MO 28: Poster: Cold Molecules

Time: Thursday 16:00–18:30 Location: Lichthof

MO 28.1 Th 16:00 Lichthof

Cold molecular anions in a multipole rf trap — •Rico Otto, Petr Hlavenka, Thorsten Best, Sebastian Trippel, Martin Stei, and Roland Wester — Physikalisches Institut, Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg

When studying interaction processes of trapped cold anions only few quantum states of the investigated systems are populated. Energies on the scale of rotational levels become dominant at temperatures of only a few Kelvin. We study slow collisions [1] and laser induced processes of cold anions in a 22pole radio frequency trap. Near threshold photodetachment serves as a tool to determine internal temperatures of molecular ions. A novel laser depletion tomography method allows us to measure absolute photodetachment cross sections of trapped ions with high accuracy [2]. For O^-, a calibration standard system for photodetachment, we found a significant deviation from ab initio calculations. The OH^- photodetachment cross section showed no temperature dependence in the range between 8 - 300K [3]. Using this 2D tomography technique we are able to image the distribution of trapped ions inside the 22pole trap. This reveals unexpected information on the structure of the trapping potential [4].

[1] R. Otto *et al.*, Phys. Rev. Lett. **101**, 063201 (2008)
[2] S. Trippel *et al.*, Phys. Rev. Lett. **97**, 193003 (2006)
[3] P. Hlavenka *et al.*, J. Chem. Phys. **130**, 061105 (2009)
[4] R. Otto *et al.*, J. Phys. B **42**, 154007 (2009)

MO 28.2 Th 16:00 Lichthof

Trapping cold molecules in an aperture: Effect of internal structure on particle transmission through an opening — •Piroska Dömötör[1], Emerson Sadurni[1], Bruce W. Shore[2], Georg Süssmann[3], and Wolfgang P. Schleich[1] — [1]Institut für Quantenphysik, Universität Ulm, D-89069 Ulm, Germany — [2]618 Escondido Cir., Livermore, CA 94550 — [3]Sektion Physik der Ludwig-Maximilians-Universität, D-80333 München, Germany

Classically, rigid objects with elongated shapes can fit through apertures only when properly aligned. Quantum mechanical particles which have internal structure (e.g. diatomic molecules) are also affected during attempts to pass through small apertures, however there are interesting differences to classical structured particles. We illustrate here some of these phenomena for ultra-slow particles.

MO 28.3 Th 16:00 Lichthof

Ion molecule reaction dynamics — •Sebastian Trippel[1], Martin Stei[1], Rico Otto[1], Thorsten Best[1], Matthias Weidemüller[2], and Roland Wester[1] — [1]Physikalisches Institut, Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg — [2]Physikalisches Institut, Universität Heidelberg, Albert-Überle-Str. 3-5, 69120 Heidelberg

Ion-molecule reactions exhibit a rich amount of dynamical processes due to their complex potential energy surfaces. In our experiments we are carrying out kinematically complete studies on ion-molecule reactions using a crossed beam setup combined with velocity map imaging[1][2]. We recently upgraded our detector from 2D to full 3D detection. With this detector at hand we have studied the charge transfer reaction $Ar^+ + N_2 \rightarrow Ar + N_2^+$ in all three dimensions as a function of collision energy. In order to study steric effects in ion-molecule reactions we are using strong laser pulses to adiabatically align the molecules in free space. In future this work will be extended to reactions of molecules with microsolvated ions.

[1] J. Mikosch *et al.*, Science 319, 183 (2008)
[2] J. Mikosch *et al.*, Phys. Chem. Chem. Phys. **8**, 2990-2999 (2006)

MO 28.4 Th 16:00 Lichthof

Optoelectrical Cooling of Polar Molecules — •Barbara G.U. Englert[1], Martin Zeppenfeld[1], Manuel Mielenz[1], Christian Sommer[1], Josef Bayerl[1], Michael Motsch[1], Pepijn W.H. Pinkse[1,2], and Gerhard Rempe[1] — [1]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching, Germany — [2]Mesa + Institute for Nanotechnology, University of Twente, PO Box 217, 7500 AE Enschede, The Netherlands

