

MO 11: Kalte Moleküle 2

Zeit: Dienstag 14:00–16:00

Raum: VMP 6 HS-G

MO 11.1 Di 14:00 VMP 6 HS-G

Nonadiabatic transitions in electrostatically trapped ammonia molecules — ●MORITZ KIRSTE¹, BORIS SARTAKOV², MELANIE SCHNELL¹, and GERARD MELJER¹ — ¹Fritz-Haber-Institut der MPG, Abt. Molekülphysik, Faradayweg 4-6, D-14195 Berlin — ²General Physics Institute RAS, Vavilov Street 38, 119991 Moskau

Nonadiabatic transitions are known to be major loss channels for atoms in magnetic traps. Nonadiabatic transitions are also one of the three mechanisms through which polar molecules can get lost from an electrostatic trap, beside collisions and pumping by black-body radiation, but have thus far not been experimentally reported upon for trapped molecules. We have observed and quantified losses due to nonadiabatic transitions for three isotopologues of ammonia in electrostatic traps, by comparing the trapping times in traps with a zero and a non-zero electric field at the center. Nonadiabatic transitions are seen to dominate the overall loss rate even for samples at relatively high temperatures of 10-50 mK. In this talk we will introduce our Ioffe-Pritchard type electrostatic trap and we will present our experimental and theoretical results to understand nonadiabatic transitions in ammonia.

MO 11.2 Di 14:15 VMP 6 HS-G

Electric Cooling of Polar Molecules — ●MARTIN ZEPPENFELD, MICHAEL MOTSCH, CHRISTIAN SOMMER, PEPIJN W.H. PINKSE, and GERHARD REMPE — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching, Germany

An experimentally realizable scheme to cool molecules into the sub mK regime is presented. Aspects of the scheme which are considered include cooling rates, trap design and selection of suitable molecular transitions. Basic rate equations show cooling from 1K to below 100mK in 1s and cooling to below 1mK in under 10s. During this time, the molecules are enclosed in an electric trap which can be loaded with molecules from an effusive source/quadrupole guide combination as developed in our group [1]. Depending on the implementation, cooling of both internal and external molecular degrees of freedom is possible as well as an accumulation scheme, increasing the density while keeping temperature constant.

[1] T. Junglen *et al.*, *Eur. Phys. J. D* **31**, 365 (2004)

MO 11.3 Di 14:30 VMP 6 HS-G

Cavity-enhanced Rayleigh scattering — ●MICHAEL MOTSCH, MARTIN ZEPPENFELD, PEPIJN W.H. PINKSE, and GERHARD REMPE — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching, Germany

In recent years, the field of cold and ultracold polar molecules has received a lot of attention. Sensitive, non-destructive detection techniques for molecules would be of great help for different applications. Optical cavities facilitate such detection, as has been demonstrated with atomic systems. However, the transition from atoms to molecules is not straightforward, due to the complex internal structure of molecules.

Here, we make a first step towards cavity-based detection of cold molecules. We report on measurements of cavity-enhanced Rayleigh scattering into an optical Fabry-Perot resonator using several room-temperature atomic and molecular gases. The laser light is far detuned from any optical transition. The observed enhancement factors of up to 38 are in good agreement with theoretical predictions based on the classical model of a driven oscillator and light waves interfering inside the cavity. Conclusions for applications of this method to non-destructive detection of cold molecules are drawn.

MO 11.4 Di 14:45 VMP 6 HS-G

Electrostatic Extraction of Molecules from a Cryogenic Buffer Gas — ●CHRISTIAN SOMMER, LAURENS D. VAN BUUREN, MICHAEL MOTSCH, SEBASTIAN POHLE, JOSEF BAYERL, PEPIJN W.H. PINKSE, and GERHARD REMPE — Max-Planck-Institut für Quantenoptik, D-85748 Garching, Germany

We report a new method to produce a high flux, electrically guided beam of cold and slow polar molecules based on buffer-gas cooling and electrostatic velocity filtering. In our setup room-temperature molecules are injected into a cryogenic helium buffer gas. By collisions with the helium, the external and internal degrees of freedom of the molecules are cooled. A fraction of the cold molecules is extracted by

an electrostatic quadrupole guide and transported to a high-vacuum region. There, the molecules are detected by a residual gas analyzer, to determine the flux as well as the velocity distribution of the guided molecules [1]. The internal state population is monitored by depletion spectroscopy [2]. For H₂CO, we find more than 80% of the guided molecules in a single rovibrational state [3].

[1] C. Sommer *et al.*, arXiv:0812.1923 (2008)[2] M. Motsch *et al.*, *Phys. Rev. A* **76**, 61402(R) (2007)[3] L.D. Van Buuren *et al.*, arXiv:0806.2523 (2008)

MO 11.5 Di 15:00 VMP 6 HS-G

Cold guided beams of water isotopologues — ●LAURENS D. VAN BUUREN, MICHAEL MOTSCH, CHRISTIAN SOMMER, MARTIN ZEPPENFELD, PEPIJN W.H. PINKSE, and GERHARD REMPE — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching, Germany

Electrostatic velocity filtering and guiding is an established technique to produce high fluxes of cold polar molecules [1]. The method is applicable to all polar molecules, but the beam characteristics depend strongly on the Stark shift properties of the molecules. In the experiment, we produce cold guided beams of the three water isotopologues H₂O, D₂O and HDO at temperatures of the order of 1 K. Their different rotational constants and orientations of electric dipole moments lead to remarkably different Stark shift properties, despite the molecules being very similar in a chemical sense. Therefore, the signals of the guided water isotopologues differ on an absolute scale and also exhibit characteristic electrode voltage dependencies. We find excellent agreement between the relative guided fractions and voltage dependencies of the investigated isotopologues and predictions made by our theoretical model of electrostatic velocity filtering [2].

