MS 4: Precision Mass Spectrometry and Fundamental Applications

Time: Tuesday 10:30–12:30 Location: GÖR 229

Invited Talk MS 4.1 Tue 10:30 GÖR 229

On the interconversion of an ion's motional modes in a Penning trap by quadrupolar and octupolar rf-fields — •Martin Kretzschmar — Institut für Physik, Johannes Gutenberg-Universität, 55099 Mainz, Germany

Penning trap mass spectrometry rests on the precise determination of an ion's cyclotron frequency. Part of the measurement procedure is the resonant conversion of magnetron motion into cyclotron motion by means of external quadrupolar or octupolar rf-fields.

I shall discuss the interconversion of the motional modes in a quantum mechanical formulation in conjunction with the rotating wave approximation. This permits the identification of the effective interactions responsible for the conversion process. The concept of the Bloch vector is introduced and applied to the conversion process to derive the excitation curve at the exact resonance frequency, and the conversion profile as a function of detuning.

The main emphasis shall be on novel results relating to the conversion by octupolar rf-fields with a frequency equal to twice the cyclotron frequency. Analytical solutions for the Bloch vector in terms of Jacobi elliptical functions shall be presented, the dependence of excitation curves and conversion profiles on the initial phases and amplitudes of the ion motional modes and of the octupolar field shall be discussed. The most remarkable feature of octupolar excitation is the extreme narrowness of the resonant conversion profiles, promising the possibility of very high mass resolution in future experiments. The theoretical results shall be compared to existent experimental data.

Invited Talk MS 4.2 Tue 11:00 GÖR 229

High-precision Penning trap mass spectrometry for neutrino physics — •sergey eliseev[1], christine böhm[1,2], klaus blaum[1,2], andreas dörr[2], mikhail goncharov[1], yuri novikov[3], julia repp[1,2], and christian roux[1,2] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany — [2]Physikalisches Institut, Ruprecht-Karls-Universität, 69120 Heidelberg, Germany — [3]PNPI, Gatchina, 188300 St. Petersburg, Russia

The discovery of neutrino oscillations has proven neutrinos are massive particles. However, this does not provide information on the type of the neutrino and its mass. An answer to these questions lies in a study of beta transitions, i.e., β^-, double β^-, EC and double EC decays. A crucial parameter in this study is the Q-value of the beta transitions, which has to be measured with an accuracy of 100 eV in the case of the determination of the neutrino type to better than 1 eV if the neutrino mass is concerned.

Tremendous progress in Penning traps finally allowed such high precision Q-value measurements. JYFLTRAP/Finland and SHIPTRAP/Germany, e.g., contribute to the search for neutrinoless double β transitions. In the sector of experiments for a determination of the neutrino mass two Penning trap mass spectrometers are being developed at Max-Planck Institut für Kernphysik/Germany. *THe*-TRAP is devoted to a measurement of the Q-value of Tritium beta decay for the KATRIN experiment, whereas PENTATRAP aims for a measurement of the Q-values of EC in ^{163}Ho and of β^--decay of ^{187}Re with accuracies of much below 10^{-11}.

MS 4.3 Tue 11:30 GÖR 229

Ionenerzeugung und -transport von ^{3}H und ^{3}He zur präzisen Massenbestimmung in THe-Trap — •Marius Tremer[1], Christoph Diehl[1], Martin Höcker[1], Jochen Ketter[1], David B. Pinegar[1], Sebastian Streubel[1], Robert S. Van Dyck Jr.[2] und Klaus Blaum[1] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Deutschland — [2]Department of Physics, University of Washington, Seattle, WA 98195-1560, USA

Das Massenspektrometer THe-Trap wurde zur Bestimmung des Q-Werts vom ^{3}H zu ^{3}He β-Zerfall mit einem Doppel-Penningfallensystem ausgestattet. Es ist gegenüber seinem Vorgängerexperiment unter anderem mit einer externen Ionenquelle, einer kompakten Penningionenquelle, ausgerüstet. Die Vorteile sind keine thermische Einflüsse und eine geringere Kontamination der Fallen mit Tritium. Zudem können weitere in der Ionenquelle ionisierbare Nuklide untersucht werden. Gefordert sind dabei ein fokussierter Ionenstrahl mit einstellbarer Energie und ein hoher Ionisationsgrad bei geringen Gasmengen, um die Gasdiffusion in die kryogenen Fallen zu minimieren. Diese Eigenschaften sollen in einem separaten Aufbau getestet und verbessert werden.

Zusätzlich zu den beiden Präzisions-Penningfallen von THe-Trap wurde eine weitere Penningfalle zum Ioneneinfang, bestehend aus einer Driftröhre als Ringelektrode und zwei Endkappen, in den Aufbau integriert. Die Ein- und Ausschusssequenz sowie eine Speicherung der in der Ionenquelle erzeugten Ionen soll mit Hilfe eines Nachbaus in einem 4,7 T starken Magnetfeld optimiert werden.

