MS 2: New Methods, Applications, Storage Rings

Time: Monday 17:00–19:15 Location: HS 3042

Invited Talk MS 2.1 Mon 17:00 HS 3042

Measurement of the bound-state beta decay of $^{205}Tl^{81+}$ ions at heavy-ion storage ring — •Ruijiu Chen[1], Jan Glorius[1], Guy Leckenby[2], Yury A Litvinov[1], Maria Lugaro[4], Riccardo Mancino[1], Mohammad Shahab Sanjari[1], Ragandeep Singh Sidhu[1], and Balazs Szanyi[3] for the E121 collaboration-Collaboration — [1]GSI, Germany — [2]TRIUMF, Canada — [3]University of Szeged, Hungary — [4]Konkoly Observatory, Hungary

Heavy-Ion storage rings offer unparalleled capabilities for the measurement of the radioactive decay of highly charged ions. In this talk, we report on the recent results from the first direct measurement of the bound-state beta decay of bare $^{205}Tl^{81+}$ ions. The experiment was performed in March-April 2020 by employing the unique accelerator facility at GSI. The measurement is associated with two major physics motivations. One is linked with the LOREX project (acronym of LO-Randite EXperiment) wherein the measurement is needed to determine the matrix element for the pp neutrino capture by the ground state of ^{205}Tl to the 2.3 keV excited state in ^{205}Pb. This capture reaction has by far the lowest threshold ($E_{\nu_e} > 53$ keV) and is only experiment capable of extending the neutrino flux to lower energies. The second physics case is associated with the ^{205}Pb/^{205}Tl pair as a s-process cosmochronometer. In stellar plasmas, ^{205}Tl can exist in ionized form and β_b decay to the first excited state of ^{205}Pb can counter-balance the reduction of ^{205}Pb ions due to electron capture process. The measurement is crucial for predicting the ^{205}Pb expected in meteorites in the early solar system.

MS 2.2 Mon 17:30 HS 3042

Developments for the ion supply of the Heidelberg Cryogenic Storage Ring — •Felix Nuesslein[1], Klaus Blaum[1], Manfred Grieser[1], Florian Grussie[1], Thomas Kolling[2], Holger Kreckel[1], Preeti M Mishra[1], Gereon Niedner-Schatteburg[2], Oldřich Novotný[1], Viviane C Schmidt[1], and Andreas Wolf[1] — [1]Max-Planck-Institut für Kernphysik, 69117 Heidelberg, Germany — [2]Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany

The Cryogenic Storage Ring [1] provides optimal conditions for exploring interactions of charged atoms and molecules with photons, electrons, or neutrals in a radiatively cold environment. Its fully electrostatic design enables mass-independent storage of ions with kinetic energies up to 300 keV per elementary charge. The 300 kV ion source platform, one of two dedicated setups for these ions, branches into magnetic and electrostatic sections. The magnetic branch yields mass-selected continuous beams of atomic and small molecular ions with nA to μA currents, while the electrostatic branch focuses on more complex systems like clusters or biomolecules. Its ion optics can transport pulsed and continuous ion beams from up to four stationary sources, and its diagnostic elements are sensitive to μA ion currents down to single particles. In its initial development stage, the electrostatic branch will host a pulsed Laser VAPorization (LVAP) ion source for cluster ion production. We present commissioning results and the first mass spectra from the recently commissioned LVAP ion source.

[1] R. von Hahn et al., Rev. Sci. Instrum. 87 (2016) 063115.

MS 2.3 Mon 17:45 HS 3042

First experiments with the CSR-ReMi, the Reaction Microscope inside the cryogenic ion storage-ring CSR — •Felix Herrmann, Weiyu Zhang, David V. Chicharro, Florian Trost, Klaus Blaum, Manfred Grieser, Florian Grussie, Holger Kreckel, Oldřich Novotrný, Andreas Wolf, Alexander Dorn, Robert Moshammer, Claus Dieter Schröter, and Thomas Pfeifer — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Deutschland

The CSR-ReMi is a newly installed in-ring reaction microscope for experiments with slow and cold molecular or cluster ions in the cryogenic storage ring CSR [1]. A reaction microscope (ReMi) is a combined electron and ion spectrometer [2, 3]. It offers multi-hit capability and provides high detection efficiency, acceptance and resolution. With the coincident detection of all collision fragments kinematically complete data-sets on the reaction dynamics can be collected. The integration of the CSR-ReMi into the CSR was finalized in July 2023 and first commissioning experiments under cryogenic conditions were performed recently. Emphasis was given to electron-transfer and electron-loss reactions in collisions of various types of stored ions with neutral atoms or molecules that were injected by a supersonic gas jet. Selected results of these first experiments will be presented.

