MO 57 Poster: Cold Molecules

Zeit: Donnerstag 16:30–18:30 Raum: Labsaal

MO 57.1 Do 16:30 Labsaal

Towards laser induced reactions of negative ions in a cold 22-pole ion trap — •S. Trippel, R. Berhane, R. Otto, J. Mikosch, M. Weidemüller, and R. Wester — Physikalisches Institut, Universität Freiburg, 79104 Freiburg

Radio-frequency traps are widely used to store and investigate ions. In the last decade it became clear, that collisional cooling of vibrations and rotations of molecular ions in a rf-trap requires high order multipole fields. Therefore we employ a 22-pole rf-ion trap to prepare molecular ions in certain rovibrational states and to investigate the influence of this preparation on chemical reactions such as $OH^- + H_2 \longrightarrow H_2O + H^-$. This reaction is predicted to be exoergic only if the OH^- ion populates a vibrational level $v \geq 2$. Exciting one of these levels with laser light will induce a reaction and allows for a precise spectroscopy of the involved levels and a diagnostics of the rotational level population of OH^- in the trap [1]. Currently a 10 K cooling system for the trap is constructed to cool OH^- to a single rotational state. The status of the experiment and the next steps to measure rotational state-specific collision rates at low temperatures will be described. Simulations based on the Debye-Hückel model are presented which yield predictions for the radial distribution of the trapped ions. Furthermore, the design for a new micro-ion-trap, developed in cooperation with the Institute of Microfabrication at the University of Freiburg, is presented.

[1] J. Mikosch, H Kreckel, R. Wester, R. Plašil and J. Glosík, D. Gerlich, D. Schwalm and A. Wolf, J.Chem.Phys. **121**, 11030 (2004)

MO 57.2 Do 16:30 Labsaal

Towards High Precision Spectroscopy of Ultracold Molecular Hydrogen Ions in a Linear Radiofrequency Trap — •Bernhard Roth, Heiner Daerr, Jeroen Koelemeij, Alexander Nevsky, and Stephan Schiller — Heinrich-Heine-Universität Düsseldorf

We have cooled the molecular hydrogen ions H_2^+ and H_3^+ and all their deuterated isotopomers (HD^+, H_2D^+, HD_2^+, D_3^+, D_2^+, and D^+) to translational temperatures in the 10 millikelvin range, by sympathetic cooling with laser-cooled beryllium ions, stored in a linear radiofrequency trap. The largest ion crystals contained more than 3000 well localized hydrogen molecules and up to 6000 $^9Be^+$ ions. The mass ratio m_{sc}/m_{lc} of 0.2 between sympathetically cooled H_2^+ and laser-cooled Be^+ ions is the smallest achieved so far. The different ion species were detected mass-selectively by excitation of their trap oscillation modes. The observed crystal structures agree well with results from molecular dynamics simulations which were also used to deduce an indirect upper limit for their translational temperature.

Ultracold hydrogen molecules have the potential for precision tests of molecular structure theory, tests of Lorentz invariance, and measurements of electron and nuclear masses and their time variation. In particular, HD^+ ions are of interest because they have dipole-allowed transitions.

Currently, we are performing 1+1 REMPI spectroscopy of ultracold HD^+. The ro-vibrational overtone transitions $v = 0 \rightarrow v = 4$ in HD^+ at 1.4 μm will be excited and subsequently the excited molecules will be dissociated using an 266 nm-UV-laser. The disappearance rate of ultracold HD^+ from the trap will be detected.

