Q 10: Kalte Moleküle I [gemeinsam mit MO]

Zeit: Dienstag 8:30–10:30 Raum: 3G

Hauptvortrag Q 10.1 Di 8:30 3G

Cold Polar Molecules: From Production to State-Selective Detection — •Pepijn W.H. Pinkse, Laurens D. van Buuren, Michael Motsch, Markus Schenk, Christian Sommer, Martin Zeppenfeld, and Gerhard Rempe — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching

Cold polar molecules promise opportunities in various research fields such as chemistry, metrology, molecular physics and quantum information processing. To this end, advanced production, trapping and cooling techniques are required.

An overview will be given of the methods developed in our laboratory: we filter slow molecules out of a thermal ensemble by exploiting the Stark effect in polar molecules such as formaldehyde, ammonia and water. The thermal ensemble in the source can be at room temperature or at cryogenic temperature, in which case helium is used as a cold buffer gas. Using suitably shaped electric fields, slow polar molecules are guided into ultrahigh vacuum, where we can store them in an electric trap.

While the motional energy of the filtered molecules is in the 1K range, the rotational temperature is higher. Depending on the temperature of the source and the molecular constants, many rotational states can be occupied. As a preparation for optical measurements, we performed high-resolution molecular UV spectroscopy on formaldehyde. With the gained information, we can now measure the distribution over the internal states of guided formaldehyde by state-selectively depleting the beam by optical pumping. Precise knowledge over the state distribution will be vital for further cooling down the molecules, for instance by means of an optical cavity.

Q 10.2 Di 9:00 3G

Cryogenic buffer-gas cooling and magnetic trapping of CrH and MnH molecules — •Michael Stoll[1], Joost Bakker[2], Gerard Meijer[1], and Achim Peters[3] — [1]Fritz-Haber-Institut der Max-Planck-Gesellschaft , Berlin — [2]FOM Institute for Plasma Physics, Rijnhuizen, the Netherlands — [3]Humboldt Universität zu Berlin, Institut für Physik

Buffer gas loading of molecules into a cryogenic He-filled cell and magnetic trapping of the thermalized molecules has been proven to be a powerful method for the production of samples of trapped cold molecules.

We report on the successful cooling of MnH and CrH molecules to sub-Kelvin temperatures using a He dilution refrigerator. Subsequently the molecules were loaded into a trapping field generated by a superconducting quadrupole magnet. Storage times of ˜120 ms could be demonstrated for both molecules.

We modeled the dynamics of our system using a Monte Carlo approach in order to investigate different possible inelastic scattering processes responsible for limitations to the trapping time. Collision cross sections were obtained by fitting this model to the measured diffusion times of both molecules. Combining our system with the already demonstrated methods for rapid extraction of the buffer gas should in principle allow for the preparation of thermally isolated samples with then much longer lifetimes.

Q 10.3 Di 9:15 3G

The electrostatic analogue of a Ioffe-Pritchard trap — •Moritz Kirste, Melanie Schnell, and Gerard Meijer — Fritz-Haber-Institut der MPG, Abt. Molekülphysik, Faradayweg 4-6, D-14195 Berlin

By exploiting the Stark effect one can trap polar molecules. In an electric field the molecules separate, due to the Stark effect, in low-field seeking and high-field seeking states, where molecules in low-field seeking states can be confined in the minimum of an electrostatic quadrupole trap. Trapped molecules are useful in the study of dipole-dipole interaction, the alignment of molecules in external fields and for high-resolution spectroscopy. These techniques are limited by the density of trapped molecules, the trap depth, trap frequency and trapping-time. Trap losses arise from inelastic collisions and from Majorana transitions. In electrostatic traps, the Majorana losses can be compensated by the use of an electric analogue to a magnetic Ioffe-Pritchard trap, which generates a trapping field that is non-zero at the center. In this talk we will introduce the first Ioffe-Pritchard like electrostatic trap. We will present our experimental results, characterizing the trap and will sketch its possible applications.

Q 10.4 Di 9:30 3G

Lifetime measurements with electrostatically trapped cold molecules — •Joop J. Gilijamse, Steven Hoekstra, Markus Metsälä, Sebastiaan Y.T. van de Meerakker, and Gerard Meijer — Fritz-Haber-Institut der Max-Planck-Gesellschaft, Berlin, Germany

With a Stark decelerator, bunches of state-selected molecules with a controlled velocity and with longitudinal temperatures as low as a few mK can be produced. These slow bunches of molecules can subsequently be trapped in an electrostatic trap. We will report on the deceleration and trapping of ground state OH, and metastable CO and NH molecules. The OH radicals are trapped at a density of 10^7 - 10^8 cm^{-3} and at a temperature of around 50 mK, and their trap lifetime is measured to be 2.8 s. The long interaction time afforded by the trap can be exploited to measure lifetimes of vibrationally excited states or electronically excited metastable states. Such lifetimes can be used as an accurate test of theoretical models. We will present experiments on the lifetime of OH ($X^2\Pi_{3/2}, v = 1$) and of metastable CO ($a^3\Pi, v = 0$). The different loss processes that play a role in the trap, like optical pumping by blackbody radiation, were studied in detail.

