MO 52 Cold molecules I

Zeit: Donnerstag 10:40–12:40 Raum: H10

Fachvortrag MO 52.1 Do 10:40 H10

Water vapor at one kelvin — •P.W.H. Pinkse[1], T. Rieger[1], T. Junglen[1], S.A. Rangwala[1], G. Rempe[1], and J. Bulthuis[2] — [1]Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching. — [2]Department of Physical Chemistry and Laser Centre, Vrije Universiteit, De Boelelaan 1083, 1081 HV Amsterdam, The Netherlands

Cold dilute molecular systems are an emerging front line at the interface of quantum optics and condensed matter physics. Cold gases of dipolar molecules can be produced by forging a tight bond between two chemically distinct species of laser-cooled atoms. Alternatively, cold gas ensembles can be created by buffer gas loading or electric field manipulation of naturally occurring molecules. However, so far all the cold molecules produced in this manner have a Stark effect which is predominantly linear in the experimentally relevant electric-field range of 0-150 kV/cm.

We report the creation of a confined slow beam of heavy-water (D_2O) molecules with a translational temperature around 1 kelvin. This is achieved by filtering slow D_2O with inhomogeneous electrostatic fields acting on the purely quadratic Stark shift of D_2O. Further, on the basis of elementary molecular properties and understanding of our filter technique [1] we predict that in the resulting slow molecular beam of D_2O only a few molecular ro-vibrational states are significantly populated. [2]

[1] T. Junglen, et al., Eur. Phys. J. D **31**, 365 (2004).
[2] T. Rieger, et al., arXiv/physics 0512119 (2005).

MO 52.2 Do 11:10 H10

Wege zur Manipulation der schwellnahen Photodissoziation von SO_2 in kaltes SO und O — •S. Jung, E. Tiemann und Ch. Lisdat — Institut für Quantenoptik, Universität Hannover, Welfengarten 1, 30167 Hannover

Aus kalten SO_2 Molekülen können durch Anregung eines prädissoziierenden Zustandes kalte Fragmente SO und O erzeugt werden [1]. Beide Fragmente liegen im elektronische Grundzustand vor. Die Überschussenergien der bei der Dissoziation entstehenden Fragmente liegen im Bereich weniger 100 mK. Findet der Dissoziationsprozess in elektrischen Feldern statt, so verursacht der Starkeffekt eine Verschiebung der Energieniveaus der einzelnen Spezies. Durch geeignete Wahl des elektrischen Feldes können die Überschussenergien variiert und so auch zu null gebracht werden. Den Starkeffekt und damit das Dipolmoment des $\widetilde{C}\,{}^1B_2$ Zustandes haben wir experimentell ermittelt. Der Starkeffekt des SO ist bekannt und der des Sauerstoffs ist vernachlässigbar klein. Die Messergebnisse erlauben eine Vorhersage zur Variation der Überschussenergien und sollen in dem Beitrag diskutiert werden. In unserem Experiment wird ein geschwindigkeits- und rotationsgekühlter SO_2 Molekülstrahl durch adiabatische Expansion ins Vakuum erzeugt. Moleküle in einem schwachfeldsuchendem Zustand werden mit einer Kette von inhomogenen elektrischen Feldern abgebremst und sollen zum Stillstand gebracht werden, um sie dann in einer elektrostatischen Falle zu fangen. Die mit dieser Methode erzeugten kalten und quantenzustandsselektierten Molekülen sollen dann photodissoziiert werden.

[1] S. Becker *et al.* Chem. Phys. Lett. **208**, 15, 1993.

MO 52.3 Do 11:25 H10

Deceleration of Benzonitrile — •Kirstin Wohlfart, Frank Filsinger, Hendrick L. Bethlem, Jochen Küpper, and Gerard Meijer — Fritz-Haber-Institut der Max-Planck-Gesellschaft, Faradayweg 4-6, D-14195 Berlin

During the last years our group has been developing methods to decelerate and cool neutral, polar molecules using time varying electric fields [1]. In order to extend this technique to large or heavy molecules, which have practically only high-field seeking states, Alternate Gradient focusing must be applied. Our group showed that this technique can be used to focus and decelerate molecules in high-field seeking states [2].

We have setup a new dedicated experiment for the focusing and deceleration of large molecules using a modular design, allowing to extend the beamline as required. Using one module we have decelerated metastable CO and benzonitrile (C_7H_5N). Benzonitrile is detected state specific using a narrow linewidth frequency doubled cw ring-dye-laser. Monitoring the integrated laser induced fluorescence after $S_1 \leftarrow S_0\ 0_0^0$ excitation full time of flight profiles can be observed for every molecular packet passing through the laser beam. Here the results on the deceleration of benzonitrile in different rotational states are presented and future experiments for deceleration of larger molecules will be discussed.

