Symposium 100 Years of Mass Spectrometry (SYMS)

jointly organized by
the Mass Spectrometry Division (MS),
the Atomic Physics Division (A), and
the Molecular Physics Division (MO)

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Overview of Invited Talks and Sessions

(lecture room E 415)

Invited Talks

SYMS 1.1	Fri	11:00–11:30	E 415	**MS for environmental and radiochemical applications** — •Clemens Walther
SYMS 1.2	Fri	11:30–12:00	E 415	**Modern nuclear mass models** — •Stephane Goriely
SYMS 1.3	Fri	12:00–12:30	E 415	**High-accuracy mass measurements for nuclear astrophysics** — •Susanne Kreim
SYMS 1.4	Fri	12:30–13:00	E 415	**Storage ring mass and lifetime measurements** — •Fritz Bosch
SYMS 2.1	Fri	14:00–14:30	E 415	**Search for resonant double-electron capture** — •Sergey Eliseev, Klaus Blaum, Michael Block, Christian Droese, Dmitriy Nesterenko, Yuri Novikov, Enrique Minaya Ramirez, Christian Roux, Lutz Schweikhard, Kay Zuber
SYMS 2.2	Fri	14:30–15:00	E 415	**Towards accurate T-3He Q-value** — •Tommi Eronen, Martin Höcker, Jochen Ketter, Sebastian Streubel, Robert S. Van Dyck, Klaus Blaum
SYMS 2.3	Fri	15:00–15:30	E 415	**The Avogadro constant and a new definition of the kilogram** — •Peter Becker
SYMS 2.4	Fri	15:30–16:00	E 415	**Dating human DNA with the 14C bomb peak** — •Walter Kutschera, Jakob Liebl, Peter Steier
SYMS 2.5	Fri	16:00–16:30	E 415	**Resonance ionization mass spectrometry** — •Klaus Wendt

Sessions

SYMS 1.1–1.4	Fri	11:00–13:00	E 415	**100 Years of Mass Spectrometry 1**
SYMS 2.1–2.5	Fri	14:00–16:30	E 415	**100 Years of Mass Spectrometry 2**

SYMS 1: 100 Years of Mass Spectrometry 1

Time: Friday 11:00–13:00 Location: E 415

Invited Talk SYMS 1.1 Fri 11:00 E 415

MS for environmental and radiochemical applications — •Clemens Walther — Institut für Radioökologie und Strahlenschutz, Leibniz Universität Hannover Herrenhäuser Str. 2, 30419 Hannover

MS is applied frequently for investigating environmental questions, making use of the techniques' superior sensitivity and selectivity. A particular interesting field is the detection and speciation of radionuclides. The talk will revisit historical developments and will give an overview of recent applications for both, chemical speciation of radionuclides and trace detection in the environment.

Invited Talk SYMS 1.2 Fri 11:30 E 415

Modern nuclear mass models — •Stephane Goriely — Institut d'Astronomie et d'Astrophysique, Université Libre de Bruxelles, CP226, 1050 Brussels, Belgium

The nuclear mass remains a property of fundamental importance not only for various aspects of nuclear physics, but also for some physics applications, such as nuclear astrophysics. We review the various mass models that have been developed in recent years and critically compare their predictions of experimentally known nuclear structure properties as well as their extrapolation towards the exotic neutron-rich nuclei. Special attention is devoted to recent microscopic mass models based on the mean-field Hartree-Fock-Bogolyuobov method with effective nucleon-nucleon interactions.

Invited Talk SYMS 1.3 Fri 12:00 E 415

High-accuracy mass measurements for nuclear astrophysics — •Susanne Kreim — CERN, Genf, Schweiz — Max-Planck- Institut für Kernphysik, Heidelberg, Deutschland

The mass of a nucleus delivers the binding energy giving insight into structural effects throughout the nuclear chart from the lightest to the heaviest element. Precision measurements of masses far away from the valley of stability are also important to understand nuclear stability. Both notions are crucial for a correct description of astrophysical processes.

