Q 23: Kalte Moleküle I (gemeinsam mit MO)

Zeit: Dienstag 10:30–12:45 Raum: 6B

Hauptvortrag Q 23.1 Di 10:30 6B

Ultracold Molecular Ions in Radiofrequency Traps - Production and Spectroscopy — •Bernhard Roth, Jeroen Koelemeij, Chaobo Zhang, David Offenberg, Andreas Wicht, Ingo Ernsting, and Stephan Schiller — Institut für Experimentalphysik, Universitätsstr. 1, D-40225 Düsseldorf

A general method for the production of translationally cold charged molecules is sympathetic cooling by laser-cooled atomic ions. Recently, we have shown that using two coolant species only (beryllium and barium ions) molecular ions with masses from 2 to 470 amu can be cooled to temperatures of 10-100 mK. The wide range of coolable species makes the method attractive for many studies in chemical physics, molecular physics, fundamental physics, and astrochemistry. Since the molecular ions can be trapped for times exceeding minutes in a near-collision-less environment, light-molecule and molecule-molecule interactions in a new regime can be studied. Examples are precise spectroscopy, molecular quantum state preparation, internal coherence, interactions with neutral particles, spontaneous emission. In this talk we will describe preparation methods, spectroscopy results and outline future developments.

Q 23.2 Di 11:00 6B

Chemical Probing Spektroskopie von H_3^+ in einer kryogenen RF-Falle — •Max Berg, Annemieke Petrignani, Dennis Bing, Andreas Wolf und Holger Kreckel — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg

Das H_3^+ Molekülion spielt eine fundamentale Rolle in der Chemie des interstellaren Mediums, insbesondere für das Reaktionsnetzwerk in kalten Molekülwolken. Um aussagekräftige Messungen bei niedrigen Temperaturen (10-100 K) zu machen muss H_3^+ aktiv gekühlt werden, da wegen des fehlenden Dipolmoments die radiative Kühlung zu ineffektiv ist. Zu diesem Zweck wurde am Speicherring TSR eine 22-Pol Injektor-Falle entwickelt in der H_3^+ Ionen durch Stösse mit Helium Puffergas auf interstellare Temperaturen gekühlt werden können. Um die Population in den niedrigsten Rotationszuständen von H_3^+ nachzuweisen wird eine Chemical Probing Spektroskopie eingesetzt deren gesteigerte Sensitivität Messungen mit wenigen hundert Ionen ermöglicht. Besonderes Augenmerk wird dabei auf den Kernspin von H_3^+ gelegt und es wird gezeigt, dass die Nutzung von para-H_2 Gas eine Manipulation des ortho/para-Verhältnisses von H_3^+ erlaubt.

Q 23.3 Di 11:15 6B

A negative ion proton transfer reaction at extremely low temperatures — •Rico Otto, Jochen Mikosch, Sebastian Trippel, Christoph Eichhorn, Markus Debatin, Matthias Weidemüller, and Roland Wester — Physikalisches Institut, Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg

Using a low-temperature 22-pole ion trap we have studied the reaction of NH_2^- with molecular hydrogen in the temperature interval from 300 down to 8 Kelvin. We access in this experiment the, for negative ions previously unexplored, temperature regime below 25 Kelvin. For NH_2^- + H_2 we observe an unexpected decrease of the reaction rate coefficient at low temperatures, which is indicative of a very small reaction barrier. In this presentation we will present the new low-temperature 22-pole trap setup, the employed experimental scheme to obtain absolute reaction rate coefficients, and the measurements for the proton transfer from H_2 to NH_2^-. We will then discuss the current status of the interpretation of the measured rate coefficient. In future experiments we will investigate in how far the temperature dependence of the studied proton-transfer reaction represents a general behaviour of negative ion reactions at low temperature.

Q 23.4 Di 11:30 6B

Photodetachment of cold OH^- in a multipole ion trap — •Sebastian Trippel, Jochen Mikosch, Raphael Berhane, Rico Otto, Matthias Weidemüller, and Roland Wester — Physikalisches Institut, Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg

Negative ion photodetachment is the basis of many photoelectron spectroscopy studies. It is also a fundamental destruction process for negative ions in the environment. We have developed a method to deterimine the absolute photodetachment cross section of negative ions using a 22-pole radiofrequency ion trap. Previous studies have shown that these traps are well suited for collisional cooling of molecular vibrational and rotational states. In this work we present results for the photodetachment of trapped OH^- ions at 170 K rotational temperature. We obtain the absolute cross section in a direct and model-independent approach by measuring the decay constant of the trapped ions due to photodetachment. The density of ions interacting with the laser is measured in a tomography scan through the trap. In comparison with previous results, the cross section shows a sensitive dependence on the initial rotational state distribution. These results indicate that the rotational state dependence of the cross section is given by $(2J + 1)$, where J is the rotational quantum number of OH^-. This rotational-state dependence might be relevant for models of the abundance of negative ions in the atmosphere or in interstellar space.

