MO 6: Cold Molecules I

Time: Tuesday 14:00–16:00 Location: F 142

Group Report MO 6.1 Tu 14:00 F 142

A microwave lens for polar molecules — •Melanie Schnell, Simon Merz, Hitoshi Odashima, Katsunari Enomoto, and Gerard Meijer — Fritz-Haber-Institut, Berlin, Germany

The motion of polar molecules can be manipulated using inhomogeneous electric fields. An alternative way, which is especially interesting for larger and complex molecules, is based on electromagnetic fields, such as microwave and optical fields. We are currently investigating the possibilities of using microwave radiation for focusing, decelerating and trapping molecules. The force exerted on a molecule in microwave fields depends on its dipole moment, the detuning of the microwave frequency from the molecular resonance frequency and the field strength. Microwaves are especially suited since small detunings and thus large interaction energies are possible. After a more general introduction to manipulating the motion of polar molecules using microwave radiation, this group report will focus on mainly two different aspects:

Using a cylindrically symmetric copper resonator, we can generate a standing microwave field which acts like a positive lens on polar molecules: They experience a focusing force in transverse directions which prevents them from spreading out. The characterization of this novel microwave lens is discussed.

In a second, very similar setup we will go one step further and exchange the cylindrically symmetric resonator by an open Fabry-Perot type resonator. Using fast microwave switches, it can also be used to decelerate molecules and to eventually trap them in the center of a standing wave maximum.

MO 6.2 Tu 14:30 F 142

Velocity-selected molecular pulses produced by an electric guide — •Christian Sommer[1], Michael Motsch[1], Sotir Chervenkov[1], Laurens D. van Buuren[1], Martin Zeppenfeld[1], Pepijn W.H. Pinkse[1,2], and Gerhard Rempe[1] — [1]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, D-85748 Garching, Germany — [2]Mesa+ Institute for Nanotechnology, University of Twente, PO Box 217, 7500 AE Enschede, The Netherlands

By using the technique of electrostatic velocity filtering [1] we demonstrate the production of velocity selected pulses of slow molecules from a continuous beam with a tunable center velocity. The pulses are generated by switching electric fields on adjacent segments of an electric quadrupole guide synchronously with the propagation of the molecules. We generate pulses of deuterated ammonia (ND_3) containing up to 10^6 molecules with center velocities between 20 m/s and 100 m/s and a relative spread of (7 ± 1) %.

[1] T. Junglen et al., Eur. Phys. J. D 31, 365 (2004)

MO 6.3 Tu 14:45 F 142

A Molecular Synchrotron — •Peter C. Zieger[1], Cynthia E. Heiner[1], André J. A. van Roij[2], Hendrick L. Bethlem[3], Sebastiaan Y. T. van de Meerakker[1], and Gerard Meijer[1] — [1]Fritz-Haber-Institut der Max-Planck-Gesellschaft, Faradayweg 4-6, 14195 Berlin, Germany — [2]Radboud University, Toernooiveld 1, 6525 ED, Nijmegen, The Netherlands — [3]Laser Centre Vrije Universiteit, De Boelelaan 1081, 1081 HV Amsterdam, The Netherlands

It has been shown that with the so-called Stark decelerator it is possible to produce a beam of cold neutral polar molecules with a tunable velocity that are well suited for molecular beam scattering studies. One can load these beams into a molecular synchrotron; this offers particularly interesting prospects for these kinds of scattering experiments. In principle, a storage ring allows for the confinement of multiple packets of molecules in a circle that repeatedly interact, significantly increasing the sensitivity of molecular collision experiments.

We will present a version of a molecular synchrotron that consists of 40 straight hexapoles, that allows for the simultaneous confinement of 20 molecular packets moving clockwise and 20 packets moving counter clockwise. We will explain the operation principle of the synchrotron and present our latest experiment, where a molecular packet is confined over a flight length of one kilometer. Recently, we have also demonstrated the simultaneous storage of multiple packets, moving in the same direction in the ring. Currently a second Stark decelerator beamline is being constructed to enable the injection of multiple counter-propagating packets in the synchrotron.

MO 6.4 Tu 15:00 F 142

Absolute and near threshold photodetachment cross sections of negative ions — •Rico Otto[1], Petr Hlavenka[1], Thorsten Best[1], Sebastian Trippel[1], Martin Stei[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

The photodetachment of a weakly bound electron from an anion represents a fundamental light-matter interaction. We have developed a laser depletion tomography method that allows us to measure absolute photodetachment cross sections in a multipole radiofrequency trap with high accuracy. We use this method to study the O^- cross section, which shows a significant deviation from ab initio calculations. The total cross sections of molecular OH^- measured at 662 nm and 632 nm are found to be constant in the temperature range 8-300 K [1]. Near threshold photodetachment is sensitive for internal excitations of molecular ions. Here we also present first studies to use this as a sensitive tool for determining internal temperatures of trapped ions. In future experiments this will be used to study the temperature of bigger molecular systems like water clusters.

