MO 13: Symposium SYML: Molecules and Ions in Isolation (with MS)

Time: Wednesday 14:30–16:45 Location: e415

Invited Talk MO 13.1 Wed 14:30 e415

Physics with keV Ion Beams in the Cryogenic Storage Ring CSR — •Andreas Wolf — Max-Planck-Institut für Kernphysik, 69117 Heidelberg, Germany

As a cryogenic electrostatic storage ring, the CSR offers long-time storage for ion beams with energies in the multi-keV regime. The first operation [1] showed that the 35 m diam. electrostatic lattice of the ring could be successfully realized and operated at 6 K and at a residual gas density of <100 cm^{-3}. Beam storage times reached about 10 min or more for 60 keV ion beams in the studied range of mass numbers 16–218. With this, a new tool emerges for studying internal properties and fragmentation reactions of many types of complex gas-phase ions, both anions and cations. Moreover, the ring is designed for electron cooling, presently being implemented. We discuss the experimental perspectives of this facility and of long-time stored, phase-space cooled keV ion beams more generally.

[1] S. Vogel *et al.*, this Spring Meeting, MS Division.

MO 13.2 Wed 15:00 e415

First Cold Operation of the Cryogenic Storage Ring (CSR) — •Stephen Vogel[1], Arno Becker[1], Klaus Blaum[1], Christian Breitenfeldt[1,2], Sebastian George[1], Jürgen Göck[1], Manfred Grieser[1], Florian Grussie[1], Philipp Herwig[1], Jonas Karthein[1], Claude Krantz[1], Holger Kreckel[1], Sunil Kumar[1], Jorrit Lion[1], Svenja Lohmann[1], Christian Meyer[1], Preeti M. Mishra[1], Oldřich Novotný[1], Aodh P. O'Connor[1], Roland Repnow[1], Kaija Spruck[1,3], Stefan Schippers[3], Dirk Schwalm[1,4], Lutz Schweikhard[2], Robert von Hahn[1], and Andreas Wolf[1] — [1]Max-Planck-Institut für Kernphysik, 69117 Heidelberg, Germany — [2]Institut für Physik, Ernst-Moritz-Arndt Universität Greifswald, 17487 Greifswald, Germany — [3]Institut für Atom- und Molekülphysik, Justus-Liebig-Universität Gießen, 35392 Gießen, Germany — [4]Weizmann Institute of Science, Rehovot 76100, Israel

CSR is an electrostatic storage ring for ions of <300 keV per unit charge kinetic energy. The ion beam optics and vacuum chambers of the 35-m circumference ring can be cryogenically cooled. The ring was cooled down with 4-K liquid He in 28 cryopumping units, starting from near 10^{-10} mbar vacuum at 300 K. Ion beams of 60–90 keV were stored for species including Ar^+, OH^-, CH^+, C_2^-, Co_2^-, Ag_2^- and Co_3^-. With the cold ring, extensive non-destructive beam diagnostics were performed including Schottky-noise and beam-position detection. Beam lifetimes up to 2500 s were measured by laser photodetachment. Inelastic collisions of the stored ions with rest gas molecules were nearly undetectable, indicating < 100 cm^{-3} rest-gas density (corresponding to $< 10^{-14}$ mbar pressure at 300 K). Rotational cooling of OH^- ions to $> 95\%$ in $J = 0$ was shown by near-threshold photodetachment.

Invited Talk MO 13.3 Wed 15:15 e415

A generalized theory for rovibrational motion in cold, extremely floppy molecules — •Hanno Schmiedt[1], Per Jensen[2], and Stephan Schlemmer[1] — [1]I. Physikalisches Institut, Universität zu Köln — [2]Physikalische und Theoretische Chemie, Bergische Universität Wuppertal

We present a fundamentally new theory of the non-separable [1] rotational and vibrational motion in the class of extremely floppy molecules, with a special focus on its most prominent member, protonated methane (CH_5^+). Based on the molecular symmetry, we find the rotation group in *five* dimensions, O(5), to be the underlying dynamical group. For protonated methane, it is now possible to predict for the very first time (i) energy levels in a zero-order approximation, (ii) dipole selection rules, and (iii) branching rules for the still valid three-dimensional angular momentum quantum number. Additionally, a classification of the eigenstates of the O(5) theory in the finite molecular symmetry group can be established.