MO 57.3 Do 16:30 Labsaal

Sympathetic cooling of singly-protonated polyatomic molecules to sub-Kelvin temperatures — •Bernhard Roth, Chaobo Zhang, David Offenberg, Alexander Wilson, Alexander Ostendorf, and Stephan Schiller — Heinrich-Heine-Universität Düsseldorf

Alexa Fluor 350, a fluorescent dye molecule of mass 410 AMU, has been transferred from an electro spray ionisation (ESI) source to a linear Paul trap, via a 2-m long octopole ion guide. Around 2300 laser-cooled $^{138}Ba^+$ ions in a Coulomb crystal were used to sympathetically cool approximately 600 Alexa Fluor ions to below 100 mK. The sympathetically cooled ions are identified by monitoring the resonance fluorescence of the $^{138}Ba^+$ ions during secular excitation. Observations are well described by molecular dynamic simulations, which are used to determine the number of ions, their spatial distribution and translational temperature. The ESI technique should allow many different kinds of molecules to be transferred for trapping and sympathetic cooling: of particular interest may be molecules of very high mass and those of biological relevance, indeed, Alexa Fluor 350 is usually used in biological studies for protein labelling.

MO 57.4 Do 16:30 Labsaal

A microdecelerator for polar molecules — •Samuel A. Meek, Hendrick L. Bethlem, Horst Conrad, and Gerard Meijer — Fritz-Haber-Institut der MPG, Faradayweg 4-6, 14195 Berlin

By utilizing the forces that polar molecules experience in inhomogeneous electric fields, a variety of molecular-optical elements have been experimentally demonstrated. The electrode dimensions used for previous experiments have been relatively large. To reach sufficiently high electric fields with electrodes which are several mm apart, potentials of tens of kV need to be applied. We have recently demonstrated that modest voltage differences applied to μm-sized electrodes produce equally high electric fields [1]. Here, we present design and trajectory calculations for an electrostatic decelerating and trapping device consisting of a periodic array of 1000 microstructured linear electrodes deposited on a planar insulating substrate. Alternating electric potentials are applied to the electrodes in such a way that local electric field minima occur above the electrode plane. Application of harmonic waveforms to periodic groups of 6 electrodes allows us to steer the resulting periodic minima along the array in a continuous manner without changing their distance above the electrodes. Deceleration is achieved by linearly reducing the frequency of the applied waveforms. The molecule of choice for these experiments is $a^3\Pi_1$ CO. Since the lifetime of this metastable state is about 3 ms, the molecules can be detected via their spontaneous emission. Trajectories covering a whole range of initial conditions in phase space have been calculated to estimate the stable region during deceleration.

[1] S.A. Schulz et al, Phys.Rev.Lett. 93, 020406 (2004)

MO 57.5 Do 16:30 Labsaal

Erste Stark-Abbremsung von SO_2 — •S. Jung[1], G. Meijer[2], E. Tiemann[1] und Ch. Lisdat[1] — [1]Institut für Quantenoptik, Universität Hannover, Welfengarten 1, 30167 Hannover — [2]Fritz-Haber-Institut, Faradayweg 4-6, 14195 Berlin

Kalte Schwefeldioxid Moleküle bieten interessante Möglichkeiten für Experimente, so zum Beispiel die schwellnahe Photodissoziation in die Fragmente SO + O. Kaltes SO_2 sollte aufgrund seines Dipolmomentes grundsätzlich mit einem Stark-Abbremser aus einem Molekülstrahl erzeugt werden können. Allerdings ist die Masse von SO_2 verglichen mit anderen Molekülen in Abbremsexperimenten groß, was zu einer hohen kinetischen Anfangsenergie führt und lange, vielstufige Abbremsstrecken erfordert.

Wir haben einen Abbremser für Moleküle in schwachfeldsuchenden Zuständen realisiert, der aus 140 Stufen besteht. Dieser ermöglicht, die kinetische Energie der SO_2 Moleküle um 42% zu reduzieren. Basierend auf diesen Ergebnissen wird derzeit ein verlängerter Aufbau mit mehr als 320 Stufen realisiert, der Teilchengeschwindigkeiten nahe null erzeugen kann. Diese Moleküle sollen dann in einer elektrostatischen Falle gefangen werden.