[1] P. Hlavenka *et al.*, J. Chem. Phys. 130, 061105 (2009)

MO 6.5 Tu 15:15 F 142

Prospects for ultracold molecular formation. Quantum relativistic studies of Rb-Yb and $(Rb\text{-}Ba)^+$ — •Stefan Knecht[1,2], Lasse Kragh Sørensen[2], Hans Jørgen Aagaard Jensen[3], Timo Fleig[4], Christel M. Marian[2], and Trond Saue[1] — [1]LCQ, Université de Strasbourg — [2]Institut für Theoretische Chemie, Universität Düsseldorf — [3]Department of Physics and Chemistry, University of Southern Denmark — [4]LCPQ, Université Paul Sabatier, Toulouse

Theoretical contributions to the field of (ultra-)cold molecules are of value in many different respects. Among the most important is the determination of accurate molecular potential energy curves of ground and relevant electronically excited states. Here, we present highly accurate electronic short-range potentials for the lowest molecular electronic states of the neutral system Rb-Yb[1] as well as of the molecular ion $(Rb\text{-}Ba)^+$[2],[3] derived from relativistic four-component multi-reference configuration interaction and coupled-cluster calculations. In addition, we report vibrational states, Franck-Condon factors, transition dipole moments and ground-state dipole moment functions. Based on our findings we illustrate a possible experimental two-step mechanism to reach the rovibronic ground state.

[1] L. K. Sørensen, S. Knecht, T. Fleig, and C. M. Marian, *J. Phys. Chem. A* 113, (2009) 12607.
[2] S. Knecht, H. J . Aa. Jensen, and T. Fleig, *J. Chem. Phys.* 128 (2008) 014108.
[3] S. Knecht, L. K. Sørensen, H. J . Aa. Jensen, T. Fleig, and C. M. Marian, J. Phys. B., revised manuscript submitted.

MO 6.6 Tu 15:30 F 142

Trapping Molecules on a Chip — •Gabriele Santambrogio[1], Samuel A. Meek[1], A. Isabel Gonzalez Florez[1], Boris G. Sartakov[2], Horst Conrad[1], and Gerard Meijer[1] — [1]Fritz-Haber-Institut der Max-Planck-Gesellschaft, Faradayweg 4-6, 14195, Berlin — [2]General Physics Institute, Russian Academy of Sciences, Vavilov Street 38, 119991, Moscow, Russia

It has been demonstrated how a microstructured array of electrodes can be used to decelerate and bring the polar molecules to a complete standstill directly from a molecular beam. The electrodes have been configured to generate an array of local minima of electric field strength 25 μm above a glass substrate. Polar molecules in low-field seeking quantum states can be trapped in these traveling potential wells.[1]

The main limiting factor in the number of trapped molecules are non-adiabatic losses from the low-field seeking states. In order to reduce these losses in the case of CO molecules in the $a^3\Pi_1$ state, we are performing two sets of experiments. (i) We take advantage of the hyperfine splitting present in the isotopologue ^{13}CO to lift the degeneracy between low-field seeking states and non-low-field seeking states. (ii) We apply a homogeneous magnetic field to the ^{12}CO molecules to

split the low-field and the non-low-field seeking states. Experiments are in progress to quantitatively understand the trap losses due to Majorana transitions (and the reduction thereof) in the combined electric and magnetic fields.

[1] Samuel A Meek, Horst Conrad, and Gerard Meijer, Science 324 (2009), 1699.

MO 6.7 Tu 15:45 F 142

Vibrational Spectroscopy of H_3^+ - advancing into the visible spectral region — •Max Berg, Dennis Bing, Annemieke Petrignani, and Andreas Wolf — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

The triatomic hydrogen ion H_3^+ is a highly reactive key component in many astrophysical and technological plasmas. Being the simplest polyatomic molecule, it is also an important benchmark system against which various quantum mechanical calculations are tested. While the rovibrational levels near the triangular equilibrium structure are well understood, the rovibrational spectrum of this elementary system at strongly deformed geometry, above the barrier to linearity near 10000 cm^{-1}, represents a formidable task for theory. Its experimental exploration so far ended slightly above 13900 cm^{-1} from the ground state E_0 ($\lambda \sim 720$ nm). We report new measurements in a cryogenic 22 pole trap in the range of very high vibrational overtones, reaching levels up to $\sim$16500 cm^{-1} ($\lambda \sim 600$ nm) from E_0. Chemical probing spectroscopy revealed its use for ultra-sensitive detection of transitions six to seven orders of magnitude weaker than the fundamental. Aside from the transition frequencies (± 0.005 cm^{-1}), we present results from a new method to derive precise transition intensities, helping theoretical assignement of the lines.