Most astonishing, two new quantum numbers are identified to be the basis of the new theory. In this talk, we will show its very first application to experimental data, published only recently [2], and show how they fit surprisingly well within the zero-order approximation.

[1] Schmiedt, H., Schlemmer, S., Jensen, P., J. Chem. Phys. 143 (15),154302 (2015)

[2] Asvany, O., Yamada, K.M.T., Brünken, S., Popatov, A., Schlemmer S., Science 347, 1346-1349 (2015)

MO 13.4 Wed 15:45 e415

Control of small water clusters — •Helen Bieker[1,2], Daniel Horke[1,2], Daniel Gusa[1], and Jochen Küpper[1,2,3] — [1]Center for Free-Electron Laser Science, DESY — [2]The Hamburg Center for Ultrafast Imaging, University of Hamburg — [3]Department of Physics, University of Hamburg

To unravel the microscopic details of intermolecular interactions in water, we prepare controlled samples of size- and isomer-selected water clusters. The spatial separation of neutral molecules can be achieved using inhomogeneous electric fields, allowing us to create pure samples of individual structural isomers or of size-selected clusters and to disperse molecules in a beam according to their quantum states [1].

Here, we aim to develop an understanding of the structures of water clusters containing a few monomer units. We present our first results on the production of size-selected samples using supersonic expansions and subsequent dispersion of the various clusters in strong electric fields, extending previous studies [2]. Future experiments aim at utilizing x-ray and electron diffractive imaging to study the structures and the ultrafast dissociation/fragmentation dynamics of these polymolecular systems.

[1] Y.P. Chang, D. A. Horke, S. Trippel and J. Küpper, *Int. Rev. Phys Chem.* **34**, 557-590 (2015)

[2] R. Moro, R. Rabinovitch, C. Xia, and V.V. Kresin, *Phys. Rev. Lett.* **97**, 123401 (2006)

MO 13.5 Wed 16:00 e415

Chiral rotational spectroscopy — •Robert Cameron[1,2], Jörg Götte[1,2], and Stephen Barnett[2] — [1]Max-Planck-Institut für Physik komplexer Systeme, Dresden, Deutschland — [2]School of Physics and Astronomy, University of Glasgow, Glasgow, UK

We present a new technique for the rotational spectroscopy of chiral molecules which enables the determination of individual components $G'_{XX}, G'_{YY}, G'_{ZZ}, A_{X,YZ}, A_{Y,ZX}$ and $A_{Z,XY}$ of the optical activity polarisability. Knowledge of these components fully characterises the enantiomeric constitution of a molecule. Our method gives an incisive signal for molecules with multiple chiral centres and even if the various stereoisomers of the chiral molecule are in a racemic mixture.

The necessary requirements on which our technique is based can also be found in space, which is why our method can also be exploited in the search for the molecular chirality in the interstellar medium, which, if found, could explain the existence of the biological homochirality of life as we know it.

Invited Talk MO 13.6 Wed 16:15 e415

Lead-cluster investigations at ClusterTrap — Stephan König, Paul Fischer, Gerrit Marx, •Lutz Schweikhard, Markus Wolfram, and Albert Vass — Institut für Physik, Universität Greifswald, Felix-Hausdorff-Str. 6, 17489 Greifswald

During the last couple of years the Penning-trap setup ClusterTrap has been further extended and used for studies of the production and properties of poly-anionic metal clusters, focusing mainly on the elements gold and aluminum. Recent experiments reached out to further elements including lead. As before, the lead clusters were exposed to an "electron bath": Mono-anionic lead clusters were produced in a laser vaporization source and were transferred and captured in the trap; by shooting primary electrons axially through the trap, argon buffer-gas atoms are ionized. The argon cations immediately leave the trap while the secondary electrons stay stored and can attach to the clusters - provided they overcome the repulsing Coulomb barrier. The measurements as a function of cluster size yield the appearance sizes for doubly and triply charged anionic clusters. In addition, and unlike the other clusters, the lead clusters show distinct dissociation patterns, with very prominent peaks at the (monoanionic) dodecamer and in particular the decamer. These clusters are also dominant in photodissociation spectra of larger mono-anions and apparently also of the dianions. The experiments are still ongoing and will be extended with respect to further charge states, including cationic species.