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Spektroskopie von NaK — •A. Stein, A. Gerdes, St. Falke, H. Knöckel und E. Tiemann — Institut für Quantenoptik, Universität Hannover, Welfengarten 1, 30167 Hannover

Die Untersuchung langreichweitiger Wechselwirkungen zwischen einem Kalium- und einem Natriumatom ist für Zweielementfallen von herausragender Bedeutung. Die Streulängen der heteronuklearen Stöße sollen mittels molekülspektroskopischer Experimente gewonnen werden. Große Bedeutung kommt dabei den hoch angeregten Vibrationszuständen der elektronischen Grundzustände $X\,^1\Sigma^+$ und $a\,^3\Sigma^+$ zu [1]. Diese sollen mittels Mehrphotonenanregung in einem kontinuierlichen NaK-Strahl laserspektroskopisch hochauflösend untersucht werden. Mit einem vergleichbaren Aufbau wurden in unserer Arbeitsgruppe bereits die Streueigenschaften von kaltem Natrium untersucht [2]. Zur Charakterisierung der als Zwischenzustände benutzen angeregten elektronischen Zustände werden Voruntersuchugen mit Heatpipe und Fouriertransformspektrometrie von laserinduzierter Fluoreszenz durchgeführt. Der Stand der Aufbauarbeiten einer Strahlapparatur und der Voruntersuchungen von NaK werden vorgestellt.

[1] J. Venturi *et al.* J. Phys. B **34**, 4339, 2001.

[2] Chr. Samuelis *et al.*, Phys. Rev. A **63** 012710, 2001.

MO 57.7 Do 16:30 Labsaal

A two-species experiment for ultracold chemistry — •Leif Vogel[1], Christian Giese[1], Benjamin Müller[1], Jörg Lange[1], Stephan Kraft[1], Peter Staanum[1,2], Roland Wester[1], and Matthias Weidemüller[1] — [1]Physikalisches Institut Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg — [2]Institut für Quantenoptik, Universität Hannover, Welfengarten 1, 30167 Hannover

The study of atom-molecule interactions at very low temperature has opened possibilities in the field of ultracold chemistry. In this context we are particularly interested in the exchange reaction LiCs + Cs ↔ Li + Cs_2.
We form Cs_2 by photoassociation in a quasi electrostatic optical trap and aim at forming LiCs in the same way. In our recent experiments Cs-Cs_2 collision rates at ultracold temperatures were found to be largely independent of their rotational and vibrational excitation[1]. In contrast, for ultracold exchange reactions the molecular binding energies and reaction barriers are expected to play an important role. We present our experiment aiming at the efficient production of cold molecules at high densities and discuss the prospects of studying state-resolved reactive scattering in the quantum collision regime.
[1] P. Staanum *et al.* arXiv:physics/0509123 (Phys. Rev. Lett. in press)

MO 57.8 Do 16:30 Labsaal

Cold Collisions of KRb studied by High Resolution Molecular Spectroscopy — •A. Gerdes[1], O. Docenko[2], M. Tamanis[2], R. Ferber[2], A. Pashov[3], H. Knöckel[1], and E. Tiemann[1] — [1]Institut für Quantenoptik, Universität Hannover, Welfengarten 1, 30167 Hannover — [2]Department of Physics and Institute of Atomic Physics and Spectroscopy, University of Latvia, Rainis Boulevard 19, LV 1586 Riga, Latvia — [3]Department of Physics, Sofia University, 5 James Bourchier blvd, 1164 Sofia, Bulgaria

Detailed knowledge of the electronic ground states of KRb allows for the description of cold collisions, which are governing the dynamics of ultracold K-Rb mixtures in two species traps. We record the relevant spectroscopic data with a Fourier transform spectrometer by recording laser induced fluorescence of KRb. The closer the observed levels lie at the ground state asymptote, the more relevant is the information for derivation of the scattering length or Feshbach resonance positions. The spectroscopic data allow a precise determination of the potential energy curves for singlet and triplet ground state, and together with data input from recent Feshbach resonance measurements [1] also a precise description of the long range properties for all hyperfine asymptotes becomes derivable. The status of the analysis will be reported.
[1] Francesca Ferlaino, *et al.*, arXiv:cond-mat/0510630 v1 24 Oct 2005

