MS 4: Storage Rings

Time: Tuesday 10:45–12:15 Location: H2

Invited Talk MS 4.1 Tue 10:45 H2

Reaction studies with internally cold molecular ions in a storage ring — •Oldřich Novotný — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

In last decades room-temperature ion storage rings have proven to be unique tools for investigating properties and reaction dynamics of molecular ions, in particular the low-energy electron-ion collisions in merged beams. This is mainly due to 1) the long storage of the ions allowing relaxation of the internal ion states and 2) the ion beam target preparation for experiments at high collision-energy resolution by, e.g., electron cooling. The recently built Cryogenic Storage Ring (CSR) [1] in Heidelberg, Germany, with its < 6 K vacuum wall temperature brings these advantages to a new level: the low radiation field allows the molecules to relax down to their ro-vibrational ground-state. Studying collisions of cold molecular ions with electrons, photons, and atoms give access to unprecedented details on the respective reaction dynamics. Also, the CSR environment mimics well the conditions in the cold interstellar medium, which makes CSR an outstanding experimental set-up for laboratory astrochemistry.

In the talk the measurements from the first five years of CSR operation will be reviewed, with an emphasis on the recent rotational-state resolved dissociative recombination studies [2].

[1] R. von Hahn et al. Rev. Sci. Instr. 87 063115 (2016)
[2] O. Novotny et al., Science 365, 676 (2019)

MS 4.2 Tue 11:15 H2

Integration of the 4k-pixel molecule camera MOCCA into the Cryogenic Storage Ring CSR and a CSR-independent experimental setup — •Lisa Gamer[1], Christian Enss[2], Andreas Fleischmann[2], Ansgar Lowack[2], Michael Rappaport[3], Dennis Schulz[2], Abhishek Shahi[3], Yoni Toker[4], Andreas Wolf[1], and Oldřich Novotný[1] — [1]MPIK Heidelberg — [2]KIP Heidelberg University — [3]Weizmann Institute of Science, Rehovot, Israel — [4]Bar-Ilan University, Ramat Gan, Israel

The Cryogenic Storage Ring CSR at the Max Planck Institute for Nuclear Physics, Heidelberg, can store heavy molecular ions in their rotational and vibrational ground states, thus enabling to investigate electron-ion interactions such as dissociative recombination in laboratory environment at conditions that are close to those in cold interstellar plasmas. To reconstruct the full kinematics of these processes, a position and energy sensitive coincident detection of multiple reaction products is necessary. For this purpose, MOCCA, a 4k-pixel molecule camera based on magnetic calorimeters with a detection area of $45\,\mathrm{mm} \times 45\,\mathrm{mm}$, was developed and fabricated at the Kirchhoff-Institute for Physics in Heidelberg. We present the plans for integrating MOCCA and its $^3He/^4He$ dilution refrigerator into CSR as well as a CSR-independent experimental setup where MOCCA will be used to study collision- and photon-induced ion fragmentation processes.

MS 4.3 Tue 11:30 H2

First isochronous mass spectrometry in an electrostatic storage ring — •Viviane C. Schmidt[1], Manfred Grieser[1], Klaus Blaum[1], Ábel Kálosi[1,2], Holger Kreckel[1], Damian Müll[1], Oldřich Novotný[1], Felix Nuesslein[1], and Andreas Wolf[1] — [1]Max-Planck-Institut für Kernphysik, 69117 Heidelberg, Germany — [2]Columbia Astrophysics Laboratory, Columbia University, New York, 10027 New York, USA

In magnetic storage rings isochronous mass spectrometry is a vital tool for radionuclei mass measurements. These experiments require relativistic beam energies and low beam emittance and momentum spread, reachable only by means of additional phase-space cooling. Here, we report the first isochronous operation of an electrostatic storage ring, achieved at the Cryogenic Storage Ring facility at the Max-Planck-Institut für Kernphysik in Heidelberg. At non-relativistic energies of a few hundred keV and using beams with typical momentum spreads of 10^{-3} and emittance of a few mm·mrad high resolution measurements were performed without the need of phase space cooling. Mass resolutions of $\frac{\Delta m}{m} < 10^{-5}$ could be reached and isobaric contaminations well below relative beam fractions of 10^{-4} could be identified at $A \sim 20\,\mathrm{u}$. Both the time-of-flight method and revolution frequency measurements using a Shottky pick-up were successfully employed. Due to the purely electrostatic storage, this method furthermore has the distinct advantage over magnetic storage rings of providing a nearly unlimited mass operation range, enabling measurements from small atoms to complex molecule and cluster systems.

MS 4.4 Tue 11:45 H2

High resolution and fast Schottky spectroscopy of short-lived fragments in isochronous heavy ion storage rings — •Shahab Sanjari[1,2], Klaus Blaum[3], Dmytro Dmytriiev[1,4], David Freire Fernández[1,3], Yuri A. Litvinov[4], and Wolfram Korten[5] — [1]GSI Helmholtz Center, D-64291 Darmstadt, Germany — [2]Aachen University of Applied Sciences, D-52005 Aachen, Germany — [3]Max Planck Institute for Nuclear Physics, D-69117 Heidelberg, Germany — [4]Heidelberg University, D-69117 Heidelberg, Germany — [5]IRFU, CEA, Université Paris-Saclay, F-91191 Gif-sur-Yvette, France

Using non-destructive Schottky detectors, precise determination of masses and lifetimes of exotic nuclear species and their isomeric states can be performed at the experimental storage ring ESR (GSI / FAIR) on cooled fragments (standard mode of operation) and hot fragments (isochronous mode). Single ion sensitivity has regularly been achieved in the past using the former mode of operation. Up to now only destructive detection methods were employed in the latter mode. In this work we describe how the limits of time resolution can be pushed in conjunction with non-destructive and time-resolved frequency analysis of signals acquired from recently developed detectors. These detectors deliver higher sensitivity as well as a higher frequency resolution. This approach will open new opportunities to explore highly charged exotic nuclei with lifetimes down to several tens of milliseconds and energies as low as 100 keV. It is as well a milestone achievement towards the realization of precision mass and lifetime spectrometry at future Collector Ring of FAIR.

MS 4.5 Tue 12:00 H2

Mass-spectrometry assisted measurement of the bound-state beta decay of $^{205}Tl^{81+}$ ions — •Rui-Jiu Chen, Ragandeep Singh Sidhu, Yuri A Litvinov, and E121 collaboration — GSI Helmholtzzentrumfr Schwerionenforschung, Planckstrae 1, 64291 Darmstadt, Germany

Beta decay of highly charged ions [1] has attracted much attention in recent years. The studies of beta decay of highly charged ions can be performed solely at ion storage rings and ion traps where their high atomic charge states can be preserved for extended periods of time (up to several hours) and the decay products can be identified by using precision mass spectrometry. In this talk, we will 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 at GSI. The experiment is associated with two major physics motivations. One is linked with the LOREX [2] project (acronym of LORandite 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 > 53 keV) and is thus of utmost significance for 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. The measurement is crucial for the clarification of the fate of ^{205}Pb in the early solar system. Reference: [1] Yu. A. Litvinov, F. Bosch, Rep. Prog. Phys. 74, 016301, (2011). [2] M.K. Pevićević et al., Nucl. Instr. and Meth. A 621, 282 (2010).