A 24: Cold Molecules and Reactions (joint session MO/A)

Time: Tuesday 14:00–15:45 Location: PA 2.150

Invited Talk A 24.1 Tue 14:00 PA 2.150

Towards the study of quantum-state-selected Penning reactions — Jonas Grzesiak, Simon Hofsäss, Vivien Behrendt, Frank Stienkemeier, Marcel Mudrich, and •Katrin Dulitz — Institute of Physics, University of Freiburg, Hermann-Herder-Str.3, 79104 Freiburg i.Br., Germany

Our goal is to study quantum-state-controlled Penning collisions between lithium atoms and metastable helium atoms at low collision energies, e.g., to study the influence of electron-spin polarization on the reaction rate and to observe quantum resonance effects. For this, we use an experimental apparatus which consists of a discharge source for the production of metastable helium atomic beams and a magneto-optical trap (MOT) for ultracold lithium atoms. Using a novel multi-pulse detection scheme, we are able to mass-selectively probe the ionic reaction products at improved energy resolution. In this contribution, I will give an overview of the current state of these experiments. I will also present our progress towards achieving quantum-state selectivity of the reaction partners, which includes optical quenching of the metastable He(2^1S_0) state and magnetic-hexapole focusing of the metastable He(2^3S_1, $M_J = 1$) state into the MOT target.

A 24.2 Tue 14:30 PA 2.150

Reactive scattering between metastable helium atoms and ultracold lithium atoms — •Jonas Grzesiak[1], Vivien Behrendt[1], Frank Stienkemeier[1], Marcel Mudrich[2], and Katrin Dulitz[1] — [1]Physikalisches Institut, Universität Freiburg, Hermann-Herder-Str.3, 79104 Freiburg i.Br. — [2]Department of Physics and Astronomy, Ny Munkegade 120, 8000 Aarhus C, DK

The experimental observation of quantum effects in Penning ionization reactions has recently attracted a lot of attention [1]. Our goal is to study such processes in a quantum-state-controlled manner at low collision energies, e.g., to study the influence of electron-spin polarization on the reaction rate. For this, we use an experimental setup which is composed of a magneto-optical trap for ultracold lithium atoms and a discharge source for the production of supersonic beams of metastable helium atoms. In this contribution, we will present a novel detection scheme which allows for the mass-selected detection of the ionic reaction products at improved energy resolution and we will discuss the influence of elastic collisions on the reaction rate measurements.

[1] A. B. Henson, S. Gersten, Y. Shagam, J. Narevicius, E. Narevicius, Science 338, 234 (2012).

A 24.3 Tue 14:45 PA 2.150

Blackbody-Induced Radiative Dissociation of van der Waals Clusters at the Cryogenic Storage Ring — •Felix Nuesslein[1], Klaus Blaum[1], Sebastian George[1], Jürgen Göck[1], Florian Grussie[1], Robert von Hahn[1], Matthias Klein[2], Thomas Kolling[2], Holger Kreckel[1], Michael Lembach[2], Christian Meyer[1], Preeti Manjari Mishra[1], Gereon Niedner-Schatteburg[2], Viviane Schmidt[1], and Andreas Wolf[1] — [1]Max-Planck-Institut für Kernphysik, D-69117 Heidelberg — [2]Technische Universität Kaiserslautern, D-67663 Kaiserslautern

Recently, blackbody-induced dissociation of van der Waals clusters was studied for $(SF_6)_N^-$ in a room temperature electrostatic ion beam trap [1]. However, the ground state stability of the various cluster sizes and the temperature-dependent dynamics of the infrared-active molecular clusters have not yet been investigated. For these, the Heidelberg electrostatic Cryogenic Storage Ring (CSR) provides ideal conditions. It was recently used to measure the rotational relaxation of infrared-active molecules in a ∼15 K effective radiation field [2]. Low residual gas density (<140 cm^{-3}) enables storage of fast ion beams in the CSR for times up to hours [3]. Currently, we assemble a laser vaporization source to produce $(SF_6)_N^-$ and $SF_5^+(SF_6)_{N-1}$ clusters. We aim at studying their heating dynamics inside the CSR at various temperatures via the two main infrared bands of SF_6 at 10.6 μm and 16 μm.