We present progress towards the experimental realization of optoelectrical cooling [1] which is widely applicable for producing samples of ultracold (<1 mK) polar molecules. This scheme exploits the interaction between trapped molecules and electric fields to remove energy, while a spontaneous vibrational decay removes entropy. The trap, a key element of this method, must not only provide long lifetimes, but also regions of variable homogenous electric fields, allowing the required addressing of transitions between individual rotational sublevels. We consider in detail the design of this microstructured electrical trap, where a trap depth of 1 K can be achieved. Careful patterning of the electrodes allows a suppression of trap losses by Majorana flips.

[1] M. Zeppenfeld *et al.*, Phys. Rev. A **80**, 041401(R) (2009).

MO 28.5 Th 16:00 Lichthof

Improved rotating nozzle setup for producing slow and cold molecules — •Matthias Strebel, Marcel Mudrich, and Frank Stienkemeier — Physikalisches Institut, Universität Freiburg, 79104 Freiburg, Germany

Slow beams of cold molecules are produced by supersonic expansion out of a rapidly rotating nozzle. An improved setup is presented that allows to accelerate or decelerate cold atomic and molecular beams by up to 500 m/s. For enhancing the on - axis beam intensity for polar molecules the beam source is combined with electrostatic fields. The experimental results backed by trajectory simulations yield a relative enhancement of ND_3 and CHF_3 beam density by up to a factor 5 for a linear guide. Different electrode configurations are discussed. In order to investigate reactive and non reactive collisions between atoms and molecules at very low scattering energies, we plan to combine this beam source with a magneto-optic trap (MOT) for ultracold lithium atoms.

MO 28.6 Th 16:00 Lichthof

Stark decelerated SO_2 for dissociation and collision studies — •Oleg Bucicov[1], Eberhard Tiemann[1], and Christian Lisdat[2] — [1]Institut für Quantenoptik, Leibniz Universität Hannover — [2]Physikalisch-Technische Bundesanstalt, Braunschweig

We present a Stark decelerator for low-field-seeking states with 326 stages, with which we succeeded in decelerating SO_2 molecules to the velocity of about 50 m/s [1]. With this decelerator it should be possible to bring the relatively heavy SO_2 molecules to a standstill and to trap them electrostatically.

The preliminary experiments with Xe atom ionization and detection and the two-photon dissociation of SO_2 molecules with subsequent single photon ionization of the electronically excited SO photofragment have demostrated that our developed data acquisition system is capable of detection down to the limit of single ions.

The predissociation at the threshold of cold decelerated SO_2 molecules, prepared in the first state selective excitation step using a frequency-doubled dye laser, would result in the production of cold fragments: O in its ground state and SO in few rotational levels of selected vibrational states in the lowest electronic state [2]. The detection of the molecular fragment SO by means of the (1+1) REMPI technique using a second frequency-doubled dye laser would enable measuring the velocity distribution of the both photofragments SO and O.

[1] O. Bucicov, Eur. Phys. J. D 46 463 (2008).
[2] S. Jung, J. Phys. B 39 S1085 (2006).

MO 28.7 Th 16:00 Lichthof

Continuous guided beams of slow and internally cold polar molecules — Christian Sommer[1], •Laurens D. van Buuren[1], Michael Motsch[1], Sebastian Pohle[1], Joseph Bayerl[1], Pepijn W.H. Pinkse[1,2], and Gerhard Rempe[1] — [1]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching, Germany — [2]Mesa+ Institute for Nanotechnology, University of Twente, 7500 AE Enschede, The Netherlands

In the last years we have developed a source which produces high-flux beams of electrically guided cold molecules. A molecular gas is cooled by collisions with a cryogenic buffer gas, after which an electric quadrupole guide selects slow molecules in low-field-seeking states and transports them out of the cryogenic environment. For formaldehyde we have demonstrated the high state-purity in the extracted beam by a laser-depletion experiment [1]. As an alternative to the laser-depletion technique, we have qualitatively confirmed internal cooling for other

species as well, from time-of-flight measurements obtained at different buffer-gas settings. Here, we review the source, including its technical aspects and optimization, and present its versatility from results obtained with different molecules [2].

