

MS 3: Resonance Ionization MS and others

Time: Tuesday 11:00–13:00

Location: RW 2

Invited Talk

MS 3.1 Tue 11:00 RW 2

Resonant Laser-SNMS on actinides for spatially resolved ultra-trace analysis — ●CLEMENS WALTHER¹, HAUKE BOSCO¹, LINDA HAMANN¹, MICHAEL FRANZMANN², and KLAUS WENDT² — ¹Institute for Radioecology and Radiation Protection, Leibniz-Universität Hannover, Herrenhäuser Straße 2, D-30419 Hannover, Germany — ²Institute of Physics, Johannes Gutenberg-Universität Mainz, Staudingerweg 7, D-55128 Mainz, Germany

After accidental release of radionuclides into the environments, fast and highly sensitive detection methods are required. The new resonant Laser-SNMS system at the IRS Hannover was developed to cover those specifications by combining the high element selectivity of resonance ionization with the non-destructive analysis of a static TOF-SIMS with spatial resolution down to 70 nm. The laser-ionization of a neutral particle cloud above the sample required a simulation of the expanding particles and a simulation based optimization of the TOF analyzer due to different ionization behavior. First mass spectra of synthetic uranium and plutonium samples demonstrated the expected suppression of interfering elements and molecules, which was confirmed with environmental samples. In MOX fuel Pu-238 and U-238 were successfully discriminated. It was possible to create isotope selective images of environmental sample material. We present first resonant Laser SNMS Measurements on Pu, Sr and U containing samples. First results on particles from the Chernobyl exclusion zone and from the evacuated zone close to the Fukushima Daichii nuclear power plant are presented.

Invited Talk

MS 3.2 Tue 11:30 RW 2

Developments and applications of the Resonance Ionization Laser Ion Source at the CERN-ISOLDE facility — ●BRUCE MARSH — CERN, Geneva, Switzerland

The CERN-ISOLDE Radioactive Ion Beam (RIB) Facility is at the forefront of fundamental and applied research related to the use of ion beams of artificially produced exotic isotopes.

Isotope purity - extracting a beam of ions with the desired combination of proton number (Z) and atomic mass (A) - is often an essential requirement. This is achieved by combining the element-selective process of multi-step laser resonance photo-ionization with mass-selective ion beam transmission using an electromagnetic dipole mass spectrometer. The ISOLDE Resonance Ionization Laser Ion Source (RILIS) comprises an array of industrial, scientific and custom made lasers (Nd:YAG, Ti:Sapphire and dye lasers) and is capable of selectively ionizing more than 35 different elements with efficiencies often exceeding 10%. In recent years state-of-the-art laser technologies and equipment monitoring and control systems have been implemented. These have increased the performance, reliability and capabilities of the RILIS, enabling its use for more than 75% of the ISOLDE experimental program.

In addition to its use as an efficient and selective ion source, the RILIS is itself a powerful spectroscopic tool for fundamental nuclear and atomic physics studies. Technical details and recent highlights of the various applications of the ISOLDE RILIS will be discussed.

MS 3.3 Tue 12:00 RW 2

Laser resonance photoionization spectroscopy on lutetium atoms within the MEDICIS project — ●VADIM GADELSHIN¹, THOMAS COCOLIOS², REINHARD HEINKE¹, TOM KIECK¹, BRUCE MARSH³, PASCAL NAUBERIT¹, SEBASTIAN ROTHE³, THIERRY STORA³, DOMINIK STUDER¹, PIET VAN DUPPEN², and KLAUS WENDT¹ — ¹Institute of Physics, Mainz University, Germany — ²Institute for Nuclear and Radiation Physics, KU Leuven, Belgium — ³EN Department, CERN, Switzerland

Lutetium is one of the most relevant lanthanides for the MEDICIS Project, aimed at production of innovative radiopharmaceuticals for nuclear medicine, because of extraordinary properties of its medical radioisotope Lu-177. As a part of separation technology used in the project, laser resonance ionization requires an appropriate multi-step excitation scheme for the element of interest, which will ensure the most efficient ionization process. The current report presents the results of laser resonance photoionization spectroscopy on lutetium atoms with a tunable pulsed Titanium:Sapphire laser system. In several experimental periods, various two-step ionization schemes were investigated, suitable highly efficient excitation schemes were selected,

which possess a combination of high transition strength of the first excitation step together with strong transition into an auto-ionizing state. The achieved level of the lutetium ionization efficiency in different laser excitation schemes will be presented. Further research is going to be undertaken for other relevant rare-earth elements: terbium and neodymium.