MS 4.4 Tue 11:45 GÖR 229

Minimization of environmental influences for precision mass measurements in THe-Trap — •Sebastian Streubel[1], Christoph Diehl[1], Martin Höcker[1], Jochen Ketter[1], David B. Pinegar[1], Marius Tremer[1], Robert S. Van Dyck Jr.[2], and Klaus Blaum[1] — [1]Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany — [2]Department of Physics, University of Washington, Seattle, WA 98195-1560, USA

THe-Trap is a double-Penning trap mass spectrometer dedicated to measure the mass ratio of ^{3}H to ^{3}He with an uncertainty of 10^{-11} and below. This would allow an independent measurement of the tritium Q-value, which is of relevance for the determination of the electron antineutrino mass by the KArlsruhe TRItium Neutrino Experiment (KATRIN). A control of the environmental influences is important to achieve the desired precision. Due to a temperature dependent magnetic susceptibility of the surrounding materials, the pressure and the level of the liquid helium around the traps are stabilized. With the same purpose the ambient temperature in the room is regulated. A pair of Helmholtz coils is used to minimize external fluctuations of the geomagnetic field. The remaining field fluctuation will be measured by a stored single C^{4+} Ion.

The stabilization systems as well as their performances will be presented.

MS 4.5 Tue 12:00 GÖR 229

A radiofrequency quadrupole system for mass separation and ion bunching at SHIPTRAP — •Emma Haettner[1,2], Wolfgang Plass[1,2], Samuel Ayet[1,2], Ulrich Czok[1], Timo Dickel[1,2], Hans Geissel[1,2], Wadim Kinsel[1], Felix Lautenschlaeger[1], Martin Petrick[1], Christoph Scheidenberger[1,2], Thorsten Schaefer[2], and Josephina Werner[1] — [1]II. Physikalisches Institut, Gießen — [2]GSI, Darmstadt

At SHIPTRAP, very proton-rich exotic nuclei are produced and separated from the primary beam in the velocity filter SHIP, stopped in a gas cell, bunched and transferred to a double Penning trap system. A radio-frequency quadrupole (RFQ) system consisting of a RFQ cooler, RFQ mass filter and RFQ buncher has been developed in order to remove contaminant ions and abundant reaction products other than nuclei of interest, which so far limits the performance of SHIPTRAP. The newly developed system will also allow for quick identification of the ions produced.

Operation parameters of the system have been optimized and the performance has been investigated. The cooler mass filter combination shows full transmission up to a mass resolving power of about 200 (FWHM) and suppression of neigboring masses over at least four orders of magnitude. Studies of the RFQ buncher show that peak widths of the extracted ion bunches of about 50 ns can be reached while maintaining full energy acceptance of the Penning trap. Using the detectors installed at SHIPTRAP this would allow for broadband time-of-flight mass spectrometry with a resolution of about 300.

MS 4.6 Tue 12:15 GÖR 229

Online coupling and beam preparation for the TRIGA-SPEC experiment — •Thomas Beyer[1,2], Klaus Blaum[1,2], Martin Eibach[1,3], Nadja Frömmgen[3], Christopher Geppert[3,5], Alexey Gonschior[3], Jens Ketelaer[2], Jörg Krämer[3], Szilard Nagy[2,5], Dennis Neidherr[2], Wilfried Nörtershäuser[3,5], Dennis Renisch[2,4], Christian Smorra[1,3], and the Triga-Spec Collaboration[2,4,5,6] — [1]Physikalisches Institut, Universität Heidelberg, 69120 Heidelberg — [2]Max-Planck-Institut für Kernphysik, 69117 Heidelberg — [3]Institut für Kernchemie, Universität Mainz, 55128 Mainz — [4]Institut für Physik, Universität Mainz, 55128 Mainz — [5]GSI Helmholtzzentrum für Schwerionenforschung GmbH, 64291 Darmstadt — [6]CSNSM, Université de Paris Sud, 91495 Orsay, France

Precise experimental data of the ground-state properties of short-lived nuclides are required to test the predictive power of nuclear mass models and to support nucleosythesis calculations of the astrophysical r-process. Besides the measurement of these properties with high precision, the creation and preparation of the nuclides of interest is one of the biggest challenges in this field of physics. For the TRIGA-SPEC experiment located at the TRIGA reactor in Mainz, nuclides of the neutron-rich side of the nuclear chart can be created by neutron-induced fission of an actinoide target inside the reactor. The online coupling is going to be realized with an aerosol-loaded gas-jet system, an ion source, a separator magnet, and an RFQ quadrupole for ion beam cooling and bunching. An overview of the online coupling and the ion beam preparation will be presented.