

MO 4: Cold Molecules 1

Time: Monday 14:30–16:30

Location: PH/SR106

MO 4.1 Mon 14:30 PH/SR106

Trapping of polar molecules in a segmented electrostatic quadrupole guide — •THOMAS GANTNER, JANNIK LUHN, XING WU, SOTIR CHERVENKOV, MARTIN ZEPPENFELD, and GERHARD REMPE — Max-Planck-Institut für Quantenoptik, 85748 Garching, Germany

We present a simple and robust method for trapping of neutral polar polyatomic molecules in an electrostatic quadrupole guide. A beam of polar molecules from a liquid-nitrogen-cooled nozzle is injected into an electrostatic quadrupole guide [1] consisting of four consecutive segments. One of those segments is used as a trap and thus intrinsically provides a two-dimensional transverse confinement for the molecules. To capture the molecules in the third dimension, along the guide, the segments before and after the trap are switched in a way to provide electrostatic potential barriers in the longitudinal direction. Thereby, we have achieved trapping of CH_3F molecules with a trap lifetime of about 170 ms. By implementing a more advanced guide switching scheme, we expect to boost the absolute number of trapped molecules as well as the trapping lifetime. As electrostatic guiding is well-established for various polar polyatomic molecules [2], the trap-in-guide technique is easily applicable to other species, providing a means to study electrically guided molecules, e.g., probing them spectroscopically.

References

- [1] S.A. Rangwala et al., *Phys. Rev. A* **67**, 043406 (2003)
 [2] C. Sommer et al., *Phys. Rev. A* **82**, 013410 (2010)

MO 4.2 Mon 14:45 PH/SR106

Internal state thermometry of buffer-gas cooled and electrically guided polar molecules — •XING WU, THOMAS GANTNER, SOTIR CHERVENKOV, MARTIN ZEPPENFELD, and GERHARD REMPE — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, D-85748 Garching, Germany

We present a general technique for detecting the internal states of polyatomic molecules after cryogenic buffer-gas cooling [1] and electrostatic guiding [2]. Bright beams of polar molecules produced by a cryogenic buffer-gas cell are extracted by electric quadrupole guiding, and delivered to a region of homogeneous offset electric field, where different Stark sub-levels are split. Applying an RF field resonant with a particular splitting drives $\Delta M = \pm 1$ transitions for the selected rotational state. Only molecules remaining in low-field-seeking states are further guided to a quadrupole mass spectrometer for detection. The population in each rotational state can be derived from this depletion signal. After taking into account the velocity distribution in the guide and the Stark shift of each state, internal temperatures can be assigned to the guided molecular beams. This method is extremely simple to implement and compatible with the existing electric guiding technique. Application to a variety of molecular species as well as for a range of parameters for the buffer-gas source is shown.

- [1] L.D. van Buuren et al., *Phys. Rev. Lett.* **102**, 033001 (2009)
 [2] S.A. Rangwala et al., *Phys. Rev. A* **67**, 043406 (2003)

MO 4.3 Mon 15:00 PH/SR106

IR and UV-NIR absorption spectroscopy of matrix isolated $\text{C}_{70}^{+/-}$: theory breaks down. — •DMITRY STRELNIKOV, BASTIAN KERN, ARTUR BÖTTCHER, PATRICK WEIS, and MANFRED M. KAPPES — Institute of physical chemistry II, KIT, Fritz-Haber-Weg 2, Karlsruhe, Germany

Fullerene C_{70} ions have recently become of interest to the astronomy community and are also relevant in the field of organic photovoltaics. C_{70}^+ ions were mass-selectively deposited into a neon matrix at 5 K. Like in the case of C_{60}^+ deposition [1], soft landing into neon is associated with some charge exchange processes such that C_{70}^+ as well as resulting C_{70} and C_{70}^- can be probed simultaneously. In contrast to a very good coincidence of the experimental and DFT-calculated IR spectra of $\text{C}_{60}^{+2+/-}$ [1, 2], DFT predictions for $\text{C}_{70}^{+/-}$ IR absorptions strongly deviate from our measurements. A possible explanation for this could be low lying electronically excited states of $\text{C}_{70}^{+/-}$ in the vicinity of vibrational energy levels. The corresponding non-Born-Oppenheimer case is likely of significant interest to theory.