[1] S. Hoekstra *et al.*, Optical pumping of trapped neutral molecules by blackbody radiation, PRL 98: 133001 (2007)

[2] J.J. Gilijamse *et al.*, The radiative lifetime of metastable CO ($a^3\Pi, v = 0$), J.Chem.Phys, [in press], Arxiv:0710:2240 (2007)

Q 10.5 Di 9:45 3G

Guiding and decelerating polar molecules above a microstructured electrode array — •Samuel A. Meek, Hendrick L. Bethlem, Horst Conrad, and Gerard Meijer — Fritz-Haber-Institut der MPG, Faradayweg 4-6, 14195 Berlin

The feasibility of manipulating polar molecules by means of inhomogeneous electric fields has been successfully demonstrated by various devices, such as Stark decelerators, electrostatic traps and storage rings. While previous electrode configurations at the mm scale require potential differences of tens of kV at the electrodes, similar fields can be produced between 10μm-sized electrodes using potentials of hundreds of volts. Here, we present an electrostatic decelerating and trapping device consisting of a periodic array of 1254 microstructured linear electrodes deposited on a planar glass substrate. Application of harmonic waveforms to periodic groups of six electrodes forms a series of periodic minima which move along the array in a continuous manner without changing their distances above the electrodes. Deceleration is achieved by linearly reducing the frequency of the applied waveforms.

First experiments have been performed using a supersonic beam of $a^3\Pi_1$ CO, which has a lifetime of 2.6 milliseconds. Molecules are excited with a laser directly after the nozzle and later detected using Auger deexcitation at a gold surface. TOF spectra clearly demonstrate the velocity-selective guiding of CO*, with guided velocities proportional to the frequency of the applied waveforms. First results of decelerating the CO* molecules by linearly decreasing the frequency of the waveforms, i.e. velocity of the minima, are also presented.

Q 10.6 Di 10:00 3G

Spatially separating individual conformers of neutral molecules — •Frank Filsinger, Undine Erlekam, Henrik Haak, Gert von Helden, Jochen Küpper, and Gerard Meijer — Fritz-Haber-Institut der Max-Planck-Gesellschaft, Faradayweg 4-6, Berlin, Germany

Large (bio)molecules exhibit multiple conformers (structural isomers), even under the cold conditions present in a supersonic jet. For various applications, i. e., scattering experiments, it would be highly desirable to prepare molecular packets of individual conformers.

It is well-known that polar molecules can be manipulated using strong electric fields. Many techniques have been developed for the manipulation of small molecules in low-field-seeking quantum states. However, application of these techniques to large molecules is not straightforward, because, for larger molecules, all states are high-field seeking

at the relevant electric field strengths. To manipulate the motion of large molecules one has to use Alternate Gradient (dynamic) focusing. This method has been successfully demonstrated in the Alternate Gradient deceleration of CO and YbF. Using the same Alternate Gradient focusing principle, applying switched electric fields in a *quadrupole* guide, we have set up a new experiment to spatially separate individual conformers of large molecules. This experiment exploits the different mass-to-dipole (m/μ) ratios, similar to a quadrupole mass-to-charge (m/q) filter for ions.

In a proof-of-principle experiment, we have demonstrated the conformer selection of cis- and trans-3-aminophenol.

Q 10.7 Di 10:15 3G

Formation of ultracold heteronuclear dimers in electric fields — •Michael Mayle[1], Rosario Gonzalez-Ferez[2], and Peter Schmelcher[1,3] — [1]Theoretische Chemie, Universität Heidelberg, Im Neuenheimer Feld 229, 69120 Heidelberg — [2]Instituto 'Carlos I' de Física Teórica y Computacional and Departamento de Física Atómica Molecular y Nuclear, Universidad de Granada, E-18071 Granada, Spain — [3]Physikalisches Institut, Universität Heidelberg, Philosophenweg 12, 69120 Heidelberg

The effects of a strong electric field on the radiative and steric properties of heteronuclear alkali dimers are investigated. In particular, we study the formation of ultracold LiCs molecules via stimulated emission followed by a radiative deexcitation cascade in the presence of a static electric field. By analyzing the corresponding cross sections, we demonstrate the possibility to populate the lowest rotational excitations via photoassociation. The modification of the radiative cascade due to the electric field leads to narrow rotational state distributions in the vibrational ground state. External fields might therefore represent an additional valuable tool towards the ultimate goal of quantum state preparation of molecules.