References:
[1] R. von Hahn et al., Rev. Sci. Instrum. 87, 063115 (2016)
[2] J. Ullrich et al., Rep. Prog. Phys. 66, 1463-1545 (2003)
[3] H. Schmidt-Böcking et al., Ann. d. Phys. 533, 2100134 (2021)

MS 2.4 Mon 18:00 HS 3042

Noble Gas mass spectrometry of nuclear fuel particles from Chernobyl — •Laura Leifermann[1], Greg Balco[2], Autumn Roberts[2], Paul Hanemann[1], Tobias Weissenborn[1], Manuel Raiwa[2], Darcy van Eerten[1], Michael Savina[2], Brett Isselhardt[2], and Clemens Walther[1] — [1]IRS, Hannover, Deutschland — [2]LLNL, Livermore, USA

Noble gas mass spectrometry is generally used for determination of the elemental and isotopic composition of He, Ne, Ar, Kr and Xe in terrestrial and extraterrestrial samples. Here rock samples are heated to temperatures above 1500°C to extract the noble gases. In this work we analyzed the fission gases of individual micrometer-sized spent nuclear fuel particles from the Chernobyl exclusion zone. The particles were heated up to 1200°C and the released Xe and Kr was measured by noble gas mass spectrometry. The obtained isotope ratios give insight into important nuclear forensic information like neutron flux and sample age. In addition to noble gas mass spectrometry the particles were analyzed by resonant ion mass spectrometry for the particle's actinide isotopic composition. Furthermore, gamma spectrometry and energy-dispersive X-ray spectroscopy (EDS) measurements were carried out to maximize the knowledge on these 30-year-old nuclear fuel particles form the environment.

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MS 2.5 Mon 18:15 HS 3042

Photofission of dianionic tin-34 clusters — Alexander Jankowski, Paul Fischer, Moritz Grunwald-Delitz, and •Lutz Schweikhard — Inst. of Physics, Univ. of Greifswald, 17487 Greifswald

Small tin clusters (of number of atoms n below 50) are formed by building blocks of Sn_7, Sn_{10} [1-3] and, in the case of anionic clusters, Sn_{15} [3]. This leads to corresponding fragmentation patterns [4,5] as confirmed and further investigated [6,7] at ClusterTrap [8]. In particular, dianionic tin clusters fission into two monoanionic fragments [7], as previously found for the case of lead clusters [9]. Now, selected ensembles of Sn_{34}^{2-} clusters were irradiated by nanosecond laser pulses of variable photon energies, causing photodissociation (besides electron detachment). After a variable delay time, the remaining stored cluster ensemble is analyzed by time-of-flight mass spectrometry. The time-resolved measurements allow for the reconstruction of the decay pathways, confirming the competition of fission processes.

[1] C. Majumder et.al., *Phys. Rev. B* **64**, 233405 (2001)
[2] H. Li et al., *J. Phys. Chem. C* **116**, 231-236 (2011)
[3] A. Lechtken et al., *J. Chem. Phys.* **132**, 211102 (2010)
[4] E. Oger et al., *J. Chem. Phys.* **130**, 124305 (2009)
[5] A. Wiesel et al., *Phys. Chem. Chem. Phys.* **14**, 234-245 (2012)
[6] S. König et. al., *Eur. Phys. J. D* **72**, 153 (2018)
[7] M. Wolfram et.al., *Eur. Phys. J. D* **74**, 135 (2020)
[8] F. Martinez et al., *Int. J. Mass Spectrom.* **266**, 365-366 (2014)
[9] S. König et. al., *Phys. Rev. Lett.* **120**, 163001 (2018)

