MO 19: Cold Molecules III

Time: Wednesday 16:30–18:15 Location: BAR Schön

MO 19.1 Wed 16:30 BAR Schön

Visible rovibrational spectroscopy of cold H_3^+ via chemical probing in a 22 pole trap — •Florian Grussie, Max Berg, Andreas Wolf, and Annemieke Petrignani — Max-Planck Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

H_3^+ is the cornerstone of interstellar chemistry and the simplest triatomic molecule, therefore also of fundamental interest to experimental and theoretical physics. At the MPI for Nuclear Physics, spectroscopy on cold H_3^+ is performed in a cryogenic 22-pole radiofrequency trap using laser-induced reactions with argon as chemical probe. The chemical probing technique provides high sensitivity and a low background environment, so that transitions up to at least 6 orders of magnitude weaker than the fundamental (B_{21}=4.77 · 10^{23} $cm^{-3}J^{-1}s^{-1}$) can be observed. This high sensitivity is augmented by an efficient Daly detection system where each ion is amplified into a bunch of secondary electrons that are subsequently amplified into photons before being counted by a photomultiplier tube. This has allowed us to measure transitions from the two lowest rotational states of the H_3^+ vibrational ground state to, recently, final levels up to 16600 cm^{-1}, i.e., half the dissociation energy. To observe transitions to even higher levels, the already low background needs to be minimized further. The background originates from non-laser-induced probe ions and laser photons. The latter should be eliminated by a new detection system insensitive to our laser photons. The non-laser-induced ions can be minimized by injecting the argon chemical probing gas during laser excitation only, using a pulsed valve.

MO 19.2 Wed 16:45 BAR Schön

High resolution spectroscopy of Rb_2 triplet molecules — •Christoph Strauss[1,2], Tetsu Takekoshi[2], Florian Lang[2], Klaus Winkler[2], Rudolf Grimm[2,3], Marius Lysebo[4], Leif Veseth[4], Eberhard Tiemann[5], and Johannes Hecker Denschlag[1] — [1]Universität Ulm, Institut für Quantenmaterie, Albert-Einstein-Allee 45, D-89081 Ulm, Germany — [2]Institut für Experimentalphysik und Zentrum für Quantenphysik, Universität Innsbruck, A-6020 Innsbruck, Austria — [3]Institut für Quantenoptik und Quanteninformation der Österreichischen Akademie der Wissenschaften, A-6020 Innsbruck, Austria — [4]Department of Physics, University of Oslo, 0316 Oslo, Norway — [5]Gottfried Wilhelm Leibniz Universität Hannover, D-30167 Hannover, Germany

A detailed understanding of the molecular level structure is essential for future cold collision experiments of ultracold molecules such as Rb_2. We present a complete analysis of the triplet ground state $a^3\Sigma_u^+$ and the first excited triplet state $(1)^3\Sigma_g^+$ of Rubidium 87 discussing its vibrational, rotational, hyperfine and Zeeman structure. We perform laser spectroscopy on ultracold Feshbach molecules to obtain precision data with a typical resolution of a few tens of MHz. We can describe and understand the experimental spectra quite well using model Hamiltonians. As a result we obtain optimized $a^3\Sigma_u^+$ and the $X^1\Sigma_g^+$ Born-Oppenheimer potentials within a coupled channel model. We gain interesting insights on level mixing of singlet and triplet states, and obtain evidence that the hyperfine structure in these molecules depends weakly on the vibrational level.

MO 19.3 Wed 17:00 BAR Schön

Threshold photodetachment thermometry for cold molecular anions — •Alexander von Zastrow[1], Thorsten Best[1], Rico Otto[1], Stephanie Eisenbach[1], Martin Stei[3], Sebastian Trippel[1], Matthias Weidemüller[2], and Roland Wester[3] — [1]Physikalisches Institut, Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg — [2]Physikalisches Institut, Universität Heidelberg, Philosophenweg 12, 69120 Heidelberg — [3]Institut f. Ionenphysik und Angewandte Physik, Universität Innsbruck, Technikerstr. 25/3, A-6020 Innsbruck

During photodetachment an anion's excess electron is lifted from a bound to a continuum state. The cross section for this process reveals information about the internal structure of the anion and the neutral as well as long range electron-neutral interactions. One of the best studied molecular anions is OH^-. At threshold the photodetachment cross section is sensitive to the different occupied rotational levels. From their contribution to the cross section, the anions' rotational temperature can be derived. In our experiments ions are stored and sympathetically cooled in a 22-pole radiofrequency trap which can be operated between 8 K and 300 K. To determine the ions' rotational temperature, we measure the absolute photodetachment cross section using a previously reported laser depletion tomography method [1,2]. This will allow us to investigate the efficiency of collisional cooling of internal degrees of freedom in future experiments.

