MO 25: Cold Molecules II (gemeinsam mit Q)

Zeit: Dienstag 14:00–16:15 Raum: 6B

Hauptvortrag MO 25.1 Di 14:00 6B

Manipulating large molecules: selecting isomers, orienting, and slowing polar molecules with strong electric fields — •Jochen Küpper — Fritz-Haber-Institut der MPG, Faradayweg 4-6, 14195 Berlin

Polar molecules can be manipulated using strong electric fields. Small molecules, for example OH or NH_3, have been focused and state selected by electrostatic multipole guides, they have been slowed in Stark decelerators and stored in rings or traps. Practically all these experiments have been performed on molecules in low-field-seeking quantum states. For larger molecules, however, 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. In prototype experiments small molecules in high-field seeking states have been decelerated [1]. We are extending these methods to the focusing and deceleration of large molecules. For large (bio-)molecules typically a number of different conformers (structural isomers) are present in a supersonic jet. Using switched electric fields in a "quadrupole" guide such conformers can spatially be separated due to their different mass-to-dipole (m/μ) ratios, similar to a quadrupole mass-to-charge (m/q) filter for ions. Moreover, the molecular packets transmitted through the guide are very well suited for brute-force orientation.

We have also set up a modular Alternate Gradient deceleration experiment, which allows us to slow polar molecules in low- and high-field seeking states. We have successfully decelerated several molecules, for example benzonitrile (C_7H_5N), in different quantum states.

I will discuss the prospects for novel studies on such molecular systems that these experiments on the structural and spatial separation and the deceleration of large molecules offer. For example, oriented samples of individual conformers of large molecules will greatly benefit scattering experiments for direct structure determination.

[1] H. L. Bethlem, M. Tarbutt, J. Küpper, D. Carty, K. Wohlfart, E. Hinds, and G. Meijer, *J. Phys.* B **39**, R263 (2006)

MO 25.2 Di 14:30 6B

Molecular fine structure of strong dipolar molecules — •J. Deiglmayr, M. Aymar, and O. Dulieu — Laboratoire Aimé Cotton, CNRS, Bâtiment 505, Campus d'Orsay, 91405 Orsay Cedex, France

Recently the production of ultracold heteronuclear molecules in their electronic ground state either via photoassociation [1] or Feshbach resonances [2] has been achieved. Such heteronuclear molecules, if deeply bound, have a significant permanent electric dipole moment leading to strong, long-range, and alignment dependent intermolecular forces, which offer control by external electromagnetic fields. We have calculated the R-dependent polarizabilities for all heteronuclear dimers in the ground state using quantum chemistry methods [3]. We also follow a new approach to include spin-orbit coupling in ab-initio calculations of molecular potentials: a full configuration interaction calculation with effective core potentials and a diabatization procedure is used to determine potential curves with fine structure. These new insights will be used to find efficient routes to produce and stabilize polar molecules, to model the dynamics of a dipolar gas in an optical dipole trap and to explore external field dependent scattering properties.

[1] A Kerman *et al.*, PRL 92 (2004) 153001; D Wang *et al.*, PRL 93 (2004) 243005; MW Mancini *et al.*, PRL 92 (2004) 133203; C Haimberger *et al.*, PRA 70 (2004) 021402(R); SD Kraft *et al.*, J. Phys B 39 (2006) S993
[2] C. Ospelkaus *et al*, PRL 97 (2006) 120402
[3] M. Aymar, O. Dulieu, J.Chem.Phys 122 (2005) 204302

MO 25.3 Di 14:45 6B

Electrostatic extraction of buffer-gas-cooled polar molecules — •Laurens D. van Buuren, Joseph Bayerl, Vincent Dugrain, Sebastian Pohle, Christian Sommer, Pepijn W.H. Pinkse, and Gerhard Rempe — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching, Germany

High-density samples of cold molecules are required to investigate their collisional and chemical properties at low temperatures. Once polar molecules can be cooled to the ultracold regime, where the dipole-dipole interaction dominates, new quantum phenomena can be studied. Cold polar molecules are also of interest for high-resolution spectroscopy, metrology, and quantum computation [1].

We present first results with a new cryogenic source delivering a dense and slow beam of internally cold molecules. The beam is produced by combining two powerful techniques. Molecules are cooled (translationally and internally) in a helium buffer gas at low temperature (T $\sim$ 5 K) [3]. With an electric guide slow buffer-gas-cooled molecules are filtered out of the (non-polar) helium and transported to a high-vacuum region [2], where the flux is analysed. Once the source is optimized, the cold molecules can easily be loaded into an electrostatic trap [4] for further investigations.

[1] J. Doyle et al., European Physical Journal D **31**, 149 (2004)
[2] T. Junglen et al., European Physical Journal D **31**, 365 (2004)
[3] S.E. Maxwell et al., Physical Review Letters **95**, 173201 (2005)
[4] T. Rieger et al., Physical Review Letters **95**, 173002 (2005)

MO 25.4 Di 15:00 6B

Cavity Cooling of internal and external degrees of freedom of molecules. — •Giovanna Morigi[1], Pepijn Pinkse[2], Markus Kowalewski[3], and Regina de Vivie-Riedle[3] — [1]Departament de Fisica, Universitat Autonoma de Barcelona, E-08193 Bellaterra, Spain — [2]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching — [3]LMU Department Chemie, Butenandt-Str. 11, 81377 München

A proposal is presented for effectively cooling vibrational, rotational, and translational degrees of freedom of molecules. The molecules are driven by off-resonant laser light and cooled through Raman processes, where photons are scattered into the resonator, which then decays into free space. Photon emission occurs at a multitude of cavity resonances in a suitably designed resonator. The cooling efficiency is investigated numerically for the case of the OH radical, using ab-initio data and taking into account the rovibrational dependence of the Raman scattering into the cavity modes. Extentions to more complex molecules will be considered.