MO 57.9 Do 16:30 Labsaal

High Resolution Spectroscopy and Potential Determination of the $X^1\Sigma$ and the $a^3\Sigma^+$ state of NaCs — •M. Hobein[1], A. Gerdes[1], O. Docenko[2], M. Tamanis[2], J. Zaharova[2], R. Ferber[2], A. Pashov[3], H. Knöckel[1], and E. Tiemann[1] — [1]Institut für Quantenoptik, Universität Hannover, Welfengarten 1, 30167 Hannover — [2]Department of Physics and Institute of Atomic Physics and Spectroscopy, University of Latvia, Rainis Boulevard 19, LV 1586 Riga, Latvia — [3]Department of Physics, Sofia University, 5 James Bourchier blvd, 1164 Sofia, Bulgaria

With the technique of Fourier-Transform-Spectroscopy of laser-induced fluorescence it is possible to observe fluorescence series due to singlet and triplet transitions simultaneously as long as the excitation is to a mixed singlet-triplet level. The data gained in such type of spectroscopy have been used to derive precise potential energy curves for the ground $X^1\Sigma$ state of NaCs [1] and for the $a^3\Sigma^+$ state as well. The PECs allow to derive also the long range scattering properties for cold collisions of Na + Cs, like scattering length and Feshbach resonances.
[1] O. Docenko *et al.*, Eur. Phys. Journal D, **31**, 205, 2004.

MO 57.10 Do 16:30 Labsaal

Influence of tight traps on photoassociation in ultracold alkali gases — •Sergey Grishkevich and Alejandro Saenz — AG Moderne Optik, Institut für Physik, Humboldt-Universität zu Berlin, Hausvogteiplatz 5-7, 10117 Berlin

The influence of tight harmonic traps on the photoassociation process in ultracold alkali gases is investigated. As a model system, Li atoms are considered with realistic interatomic interaction potentials. It is demonstrated that the simple rule "tighter trap leads to higher photoassociation rates"as one would expect from a simple spatial-confinement argument is not applicable for all final states. In fact, it is inapplicable for those states with the highest photoassociation rate in the trap-free case. This is in agreement with a general sum rule that can be derived and shows that the sum of the rates to all final states is in fact (almost) independent of the tightness of the trap. The findings for Li atoms are generalized by considering different atomic species as well as artificially modified scattering lengths (as may be implemented by Feshbach resonances). Furthermore, the validity of the usually adopted pseudo-potential approximation (substituting the correct interatomic potential) for describing photoassociation is discussed.

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Cryogenic source for cold polar molecules — •Laurens D. van Buuren, Pepijn W.H. Pinkse, and Gerhard Rempe — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching, Germany

Presently, there is a wide interest in cold polar molecules [1]. Dense samples of these molecules allow the study of collisions and chemistry at low temperatures. Such studies are useful in itself, but will also give insight into the possibility of evaporative cooling of these samples. This could lead to a regime where the anistropic dipole-dipole interaction becomes relatively strong and new phenomena are to be expected. Besides this, cold polar molecules can be employed in high precision measurements and are candidates for implementation of a quantum computation.

In our group, translational cold molecules ($T \sim 1$ K) are filtered out of an effusive molecular beam ($T \sim 160$ K for ammonia) using an electrical guide. The guided molecules have been stored in a trap for 130 ms at a density of 10^8 cm^{-3} [2]. These molecules occupy many internal (rovibrational) states. Our first goal is to increase the density of translational and internally cold molecules by pre-cooling them in a cryogenic helium buffer gas. First measurements of buffer-gas cooled beams show the potential of this technique [3]. Here, the proposed cryogenic source to load cold polar molecules into the electric guide will be presented.
[1] J. Doyle et al., Eur. Phys. J. D **31**, 149-164 (2004).
[2] T. Rieger et al., Phys. Rev. Lett. **95**, 173002 (2005).
[3] S. Maxwell et al., arXiv/physics 0508100 (2005).