[1] S. Trippel *et al.*, Phys. Rev. Lett. 97, 193003 (2006)

Q 23.5 Di 11:45 6B

Production of Cold Neutral Molecules via the Deceleration and Photodetachment of Anions — •Andreas Osterwalder, Thomas Middelmann, and Gerard Meijer — Fritz-Haber-Institut der MPG, 14195 Berlin

A new method for the production of cold neutral molecules is presented: the molecules are prepared as negative ions, decelerated, and subsequently neutralized by photodetachment.

The neutrals shall be investigated by high-resolution spectroscopy and used for chemical dynamics research in the range below 10 K. Experiments in this temperature range are essential for a complete understanding of astrochemistry and of many fundamental aspects of scattering dynamics. Nevertheless, no experimental data are available.

The new approach has the following advantages over existing techniques:

1. It is very general since it can be applied to any neutral molecule that possesses a stable anion (which is the case for many molecules, ranging from small diatomics to large bio molecules);

2. A single species can be selected for the deceleration by coupling a mass-spectrometer to the deceleration apparatus;

3. Because the neutral is formed only at the very end of the deceleration procedure the technique is also well-suited for short-lived and reactive species (in particular also for radicals);

4. The choice of the detachment wave length allows the production of the neutral in the ground state or in an excited state.

Q 23.6 Di 12:00 6B

A molecular synchrotron — •Cynthia E. Heiner[1], David Carty[1], Hendrick L. Bethlem[1,2], and Gerard Meijer[1] — [1]Fritz-Haber-Institut der Max-Planck-Gesellschaft, Berlin, Germany — [2]Laser Centre Vrije Universiteit, Amsterdam, The Netherlands

The tools for manipulating the motion of neutral atoms and molecules are inspired from the techniques developed for charged particles. Traps for atoms, akin to the Paul trap for ions, are widely implemented; surprisingly however, little attention has been paid to developing a neutral analog of a synchrotron. One great advantage of a synchrotron over a trap is that (many) bunches of cold molecules can be made to interact repeatedly, at well defined times and distinct positions with electromagnetic field and/or particles.

I will present recent results demonstrating a molecular synchrotron consisting of two hexapoles bent into a semi-circle separated by a 2 mm gap. I will detail our simple scheme for exploiting the fringe fields in these gaps to accelerate, decelerate, and focus along the longitudinal direction (”bunch”) a packet of ammonia molecules. The stored bunch of cold molecules (T=0.5 mK) is confined to a 3 mm packet even after completing 40 roundtrips, which corresponds to a flight distance of over 30 meters. Furthermore, the injection of multiple packets into the ring will be shown.

Q 23.7 Di 12:15 6B

Efficient Cooling in Supersonic Jet Expansions of Supercritical Fluids — •Wolfgang Christen[1], Klaus Rademann[1], and Uzi Even[2] — [1]Institut für Chemie, Humboldt-Universität zu Berlin, Brook-Taylor-Strasse 2, 12489 Berlin, Germany — [2]Sackler School of Chemistry, Tel Aviv University, 69978 Tel Aviv, Israel

Pulsed, supersonic beams of carbon monoxide and carbon dioxide at stagnation conditions above their critical point have been investigated by time-of-flight measurements as a function of pressure and temperature[1]. Surprisingly large speed ratios (above 100) have been achieved that are indicative of very low translational temperatures ($\leq$ 0.1 K). In particular, the supersonic expansion of CO_2 at stagnation temperatures slightly above the phase transition to the supercritical state results in unprecedented cold beams. This efficient cooling is attributed to the large values of the heat capacity ratio of supercritical fluids in close vicinity of their critical point.

[1] Wolfgang Christen, Klaus Rademann, Uzi Even, *J. Chem. Phys.* **125**, 174307 (2006).

Q 23.8 Di 12:30 6B

Beams of slow and heavy molecules for interferometry — •András Major, Hendrik Ulbricht, Sarayut Deachapunya, and Markus Arndt — Fakultät für Physik, Universität Wien, Boltzmanngasse 5, A-1090 Wien

We show experimentally that an effusive source can create a slow beam of large molecules. Owing to the very slow speeds achieved with these molecules, whose molecular weights are comparable to that of insulin, this source promises exciting new possibilities in interferometry as well as the cooling and trapping of these molecules. This report also presents a theoretical evaluation of the results with the emphasis on supersonic expansion of the beam.