[1] T. Junglen *et al.*, *Eur. Phys. J. D* **31**, 365 (2004)[2] M. Motsch *et al.*, arXiv:physics/0809.1728 (2008)

MO 11.6 Di 15:15 VMP 6 HS-G

Translational cooling and storage of protonated proteins in an ion trap at subkelvin temperatures — ●DAVID OFFENBERG, CHAOBO ZHANG, CHRISTIAN WELLERS, BERNHARD ROTH, and STEPHAN SCHILLER — Institut für Experimentalphysik, Heinrich-Heine-Universität Düsseldorf, 40225 Düsseldorf, Germany

The remarkable advances in the development of techniques for producing cold molecules (< 1 K) enabled studies of light-molecule, atom-molecule, and molecule-molecule interactions in a temperature regime that has not been accessible previously. So far, complex molecules, like biomolecules or anorganic clusters, have been studied in ion traps using buffer gas cooling, with lowest temperatures of ≈ 10 K. Recently we have reported on a technique for translationally cooling polyatomic molecular ions of mass 410 Da produced by electrospray ionization (ESI) to less than 140 mK via their mutual Coulomb interaction with laser-cooled ¹³⁸Ba⁺ ions in a linear quadrupole trap [1]. We have extended this approach to proteins. In one case, an ensemble of 53 cytochrome c molecules (mass ≈ 12390 amu, protonation charge +17 e) was cooled by ≈ 160 laser-cooled barium ions to less than 0.75 K secular temperature [2]. The temperature was determined by comparing experimentally acquired images of the Ba⁺/cytochrome⁺¹⁷ ion ensembles with those from molecular dynamics simulations. Storage times of more than 20 minutes have been observed. This technique is applicable to a wide variety of complex molecules.

[1] A. Ostendorf *et al.*, *Phys. Rev. Lett.* **97**, 243005 (2006)[2] D. Offenbergl *et al.*, *Phys. Rev. A* **78**, 061401(R) (2008)

MO 11.7 Di 15:30 VMP 6 HS-G

Measurement of small photodestruction rates of cold, charged biomolecules in an ion trap — ●DAVID OFFENBERG, CHRISTIAN WELLERS, CHAOBO ZHANG, BERNHARD ROTH, and STEPHAN SCHILLER — Institut für Experimentalphysik, Heinrich-Heine-Universität Düsseldorf, 40225 Düsseldorf, Germany

Photodestruction spectroscopy is a common tool to gain information on structures of biomolecules or to study the energetics and pathways of fragmentations. The investigation of these processes on cooled molecular ions in ion traps provides advantageous conditions. Through the long storage times here, the time scale of observable destruction processes can be extended to rates smaller than 1 s⁻¹ that are not

accessible with non-trapping approaches. In future, by internal cooling the trapped molecules, spectral congestion and inhomogeneous line broadening can be reduced and photodestruction spectra of high resolution can be obtained. We have demonstrated two techniques for the measurement of photodestruction rates on singly protonated molecules of the organic compound glycyrrhetic acid ($C_{30}H_{46}O_4$) in a linear ion trap, dissociated by a continuous-wave UV laser (266 nm) at different intensities [1]. The molecules were sympathetically cooled by simultaneously trapped laser-cooled barium ions to translational temperatures < 150 mK. Destruction rates of less than 0.05 s^{-1} and a cross section of $(1.1 \pm 0.1) \cdot 10^{-17} \text{ cm}^2$ have been determined. An extension to tunable UV laser sources would permit high-resolution dissociation spectroscopic studies on a wide variety of cold complex molecules.

[1] D. Offenberg et al., to appear in J. Phys. B, arXiv:0810.5097v2

MO 11.8 Di 15:45 VMP 6 HS-G

Rotational and fine-structure resolved fragmentation energies in HF^+ reactions with cold electrons — ●JULIA STÜTZEL¹, OLDŘICH NOVOTNÝ¹, JENS HOFFMANN¹, SIMON ALTEVOGT¹, MAX H. BERG¹, DENNIS BING¹, MICHAEL FROESE¹, MANFRED GRIESER¹,

BRANDON JORDON-THADEN¹, CLAUDE KRANTZ¹, MICHAEL LANGE¹, MARIO MENDES¹, STEFFEN NOVOTNY¹, DIMITRY A. ORLOV¹, ANNE-MIEKE PETRIGNANI¹, SASCHA REINHARDT², TOBIAS SORG¹, HENRIK BUHR³, and ANDREAS WOLF¹ — ¹Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany — ²Max Planck Institut für Quantenoptik, Hans-Kopfermann-Str. 1 85748 Garching, Germany — ³Department of Particle Physics, Weizmann Institute of Science, 76100 Rehovot, Israel

The dissociative recombination (DR) of $HF^+ + e \rightarrow H(n=2) + F$ has been investigated at the storage ring TSR. With the HF^+ dissociation energy being equal to the binding energy of the $H(n=2)$ product within the rotational energy spread, we were able to resolve for the first time directly the individual rotational levels of HF^+ in the fragment energy spectrum of DR (lowest kinetic energy release ~ 4 meV). For this we measured the projected distance of the neutral fragments on a fragment-imaging detector behind an interaction region with meV electron collisions in merged beams. Modelling the data yielded the electron temperature and provided a highly precise value of the HF^+ dissociation energy with an error below 1 meV.