The so-called rapid neutron-capture process (r-process) of stellar nucleosynthesis is held responsible for the production of the heavy elements. However, the astrophysical site for a successful r-process has not been identified yet. A possible theory, alternative to the supernova-induced r-process, is the decompression of neutron-star matter by its merger with another neutron star. In the neutron-star crust, exotic rare isotopes become so-called equilibrium nuclei and can contribute to the elemental abundance. Another mechanism of stellar nucleosynthesis is the rp-process, rapid proton-capture process, which takes place on the proton-rich side of the valley of stability and originates in x-ray bursts.

Precise mass values are input parameters that constrain the models for the stellar creation of elements. Whenever masses are not (yet) available, one has to rely on mass models for the nuclei participating in astrophysical processes. New masses offer the required test bench for the predictive power of models. In this contribution, recently performed mass measurements as well as still desired ones will be discussed.

Invited Talk SYMS 1.4 Fri 12:30 E 415

Storage ring mass and lifetime measurements — •Fritz Bosch — GSI Helmholtzzentrum, Darmstadt, Germany

The Experimental Storage Ring ESR provided the first opportunity for addressing precision masurements of masses and beta-decay characteristics of stored and cooled unstable highly-charged ions. This talk will focus on the first observations of the orbital electron-capture decay of H-like and He-like ions in well-defined quantum states. The ESR is for this purpose a unique tool, since the only, but unambiguous signature for these two-body decays is a sudden tiny jump of the revolution frequency. If only a few parent ions are injected and subsequently cooled, this extremely small change of the revolution frequency can be observed and clearly resolved. The first results of this "single-ion decay spectroscopy" will be reported and discussed.

SYMS 2: 100 Years of Mass Spectrometry 2

Time: Friday 14:00–16:30 Location: E 415

Invited Talk SYMS 2.1 Fri 14:00 E 415

Search for resonant double-electron capture — •Sergey Eliseev[1], Klaus Blaum[1], Michael Block[2], Christian Droese[3], Dmitriy Nesterenko[4], Yuri Novikov[4], Enrique Minaya Ramirez[2], Christian Roux[1], Lutz Schweikhard[3], and Kay Zuber[5] — [1]Max-Planck-Institut für Kernphysik, Heidelberg, Germany — [2]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany — [3]Institut für Physik, Ernst-Moritz-Arndt-Universität, Greifswald, Germany — [4]PNPI, St. Petersburg, Russia — [5]Institut für Kern- und Teilchenphysik, Technische Universität, Dresden, Germany

It is still unknown whether neutrinos are Dirac or Majorana particles. An answer to this question can be obtained from neutrinoless double-electron capture. An observation of this process would prove that the neutrino is a Majorana particle. A measurement of the half-life of this process would allow a determination of the effective Majorana neutrino mass.
In the search for the nuclide with the largest probability for neutrinoless double-electron capture, we have determined the Q-values of several potentially suitable nuclides with SHIPTRAP by Penning-trap mass-ratio measurements. The ECEC-transition in ^{152}Gd has been determined to have the smallest half-life of 10^{26} years for a 1 eV neutrino mass among all known 0νECEC-transitions, which makes ^{152}Gd the most promising candidate for the search for neutrino-less double electron capture. This contribution will summarize the recent experimental results.

Invited Talk SYMS 2.2 Fri 14:30 E 415

Towards accurate T-3He Q-value — •Tommi Eronen[1], Martin Höcker[1], Jochen Ketter[1], Sebastian Streubel[1], Robert S. Van Dyck[2], and Klaus Blaum[1] — [1]Max-Planck Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg — [2]Department of Physics, University of Washington, Seattle, WA 98195-1560, USA

Great efforts have been put forward to determine the neutrino mass from tritium β decay. The most prominent experimental setup, KATRIN [1], is expected to deliver an upper limit to the neutrino mass that is one order of magnitude more stringent than the current value by measuring the endpoint and the shape of the β spectrum of the tritium decay.