[1] I. Rahinov et al., Eur. Phys. J. D 70 (2016) 260.
[2] C. Meyer et al., Phys. Rev. Lett. 119 (2017) 023202.
[3] R. von Hahn et al., Rev. Sci. Instrum. 87 (2016) 063115.

A 24.4 Tue 15:00 PA 2.150

Molecular conformer-selection by matter-wave diffraction at narrow-band optical phase gratings — •Christian Brand[1], Benjamin A. Stickler[2], Christian Knobloch[1], Armin Shayeghi[1], Klaus Hornberger[2], and Markus Arndt[1] — [1]Faculty of Physics, University of Vienna, Boltzmanngasse 5, A-1090 Vienna, Austria — [2]Faculty of Physics, University of Duisburg-Essen, Lotharstraße 1, 47048 Duisburg, Germany

Molecular conformations are of utmost importance in molecular recognition processes and recent collision studies have demonstrated the strong influence of molecular conformation on bimolecular reaction rates [1]. It is therefore of great interest to develop methods that are capable of separating single structures even from a congested conformational space. Here propose a new method that can separate conformers independently of their molecular dipole moment [2]. By diffraction the matter-wave at a near-resonant ultraviolet optical grating, individual conformers of complex molecules can be spatially isolated in a selected diffraction order. We illustrate the principle and discuss how to prepare a conformer-pure molecular beam of the neurotransmitter 2-phenylethylamine. The technique thus paves the way for structure-sensitive experiments with hydrocarbons and biomolecules, such as neurotransmitters and hormones, which evaded conformer-pure isolation so far. The applications range from environmental research, biomolecular physics to astrophysics.

[1] Chang et al., Science 342 98 (2013)
[2] C. Brand et al., ArXiv 1710.01035 (2017)

A 24.5 Tue 15:15 PA 2.150

Separation of water dimer — •Helen Bieker[1,2], Melby Johny[1], Thomas Kierspel[1], Boris Sartakov[3], Andrey Yachemenev[1], Sebastian Trippel[1,3], Daniel A. Horke[1,2], and Jochen Küpper[1,2,4] — [1]Center for Free-Electron Laser Science, DESY — [2]The Hamburg Center for Ultrafast Imaging, University Hamburg — [3]General Physics Institute, Russian Academy of Sciences — [4]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. Inhomogeneous electric fields allow us to create pure samples of individual structural isomers or of size-selected molecular 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, subsequent separation of water dimer in strong electric fields, extending previous studies [2].

Future experiments aim at utilizing x-ray and electron diffractive imaging to study the structures and ultrafast dissociation 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)

A 24.6 Tue 15:30 PA 2.150

A Molecular Zeeman slowing scheme — •Maurice Petzold, Paul Kaebert, Philipp Gersema, Mirco Siercke, and Silke Ospelkaus — Institut für Quantenoptik, Leibniz Universität Hannover

We present our results on implementing a novel technique for slowing molecules to velocities trappable by magneto-optical traps. The scheme relies on the decoupling of angular momenta at high magnetic fields and is capable of continuously slowing and compressing the 1D velocity distribution. Detailed Monte-Carlo simulations show a significant increase in flux of slow molecules compared to current slowing techniques. To underline our theoretical efforts, we perform an experiment on an atomic test bed with similar level structure, showing good agreement between experimental and theoretical results. The advantages and implementation of our scheme closely resemble those of atomic Zeeman slowing, and implementation of our idea in a molecular system could be the missing link for realizing a large, ultra-cold ensemble of directly cooled molecules.