References:

1. B. Kern, D. Strelnikov, P. Weis, A. Böttcher, M. M. Kappes. *J. Phys. Chem. A* **2013**, *117*, 8251–8255.
 2. B. Kern, D. Strelnikov, P. Weis, A. Böttcher, M. M. Kappes. *J. Phys. Chem. Lett.* **2014**, *5*, 457–460.

MO 4.4 Mon 15:15 PH/SR106

Rotational state-changing cold collisions of hydroxyl ions with helium — •DANIEL HAUSER, SEUNGHYUN LEE, FABIO CARELLI, STEFFEN SPIELER, OLGA LAKHMANSKAYA, ERIC ENDRES, SUNIL KUMAR, FRANCO GIANTURCO, and ROLAND WESTER — Institute for Ion Physics and Applied Physics, University of Innsbruck, 6020 Innsbruck, Austria

Sympathetic collisions with cold atoms and atomic ions are widely used to prepare translationally cold molecules and molecular ions. Inelastic collisions with neutral atoms have proven to be a general approach to cool internal degrees of freedom [1,2]. Here we present a new scheme to measure the absolute quantum scattering rate coefficients for the rotationally inelastic collision of hydroxyl anions and their deuterium-containing counterparts upon interaction with helium in a multipole radio-frequency ion trap. The measured rates and the ab initio quantum scattering calculations agree very well with each other. With the methods developed, improved quantum state-preparation of molecular ions for precision spectroscopy or quantum information research is achieved.

- [1] R. Otto, A. von Zastrow, T. Best and R. Wester, *2013 Physical Chemistry Chemical Physics* **15** 612-618 (2013)
 [2] A. K. Hansen, O. O. Versolato, L. Klosowski, S. B. Kristensen, A. Gingell, M. Schwarz, A. Windberger, J. Ullrich, J. R. C. Lopez-Urrutia, M. Drewsen, *Nature* **508**, 76-79 (2014).

MO 4.5 Mon 15:30 PH/SR106

The Characterization of Complex Carbohydrates in Liquid Helium Nanodroplets using IR Spectroscopy — •CHRISTIANE STACHL¹, JOHANNA HOFMANN¹, HEUNG SIK HAHM², PETER SEEBERGER², KEVIN PAGEL¹, and GERT VON HELDEN¹ — ¹Fritz-Haber-Institut der MPG, Berlin, Germany — ²Max-Planck-Institut für Kolloid- und Grenzflächenforschung, Potsdam, Germany

Complex carbohydrates are typically characterized using mass spectrometry (MS)-based techniques. However, because the atomic composition of entire classes of monosaccharide building blocks is identical, it has proven difficult to differentiate the molecular structure of these biomolecules based on MS data alone. To overcome this fundamental problem, ion mobility-MS has been used to separate carbohydrates of identical mass but different structure according to their collision cross sections [1]. Conversely, it also is possible to use gas-phase infrared spectroscopy to gain additional information regarding the structure of complex carbohydrates. Ideal matrices in which to do this are liquid helium droplets, which are isothermal at 0.37 K, interact only weakly with an embedded molecule, and are transparent over a wide spectral range [2]. Here, we present the cold-ion IR spectroscopy of complex carbohydrates doped in liquid helium droplets using the Fritz-Haber-Institut free electron laser. We show that a nano-cryostat environment is an idyllic method to better resolve differences in the conformations of complex carbohydrates. [1] Pagel, K., Harvey, D. J., *Anal. Chem.*, **2013**, *85*, 5138. [2] Toennies, J. P., Vilesov, A. F., *Angew. Chem. Int. Ed.*, **2004**, *43*, 2622.