[1] H. L. Bethlem and G. Meijer, *Int. Rev. Phys. Chem.* **22**, 73-128 (2003)
[2] H. L. Bethlem, A. J. A. van Roij, R. T. Jongma and G. Meijer, *Phys. Rev. Lett.* **88**, 133003 (2002)

MO 52.4 Do 11:40 H10

An AC electric trap for molecules in high-field seeking states — •Jacqueline van Veldhoven[1], Hendrick L. Bethlem[1,2], Melanie Schnell[1], and Gerard Meijer[1] — [1]Fritz-Haber-Institut der Max-Planck-Gesellschaft, Berlin, Germany — [2]Laser Centre Free university, Amsterdam, the Netherlands

The absolute ground state of any molecule is high-field seeking. It is therefore very important to develop deep traps with large volumes for molecules in high-field seeking states. Only ground state molecules can be evaporatively cooled, as trap loss due to inelastic collisions is avoided. Furthermore, only traps for molecules in high-field seeking states can be used to trap heavier molecules with small rotational constants.

A maximum of the static electric field in free space can be created in one or two dimensions only. In a cylindrically symmetric geometry, for instance, a static electric field can be made with a maximum in the radial and a minimum in the axial direction, or vice versa. Switching between these two saddle point configurations results in a field that is alternately focusing and defocusing in each direction for molecules in high-field seeking states. At the right switching frequency the overall effect is focusing, and confinement in three dimensions can thus be obtained.

We here report on the trapping of ammonia molecules in both high-field and low-field seeking states in such a novel AC electric trap. We have studied the stability of the AC electric trap as a function of switching frequency, and we have characterized the spatial distribution and the temperature of the trapped cloud of molecules [1].

[1] J. van Veldhoven, H.L. Bethlem and G. Meijer, PRL**94**, 083001 (2005).

MO 52.5 Do 11:55 H10

Development of traps for ground-state molecules — •Melanie Schnell, Peter Lützow, Jacqueline van Veldhoven, Bretislav Friedrich, and Gerard Meijer — Fritz-Haber-Institut der Max-Planck-Gesellschaft, Abt. Molekülphysik, Faradayweg 4-6, 14195 Berlin

Cold molecules offer unique possibilities for studying cold collisions, molecular Bose-Einstein condensates (BEC), or performing high-resolution spectroscopy experiments. For these experiments confining molecules in a trap is either necessary or will enhance the potential of the method considerably. We are developing traps for molecules in high-field seeking (hfs) states, since states of larger molecules as well as the ground state of any molecule will always be hfs. Since in such a trap it is possible to confine the molecular ground state it will also be possible to increase their phase-space density via evaporative cooling, as trap loss due to inelastic collisions can be avoided.

The generation of a static electric field maximum in free space is impossible, so that traps for molecules in hfs states have to employ time-dependency. Here we report on the development of different kinds of traps for molecules in hfs states. One kind considers switched static electric fields (ac traps) while another approach consists of a deep trap for ground-state molecules using near-resonant microwave radiation. Molecules in hfs states will be trapped in the amplitude maximum of the standing wave microwave field in an open near-confocal Fabry-Perot type resonator. Besides the characterization of the traps we will present prospects for their applications in high-resolution spectroscopic studies and for evaporative cooling experiments.

MO 52.6 Do 12:10 H10

Sympathetic cooling of singly-protonated polyatomic molecules to sub-Kelvin temperatures — •Alexander Wilson, Chaobo Zhang, David Offenberg, Alexander Ostendorf, Bernhard Roth, 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. 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. 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 52.7 Do 12:25 H10

Magnetic trapping of buffer gas loaded atoms and molecules — •Michael Stoll[1,2], Joost M. Bakker[1,2], Gerard Meijer[1], and Achim Peters[2] — [1]Fritz-Haber-Institut der Max-Planck-Gesellschaft, Berlin, Germany — [2]Department for Quantum Optics and Metrology, Humboldt-Universität zu Berlin, Berlin, Germany

We report on the successful buffer-gas loading and trapping of atomic Chromium in a quadrupole magnet using a ^{3}He-^{4}He dilution refrigerator. The technique to buffer gas cool neutral molecules can provide samples of cold molecules with very high densities. Such dense samples of ultracold molecules can form a starting point for a large variety of experiments. Among these are the formation of a molecular quantum gas, ultra-high resolution spectroscopic measurements to test fundamental physics and the study of interactions between ultracold molecules. In the present experiment chromium atoms have been trapped for periods of minutes.

We observed densities exceeding 10^{13} particles per cm^3 and temperatures below 400mK. Trap loss is mainly due to evaporative cooling of the isolated sample. These results constitute the first successful buffer-gas loading experiment in Europe, and the extension of the technique to load and trap neutral polar molecules is readily foreseen.