[2], and Stefan Stahl[3] — [1]Max-Planck-Institute for Nuclear Physics, Heidelberg — [2]Universidad de Huelva - Avda. de las Fuerzas Armadas s/n 21071 Huelva — [3]Stahl Electronics. Kellerweg 23, 67528 Mettenheim

The KATRIN experiment has been designed to measure the mass of the electron antineutrino directly with a sensitivity of 0.2 eV, one order of magnitude better than the present upper limit. The intended sensitivity will be obtained by analyzing the end-point of the β spectrum from the decay of tritium gas molecules $T_2 \rightarrow (^3HeT)^+ + e^- + \bar{\nu}_e$. The KATRIN setup comprises a gaseous tritium source, a transport section, a pre-spectrometer, the main spectrometer and the detector. In the main spectrometer the electrons from the decay are guided by a strong magnetic field and analyzed using electrostatic fields. The tritium gas is removed from the system by differential pumping and cryogenic trapping. The formation of ion clusters $(T_{2n+1})^+$ which decay with different end-points than T_2, will prevent unambiguous analysis of the end-point of the tritium decay. Therefore, the knowledge of the concentrations of these ions is essential to evaluate the β spectrum. The best way for a precise determination of these concentrations is the use of Penning traps with FT-ICR detection systems. These Penning trap systems will be located in the transport section. A prototype is currently under commissioning at the Max-Planck Institute for Nuclear Physics in Heidelberg. The status and results will be presented.

MS 3.6 Mo 17:30 VMP 8 R05

Cryogenic trapping of keV ion beams at the CSR prototype — •Sebastian Menk[1], Klaus Blaum[1], Michael Froese[1], Manfred Grieser[1], Oded Heber[2], Michael Lange[1], Dimitry Orlov[1], Thomas Sieber[1], Michael Rappaport[2], Robert von Hahn[1], Jozef Varju[1], Andreas Wolf[1], and Daniel Zajfman[2] — [1]Max-Planck-

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A Cryogenic Trap for Fast ion beams (CTF) was built to explore cooling techniques and test thermal decoupling of ion optics for the development of the electrostatic Cryogenic Storage Ring (CSR). These challenging projects will lead to a new experimental field of atomic and molecular physics with keV ion beams. The cold conditions of 2-10 K minimize the blackbody radiation field and are expected to lead to extremely low restgas densities (equivalent pressure at room temperature $\approx 10^{-13}$ mbar) which result in long storage lifetimes and for molecular ions to radiative cooling to their ro-vibrational ground states.
The CTF consists of two stacks of electrostatic mirror electrodes allowing the storage of up to 20 keV ion beams. Cryogenic ion beam storage has been realized with this device using a liquid helium refrigeration system to cool down the experimental trapping area to few-Kelvin cryogenic temperatures and experiments with cryogenically trapped molecular nitrogen ions have been performed to verify the low vacuum conditions by measuring their storage lifetimes.

MS 3.7 Mo 17:45 VMP 8 R05

Intense electron pulses for HITRAP from a robust GaAs photocathode using UV pulse irradiation — •Claude Krantz[1], Dmitry A. Orlov[1], Andreas Wolf[1], Giancarlo Maero[2], Frank Herfurth[2], and Wolfgang Quint[2] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg — [2]Gesellschaft für Schwerionenforschung, Planckstraße 1, 64291 Darmstadt

The HITRAP facility includes a multiring Penning trap to store decelerated highly charged ions (HCI) from the GSI accelerator complex at temperatures of 4 K. The trap will simultaneously store 10^5 HCI of initial kinetic energies of 6 keV/u and 10^9 cold electrons of temperature $k_B T = 10$ eV, achieving electron cooling of the ions through Coulomb scattering with the electrons and subsequent synchrotron radiation of the latter. Electrons need to be produced in pulses of around 100 ns in order to efficiently fill the cooler trap. For this purpose a photoelectron gun has been developed at the Max-Planck-Institute of Nuclear Physics (MPIK) based on a GaAs-photocathode. Following experience gathered at the MPIK in the operation of such photocathodes, the electron gun will be operated in reflection mode using a pulsed UV light source. Test measurements performed at the MPIK show that in this regime the quantum efficiency of the photocathode can be expected to be stable and robust against many vacuum degradations at a value $> 10^{-3}$, which, by itself, would permit single-shot filling of the cooler trap. Commissionning will allow to determine an optimal trap-filling procedure.

MS 3.8 Mo 18:00 VMP 8 R05

Cryogenic hydrogen ions and chemical probing spectroscopy in rf ion cages — •Max H. Berg[1], Annemieke Petrignani[1], Dennis Bing[1], Holger Kreckel[2], and Andreas Wolf[1] — [1]Max-Planck Institut fuer Kernphysik, Heidelberg D-69117 — [2]Columbia University, New York, NY 10027, USA

Radio frequency ion cages in the 22-pole geometry are well established tools for confining molecular ions in an almost field-free space, providing distinctly lower ion micromotion than standard Paul traps. We are applying these devices for the cryogenic cooling of H_3^+ ions by He buffer gas down to the lowest rotational levels. H_3^+ plays an important role in astrophysical and technical hydrogen plasmas, and is also a benchmark for quantum mechanical calculations of rovibrational energy levels of polyatomic molecules. For rovibrational spectroscopy, the conventional absorption method is a cumbersome approach as densities are low and H_3^+ rovibrational transitions are weak. A much more efficient detection method adapted to the cold multipole traps is to probe photon absorption by laser induced chemical reactions. The reaction products are detected via a mass spectrometer with near unity efficiency. This method revealed in the latest measurements the weakest H_3^+ rovibrational transitions observed to date, accessing vibrational levels more than 1.6 eV above the ground state.