[1] S. Trippel *et al.*, Phys. Rev. Lett. 97, 193993 (2006)
[2] P. Hlavenka *et al.*, J. Chem. Phys. 130, 061105 (2009)

MO 19.4 Wed 17:15 BAR Schön

Interaction of cold atoms with molecular ions — •Anna Göritz[1], Johannes Deiglmayr[1], Thorsten Best[2], Rico Otto[2], Matthias Weidemüller[3], and Roland Wester[2] — [1]Physikalisches Institut, University of Freiburg, Germany — [2]Physikalisches Institut, University of Innsbruck, Austria — [3]Physikalisches Institut, University of Heidelberg, Germany

Sympathetic cooling of atomic and molecular ions by ultracold gases has recently gained significant interest[1]. For the investigation of a wider range of molecular ions high order multipole radio frequency (rf) traps in combination with helium buffer-gas cooling are an established tool. In order to reach lower temperatures it is intriguing to replace helium with laser-cooled atoms. To this aim we develop a new rf octopole trap with thin wire-electrodes, yielding high optical access to the trapping region. A vapour-loaded magneto-optical trap provides ultracold ^{85}Rb atoms. The design of the hybrid trap is chosen for optimally adapted density distributions of atoms and ions, where the latter is measured directly by photodetachment depletion tomography of anions. Here, we report on first results on the interaction of the trapped ions with ultracold rubidium. In particular we observe the inelastic collision $OH^-+Rb^* \rightarrow OH^-+Rb+E_{kin}$, leading to loss of ions from the trap. The prospects for sympathetic cooling of molecular ions by laser-cooled Rb are discussed.

[1] Christoph Zipkes et al., Nature 464, 388 (2010); Stefan Schmid et al., PRL 105, 133202 (2010); X. Tong et al., PRL 105, 143001 (2010)

MO 19.5 Wed 17:30 BAR Schön

Reaction of D^- with H_2 at low temperatures — •Stephanie Eisenbach[1], Rico Otto[1], Alexander von Zastrow[1], Thorsten Best[1,2], and Roland Wester[1,2] — [1]Physikalisches Institut, Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg — [2]Institut f. Ionenphysik und Angewandte Physik, Universität Innsbruck, Technikerstr. 25/3, A-6020 Innsbruck

Tunneling through barriers, one of the most fundamental processes in quantum mechanics, can be an important reaction mechanism for chemical reactions at low temperatures see e.g. $F+H_2$. Another example may be the isotope exchange reaction $D^-+H_2 \rightarrow H^-+HD$, with a reaction barrier height of 330 meV. This reaction can proceed over the barrier at high kinetic energies of the reactands [1]. In a 22-pole radio-frequency ion trap we can study reactions of buffer gas cooled molecular or atomic anions with neutral molecules down to 8 Kelvin temperature [2,3]. From these measurements an upper limit for the tunneling rate in H^-+D_2 is derived.

[1] E. Haufler, *et al.*, J. Phys. Chem. A **101**, 6441 (1997)
[2] R. Wester, J.Phys. B: At. Mol. Opt. Phys. **42**, 154001 (2009)
[3] R. Otto, *et al.*, PRL **101**, 063201 (2008)

MO 19.6 Wed 17:45 BAR Schön

Reactive Scattering with cold Molecules out of a RF Multipol Ion Trap — •Jonathan Brox[1], Rico Otto[1], Sebastian Trippel[1], Martin Stei[2], Thorsten Best[1], and Roland Wester[2] — [1]Physikalisches Institut, Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg — [2]Institut f. Ionenphysik und Angewandte Physik, Universität Innsbruck, Technikerstr. 25/3, A-6020 Innsbruck

Crossed beam experiments offer a maximum amount of information about the dynamics of a reactive collision. If the process involves a molecular ion its internal excitation is expected to influence the reaction. To control these internal degrees of freedom we combined our velocity map imaging setup with a multipol rf trap, which allows us to control the internal state distribution of the molecular ion. The trap can be operated in a temperature range from 100 to 400 K. The extraction out of the rf trap provides a translational energy distribution of 100meV FWHM. In this talk we will present first test measurements

on reactive scattering of OH^- and CH_3I for relativ energies between 0.15eV and 3.0eV.

MO 19.7 Wed 18:00 BAR Schön

Manipulation of Polar Molecules in a Microstructured Electric Trap — •Barbara G.U. Englert, Manuel Mielenz, Christian Sommer, Josef Bayerl, Michael Motsch, Pepijn W.H. Pinkse, Martin Zeppenfeld, and Gerhard Rempe — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching

Cold polar molecules offer exciting new possibilities for research in physics and chemistry, such as molecular precision spectroscopy or cold collision studies. For all of these experiments, long interaction times are essential. Additionally, homogeneous electric fields are desirable for laser addressing of individual molecular states or the control of chemical reactions. These requirements are assured by using a properly designed electric trap. In our experiment, molecules are confined between two capacitor plates which are microstructured with a suitable charged electrode array to avoid collisions with the plate surfaces [1]. A novel feature of our trap is that it is devided into two separate regions to which independent homogeneous fields can be applied, giving rise to a tunable potential step for the molecules. This allows for a controlled manipulation of the molecular motion. Latest experimental results towards the cooling of the molecular motion are presented.

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