[1] L.D. van Buuren *et al.*, Phys. Rev. Lett. **102**, 033001 (2009)
[2] C. Sommer *et al.*, Faraday Discussions **142**, 203 (2009)

MO 28.8 Th 16:00 Lichthof

Deceleration of molecular beams of NO radicals — •Alexander Klenner, Moritz Kirste, Christian Schewe, Ludwig Scharfenberg, Gerard Meijer, and Sebastiaan Y. T. van de Meerakker — Fritz-Haber-Institut der Max-Planck-Gesellschaft Faradayweg 4-6, 14195 Berlin, Germany

The motion of neutral molecules in a beam can be manipulated with inhomogeneous electric and magnetic fields. Time-varying fields can be used to decelerate or accelerate beams of molecules to any desired velocity. Molecular beams with a tunable velocity find applications in experiments such as the production and investigation of cold molecules or crossed beam collision studies [1].

Molecules with an open shell structure like the OH (X 2Π 3/2, J = 3/2) radical are of special interest and have often been used. The NO (X 2Π 1/2, J = 1/2) radical would be the ideal molecule in these experiments, as beams of NO can be produced with superior number densities and can be detected more sensitively than OH. But Stark deceleration of NO radicals appears only feasible in the X 2Π 3/2, J = 3/2 state, that is not populated under normal conditions. We present the production of intense beams of NO radicals in the X 2Π 3/2, J = 3/2 state by stimulated emission pumping of ground-state NO (X 2Π 1/2, J = 1/2) radicals via the A $2\Sigma^-$ state. This state also has a large magnetic dipole moment, and we discuss the prospects for the Zeeman deceleration of NO (X 2Π 3/2, J = 3/2) radicals.

[1] S.Y.T. van de Meerakker, Hendrick L. Bethlem, and G. Meijer, Taming Molecular Beams, Nature Physics 4, 595 (2008).

MO 28.9 Th 16:00 Lichthof

Photodissociation and chemical probing spectroscopy of H_3^+ — •Dennis Bing[1], M.H. Berg[1], H. Buhr[2,1], M. Grieser[1], C. Kranz[1], M.B. Mendes[1], S. Menk[1], S. Novotny[1], O. Novotný[1,3], D.A. Orlov[1], A. Petrignani[1], R. Repnow[1], T. Sorg[1], J. Stützel[1], X. Urbain[4], and A. Wolf[1] — [1]Max-Planck-Institut für Kernphysik, Heidelberg — [2]Weizmann Institute of Science, Rehovot, Israel — [3]Columbia University, New York, USA — [4]Université catholique de Louvain, Louvain-la-Neuve, Belgium

We present developments towards resonantly enhanced multiphoton dissociation (REMPD [1]) spectroscopy on cold H_3^+ by (a) driving rovibrational excitation from the ground state towards the H_3^+ dissociation limit near 4.4 eV and (b) establishing single photon dissociation of vibrationally excited H_3^+ into the channel H_2^+ + H. Rovibrational excitation spectroscopy of H_3^+ was performed in a 22-pole RF ion trap, where the ions were cooled down to their lowest rotational states and then excited above the barrier to linearity (E>1.24 eV). Transitions up to the visible range (reaching E>2 eV) were scanned with a cw dye laser. The photodissociation of H_3^+ was performed separately [2] in a collinear ion-laser-beam setup at the ion storage ring TSR using ion-source-excited H_3^+ and pulsed Nd:YAG laser harmonics of 266 and 532 nm. An H_2^+ signal from laser dissociation of stored H_3^+ ions carrying about 3.4 eV internal excitation was seen with 266 nm and decayed with 1 ms lifetime after the ion beam injection. Combination in a REMPD scheme is coming into reach. [1] B. Roth et al., PRA 74, 040501(R); [2] A. Petrignani et al., J. Phys. Chem. A (submitted).