MO 25.5 Di 15:15 6B

Alternate Gradient deceleration of large molecules — •Kirstin Wohlfart, Frank Filsinger, Jochen Küpper, and Gerard Meijer — Fritz-Haber-Institut der MPG, Faradayweg 4–6, 14195 Berlin

Over the last years fascinating progress has been made in the spectroscopy of large (bio-)molecules, e.g. the *building blocks of life*. Meanwhile, our group has been developing methods to decelerate and cool neutral, polar molecules using time varying electric fields. In order to extend these techniques to the deceleration of large or heavy molecules, which have practically only high-field seeking states, or molecules in their absolute ground state, Alternate Gradient focusing must be applied. We showed that this technique can be used to focus and decelerate molecules in high-field seeking states [1].

Using a modular Alternate Gradient deceleration experiment different states of benzonitrile (C_7H_5N) and OH, in both high-field and low-field seeking components of its ground state, have been decelerated. The time-of-flight profiles are quantum-state-selectively measured using high-resolution laser induced fluorescence spectroscopy. We compare the efficiency of different high voltage switching schemes and will discuss the prospects of future experiments for the deceleration of larger molecules.

[1] H. L. Bethlem, M. Tarbutt, J. Küpper, D. Carty, K. Wohlfart, E. Hinds, and G. Meijer, *J. Phys. B* **39**, R 263 (2006)

MO 25.6 Di 15:30 6B

Supersonic Beams at High Stagnation Pressures: Thermodynamics and Translational Cooling — •Wolfgang Christen, Tim Krause, Sibylle Rabeus, and Klaus Rademann — Institut für Chemie, Humboldt-Universität zu Berlin, Brook-Taylor-Strasse 2, 12489 Berlin, Germany

Pulsed, supersonic beams of rare gases at high stagnation pressures ($10 < p_0 < 120$ bar) have been investigated by time-of-flight measurements as a function of gas temperature T_0. The numerical evaluation of the arrival time distribution $f(t)dt$ permits an accurate determination of the velocity distribution, characterized by the flow velocity v_0 and the velocity spread $\Delta v_{\|}$ of the expanded beam. We compare the

experimental results $v_0(p_0, T_0)$ with values calculated for a supersonic expansion of an ideal gas. Because the translational cooling of a supersonic jet is usually characterized by the speed ratio $S = v_0/\Delta v_\parallel$, we discuss the applicability of this approach at high pressure conditions. The effect of condensation on cooling is investigated by retarding field measurements, determining the cluster size distribution in the beam.

MO 25.7 Di 15:45 6B

Deceleration of polar molecules using a microstructured electrode array — •Samuel Meek, Hendrick 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 inhomogenous electric fields, a variety of molecular-optical elements have been experimentally demonstrated. While previous electrode configurations at the mm scale require potential differences of tens of kV at the electrodes, similar fields can be produced between $10\mu m$-sized electrodes using potentials of hundreds of volts. Here, we present trajectory calculations for a recently constructed 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 already been performed using beams of $a^3\Pi_1$ CO, which has a lifetime of a few milliseconds. Such a long lifetime allows laser excitation directly after the nozzle where the densities are higher, followed by detection of the fluorescence with a photomultiplier tube, or using Auger deexcitation at a microchannel plate or a gold surface. Operating the device in a mirror mode by applying a static dipole field, we were able to vary the deflection of the molecules from one to four degrees, simply by changing the tilt of the structure.

MO 25.8 Di 16:00 6B

Trapping ground-state molecules — •Melanie Schnell, Jacqueline van Veldhoven, Peter Lützow, Bretislav Friedrich, Hendrick Bethlem, and Gerard Meijer — Fritz-Haber-Institut der Max-Planck-Gesellschaft, Berlin

Trapping of neutral molecules in high-field seeking states is important since the absolute molecular ground state and most of the states of heavier molecules with small rotational constants are high-field seeking. When molecules are trapped in their absolute ground state with a high enough density and the trap depth can be varied, increasing their phase-space density via evaporative cooling will be possible, as trap loss due to inelastic collisions can be avoided. This is one important step towards the realization of a molecular Bose-Einstein condensate. Another application is located in the field of high-resolution spectroscopy. Due to the long interaction times of the trapped molecules with the electromagnetic radiation an increased resolution in the spectroscopic experiment can be reached.

Trapping ground state molecules, however, is challenging since the realization of a maximum of a static electric field in free space is not possible. It can be achieved using time-dependent fields. One approach is to employ dynamic confinement using switched electric fields (AC trap). So far, both a cylindrically symmetric and a linear AC trap have been realized. We will present our newest results on AC trapping, which include the characterization of the two traps, and we will discuss some future applications of AC trapping of ground state molecules.