The endpoint energy (assuming zero neutrino mass) can also be deduced from the Q-value of the decay by measuring the mass difference of tritium and the daughter ^{3}He using high-resolution mass spectrometry. Such a measurement would give an excellent, independent calibration point for the KATRIN experiment to deduce its systematics.

Our mass-difference measurement utilizes the **T**ritium-**He**lium double Penning trap (THe-Trap) setup [2]. Based on the anharmonic cyclotron frequency determination method pioneered at the University of Washington, Seattle, precision at the level of 1 part in 10^{11} in the T/^{3}He mass ratio is expected. In this contribution, I will describe the motivation, the principle, current status, and expectations of the experiment.

[1] Wolf J., Nucl. Instr. Meth., Sect. A **623**, 442 (2010).
[2] Diehl C. *et al.*, Hyperfine Interact. **199**, 291 (2011).

Invited Talk SYMS 2.3 Fri 15:00 E 415

The Avogadro constant and a new definition of the kilogram — •Peter Becker — PTB, Bundesallee 100, 38116 Braunschweig

The Avogadro constant, the number of entities in the amount of substance of one mole, links the atomic and the macroscopic properties of matter. Since the molar Planck constant is very well known via

the measurement of the Rydberg constant, the Avogadro constant is also closely related to the Planck constant. In addition, its accurate determination is of paramount importance for a new definition of the kilogram in terms of a fundamental constant. The talk describes a new and unique approach for the determination of the Avogadro constant by *counting* the atoms in 1 kg single-crystal spheres, which are highly enriched with the 28Si isotope. This approach has enabled us to apply isotope dilution mass spectroscopy to determine the molar mass of the silicon crystal with unprecedented accuracy. The value obtained, NA = 6.022 140 84(18) x 1023 mol-1, is now the most accurate input datum for a new definition of the kilogram.

Invited Talk SYMS 2.4 Fri 15:30 E 415

Dating human DNA with the 14C bomb peak — •Walter Kutschera, Jakob Liebl, and Peter Steier — VERA Laboratory, University of Vienna, Vienna, Austria

In 1963 the limited nuclear test ban treaty stopped nuclear weapons testing in the atmosphere. By then the addition from bomb-produced 14C had doubled the 14C content of the atmosphere. Through the CO2 cycle this excess exchanged with the hydrosphere and biosphere leading to a rapidly decreasing 14C level in the atmosphere. Today we are almost back to the pre-nuclear level. As a consequence all people on Earth who lived during the second half of the 20th century were exposed to this rapidly changing 14C signal.

A few years ago, a group at the Department of Cell and Molecular Biology of the Karolinska Institute in Stockholm started to use the 14C bomb peak signal in DNA to determine retrospectively the age of cells from various parts of the human body (brain, heart, fat). In a collaboration with this group, we have studied the age of olfactory bulb neurons in the human brain. For this investigation, 14C AMS measurements were developed at VERA for very small carbon samples in the range from 2 to 4 micrograms.

In the presentation the general concept of 14C bomb peak dating of human DNA and several applications will be discussed.

Invited Talk SYMS 2.5 Fri 16:00 E 415

Resonance ionization mass spectrometry — •Klaus Wendt — Institut für Physik, Johannes Gutenberg-Universität Mainz

The second key issue of elemental mass spectrometry - apart from its overall sensitivity - is the achievable selectivity in respect to any kind of contamination within the sample or ion beam, which defines the significance of results. While the suppression of neighbouring masses is usually high and primarily governed by the resolution of the mass spectrometer in use, isobaric interferences cause the dominant limitation for conventional mass spectrometers.

The implementation of element-specific ion sources which employ resonant excitation processes and subsequent ionization by powerful and properly tuned laser light, has drastically altered this situation. Resonance ionization mass spectrometry adds optical selectivities of many orders of magnitude in respect to isobars and even isotopes of the same element within such a laser ion source to the performance of a well adapted mass spectrometer. Applications focus on the selective production of radioactive ion beams of exotic species at on-line facilities as well as the ultra trace analysis of radioisotopes at lowest concentration levels. The presentation gives an overview of the state of the art of this challenging technique.