MS 2.6 Mon 18:30 HS 3042

Solvation of Cun+/- in He and H2 — •Olga Lushchikova[1], Johannes Reichegger[1], Fabio Zappa[1], Machael Gatchell[2], Massimiliano Bartolomei[3], Jose Campos-Martínez[3], Tomas González-Lezana[3], Fernando Pirani[3], and Paul Scheier[1] — [1]Institut für Ionenphysik und Angewandte Physik, Universität Innsbruck, Austria — [2]Department of Physics, Stockholm University, Sweden — [3]Instituto de Física Fundamental, IFF-CSIC, Spain

The exploration of copper's versatility in hydrogen (H2) and helium (He) interactions at a microscale holds promise for novel energy stor-

age and chemical applications. This research addresses the intricate challenges of understanding these interactions. Through mass spectrometry, we investigate how small copper clusters (Cun+/-, n=1-10) solvate in He and H2. Grown within superfluid helium nanodroplets, these clusters are exposed to room temperature He or H2, yielding He/H2-solvated copper ions. The low temperature and high collision rate enable the solvation of positively/negatively charged clusters in over fifty H2/He units, analyzed via high-resolution mass spectrometry.

Key findings identify stable structures in Cun+/- clusters, utilizing helium as a probing species. In H2 settings, alongside the Cu core, an H-Cu core has been observed within cationic clusters, displaying a unique series of solvation with the initial layer composed of four H2 molecules. Anionic clusters, in contrast, exhibit very weak binding to both H2 and He. These complexes became observable only due to ultracold helium droplet conditions.

MS 2.7 Mon 18:45 HS 3042

Resonant ionization spectroscopy (RIS) of Tm-169 with a quadrupol mass separator (QMS) setup — •Jana Weyrich[1,3], Michael Block[1,2,3], Premaditya Chhetri[1,3], Tom Kieck[1,2], Danny Münzberg[1,2,3], Sebastian Raeder[1,2], and Dominik Studer[1,2] — [1]Helmholtz-Institut, Mainz, DE — [2]GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, DE — [3]Johannes Gutenberg-Universität, Mainz, DE

Experimental studies on heavy and superheavy elements are an important field of research to contribute to our understanding of the underlying nuclear structure which stabilizes these nuclei against fission. As the heaviest nuclides are radioactive and often short-lived, they are typically only available in small quantities. Resonant ionization spectroscopy (RIS) and subsequent mass selection proves to be a useful technique to determine atomic and nuclear properties by probing atomic spectra. Additionally, preceding analysis of stable isotopes or lighter homologues of the nuclide under investigation is indispensable to optimize and tailor the techniques for gaining insight into the structure of the target nuclide.

Therefore, an existing setup was further developed for the investigation of elements available off-line and in macroscopic quantities using RIS and a quadrupole mass separator (QMS). As a first result an ionization scheme of thulium was developed for future studies of neutron deficient isotopes of thulium at the GSI facility with the RADRIS technique. In this contribution the setup will be presented, together with laser spectroscopic results and the future prospects will be discussed.

MS 2.8 Mon 19:00 HS 3042

MetroPOEM - Metrology for the harmonisation of measurements of environmental pollutants in Europe — •Stephan Winkler for the MetroPOEM-Collaboration — Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany

The European Green Deal's commitment to achieving zero pollution necessitates the development of highly sensitive techniques for detecting minute amounts of pollutants. Fulfilling this need involves implementing strategies outlined by two European Metrology Networks (EMN): Pollution Monitoring (PolMo) and Radiation Protection. These networks support the Basic Safety Standards directive. Detecting radioactive isotopes and stable polluting elements in the environment requires analytical procedures that are not only fast, sensitive, and inexpensive but also validated using traceable multi-element reference materials for the optimal application of single collector ICP-MS. Unfortunately, multi-element certified reference materials are typically unavailable, and single-element certified reference materials are limited to a handful of elements. However, the urgent need for these reference materials persists, as they play a crucial role in calibrating mass spectrometric measurements and mitigating mass bias effects during the measurements in mass spectrometers. To tackle these challenges, the MetroPOEM project (21GRD09) has been initiated. Coordinated by the Physikalisch-Technische Bundesanstalt of Germany, MetroPOEM will be executed by a consortium of 23 partners spanning 13 European countries.