MO 4.6 Mon 15:45 PH/SR106

The cross-over from free to hindered rotation in liquid helium — LUIS G. MENDOZA LUNA¹, NAGHAM SHILTAG¹, MARK J. WATKINS¹, •KLAUS VON HAEFTEN¹, NELLY BONIFACI², and FREDERIC AITKEN² — ¹Department of Physics and Astronomy, University of Leicester, Leicester, LE1 7RH, UK — ²G2ELab-CNRS Equipe MDE 25 Av. des Martyrs BP 166, 38042 Grenoble Cedex 9 France

The observation of free rotation of single molecules in superfluid helium droplets 20 years ago has caused considerable interest. To better understand free rotation in quantum fluids we have investigated the rotational motion of single molecules in bulk liquid helium as a function of hydrostatic pressure and temperature using fluorescence spectroscopy in the visible region. A corona discharge was employed to generate electronic excitations in liquid helium. He_2^* excimers formed and decayed via cascade-radiative transitions to the ground state. During

their short life the excimers do not aggregate, hence, molecular interactions in bulk liquid helium can be conveniently probed. At low hydrostatic pressures well-resolved rotational lines, indicating free rotation of He_2^* within liquid helium, are observed. When the hydrostatic pressure is increased the rotational lines broaden until they disappear around 6 bar. The line width depends distinctly on pressure and rotational excitation and is attributed to the reduced space available to the molecule to perform rotational motion. Our results are contrasted with the findings of molecular infrared spectroscopy in helium droplets. The microscopic origin of free molecular rotation in liquid helium is discussed.

MO 4.7 Mon 16:00 PH/SR106

Traveling-wave deceleration of SrF molecules — ●SREEKANTH MATHAVAN, JOOST VAN DEN BERG, CORINE MEINEMA, ARTEM ZAPARA, KLAUS JUNGMANN, RONNIE HOEKSTRA, and STEVEN HOEKSTRA — University of Groningen, The Netherlands

We work on the development of methods to cool and trap selected diatomic molecules suited for precision measurements, exploiting the long coherence time offered by cold, trapped molecules.

Traditional stark decelerators are inefficient for the deceleration of heavy diatomics such as SrF, due to instabilities. We have built a traveling-wave decelerator in our lab for the deceleration of heavy diatomics, which is inherently stable. We are improving the molecular source in order to achieve optimal rotational cooling and molecular density. Following the deceleration, we will laser cool the molecules to prepare them for a parity violation measurement.

We present the status of the experiment and present the first results on the deceleration of SrF molecules in a traveling-wave decelerator

MO 4.8 Mon 16:15 PH/SR106

Superradiance of Organic Molecules Attached to the Surface of Solid Neon Cluster — ●SHARAREH IZADNIA, MARKUS MÜLLER, AARON LAFORGE, and FRANK STIENKEMEIER — Physikalisches Institut, Universität Freiburg, Hermann-Herder-Str.3 ,79104 Freiburg

Superradiance [1] is a collective effect where all excited states simultaneously emit radiation. This can lead to a reduced effective lifetime and an enhancement in the radiative intensity, which has been observed almost universally in weakly interacting systems such as hot dense gases [2] and films [3] and Bose-Einstein-Condensates [4]. Recently, we observed a new superradiative system where large immobile chromophores (e.g. tetracene, pentacene, PTCDA) attached to the surface of neon clusters exhibit the characteristic lifetime shortening of superradiance.

In this talk, we will present absorption spectra, emission spectra, and fluorescence lifetime measurements which indicate the first observation of superradiance in such a system.

[1] R. H. Dicke, Phys. Rev. 93, 99 (1954).

[2] N. Skribanowitz, I. P. Herman, J. Macgilli, and M. S. Feld, Phys. Rev. Lett. 30, 309 (1973).

[3] M. Müller, A. Paulheim, A. Eisfeld, and M. Sokolowski, J. Chem. Phys. 139, 044302 (2013).

[4] D. Schneble, Y. Torii, M. Boyd, E. W. Streed, D. E. Pritchard, and W. Ketterle, Science 300, 475 (2003).