MS 3.4 Tue 12:15 RW 2

Towards High-resolution In-source Laser Spectroscopy On-line: A Perpendicular Laser - Atom Beam Upgrade for the Laser Ion Source and Trap (LIST) at CERN/ISOLDE — ●REINHARD HEINKE¹, VALENTIN FEDOSSEEV², TOM KIECK¹, TOBIAS KRON¹, BRUCE MARSH², SEBASTIAN RAEDER³, SEBASTIAN ROTHE², MARCEL TRÜMPER¹, CARSTEN WEICHOLD¹, and KLAUS WENDT¹ — ¹Johannes Gutenberg-Universität, Mainz — ²EN-STI Department, CERN — ³Helmholtz-Institut Mainz

Highly selective and efficient laser ion sources are of fundamental importance to study atomic and nuclear properties along the nuclear chart. Upgrading the well-established, highly element-selective laser resonance ionization technique with additional suppression of isobaric contaminations immediately at the exit of the hot ion source cavity led to the development of the Laser Ion Source and Trap LIST, operated at the radioactive ion beam facility ISOLDE at CERN.

For high precision spectroscopic studies and isomer-selective ionization, a crossed atom - laser beam interaction geometry based on robust metal mirrors near the ionization region has been integrated into the LIST, reducing the experimentally realized spectral linewidth due to Doppler broadening in the atom vapor from a few GHz down to below 100 MHz. In the framework of the ECHO project, hyperfine structure studies on the radioactive isotopes ^{163,166m}Ho were performed at the RISIKO off-line mass separator at Mainz University, showing opportunities and constraints of a future implementation of this novel PI-LIST (Perpendicularly Illuminated) design at on-line facilities.

MS 3.5 Tue 12:30 RW 2

New insights into CD-REMPI-MS method — ●FARINAZ MORTAHEB, JÖRN LEPELMEIER, ARAS KARTOUZIAN, ULRICH BOESL, and UELI HEIZ — Technical University of Munich, Chair of Physical Chemistry, Lichtenbergstraße 4, 85748 Garching, Germany

The importance of analytical methods, which give us the ability to have deeper, faster and more accurate information about the enantiomeric excess of mixtures of chiral molecules in different environments and conditions, is clear. CD-REMPI-MS is one such technique. Circular Dichroism (CD) effect is achieved by the different absorption of left and right circularly polarized light for chiral molecules. CD can be integrated into REMPI-MS, by circularly polarizing the excitation beam. Thus, CD-REMPI-MS becomes a sensitive method with the ability to give a mass- wavelength- and enantiomer selectivity in the analysis of chiral molecules, even in the mixture with achiral ones in the gas phase. Such a method can be employed to enantio-analyse the products of heterogeneous asymmetric catalytic processes. In the present work, 1-Phenylethanol is investigated. Using CD-REMPI-MS, anisotropy factors (g-value) of multiple vibronic transitions have been determined.

[1] C. Logé and U. Boesl, ChemPhysChem, 12 (2011) 1940-1947
[2] J.Lepelmeier, K. Titze, A. Kartouzian, U. Boesl, and U. Heiz, chemphyschem, 17 (2016)

MS 3.6 Tue 12:45 RW 2

Distinction of structural isomers by means of chirped femtosecond laser ionization — ●VIOLA KREIN, NICOLA REUSCH, NIKOLAUS WOLLSCHIED, and KARL-MICHAEL WEITZEL — Philipps-Universität Marburg

Structural isomers of disubstituted benzenes are difficult to distinguish with most mass spectrometric methods, in particular when both substituents are identical. In those cases, a distinction is possible by coupling mass spectrometry with a chromatographic method. An alternative approach is the combination of femtosecond laser ionization with time-of-flight mass spectrometry (fs-LIMS). Here, the variation of several laser pulse characteristics opens access to a multidimensional analytical technique. In the current work we present a systematic chirped fs-LIMS investigation of two different ortho-, meta- and para-

disubstituted benzenes, i. e. difluorobenzene and benzenediamine. In both cases the mass spectra for the three structural isomers look similar for transform limited laser pulses. By systematic variation of linear and quadratic chirp we are able to enhance small differences between the ortho-, meta- and para-isomers for specific fragments. Ultimately, we demonstrate, that we are able to distinguish the three structural iso-

mers. In this context we will address i) differences in intensity-driven vs. non-intensity-driven fragmentation channels; ii) the mechanism for the formation of specific fragments; and iii) the relevance of a ring opening as start of the fragmentation process, as it is known for difluorobenzene [1]. [1] A.-M. Boulanger, D. M. P. Holland, D. A. Shaw, P. M. Mayer, *J. Am. Soc. Mass Spectrom.*, 20, 20-24, (2009)