MO 5: Cold Molecules I

Time: Monday 14:00–16:00 Location: F 107

MO 5.1 Mon 14:00 F 107

A centrifuge decelerator for continuous beams of cold polar molecules — •Xing Wu, Sotir Chervenkov, Joseph Bayerl, Andreas Rohlfes, Martin Zeppenfeld, and Gerhard Rempe — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching, Germany

We present the concept of and the first experimental results from a decelerator for continuous beams of neutral polar molecules, which employs the centrifugal potential in a rotating frame. A beam of polar molecules is injected at the periphery and electrically guided [1] to the center of the rotating frame along a spiral trajectory. Thus the molecules climb up the centrifugal potential hill and get decelerated as they propagate. Since the rotation speed is tunable, the centrifuge decelerator is well-suited for a large range of input velocities. In a proof-of-principle experiment we demonstrate the deceleration of a neutral CF_3H beam from an effusive source at room temperature, yielding a continuous output with a flux of several 10^9/s for molecules with velocities below 20m/s. Moreover, in combination with our cryogenic source [2,3], deceleration of dense and internally cold molecular beams is conceivable. This could provide an ideal source of cold and slow molecules for various experiments and applications, in particular, for trapping and subsequent opto-electrical cooling [4].

[1] S.A. Rangwala *et al.*, Phys. Rev. A **67**, 043406 (2003)
[2] L.D. van Buuren *et al.*, Phys. Rev. Lett. **102**, 033001 (2009)
[2] C. Sommer *et al.*, Faraday Discuss. **142**, 203 (2009)
[4] M. Zeppenfeld *et al.*, Nature **491**, 570 (2012)

MO 5.2 Mon 14:15 F 107

Microwave manipulation of neutral polar molecules — •Simon Merz[1,2], Nicolas Vanhaecke[3], Gerard Meijer[3], and Melanie Schnell[1,2] — [1]Center for Free-Electron Laser Science, 22607 Hamburg — [2]Max-Planck-Institut für Kernphysik, 69117 Heidelberg — [3]Fritz-Haber-Institut der Max-Planck-Gesellschaft, 14195 Berlin

An important remaining challenge in the field of cold molecules is a general technique to manipulate the motion of polar molecules in high-field-seeking states. This is a crucial step towards control of cold molecules in their ground states and of all large and more complex molecules. As an interesting alternative to the already demonstrated and experimentally rather demanding alternating gradient methods, we use the interaction of polar molecules with near resonant microwave radiation.

Here, we present the latest results of our microwave decelerator [1], and we will show full control over the longitudinal phase space distribution of a slow packet of ammonia molecules. Furthermore, the next steps towards efficient microwave trapping will be discussed.

[1] S. Merz et al. Decelerating molecules with microwave fields. Phys. Rev. A. **85**:063411 (2012).

MO 5.3 Mon 14:30 F 107

Decelerating and trapping molecules with a travelling wave decelerator — •Joost van den Berg[1], Marina Quintero-Pérez[2], Paul Jansen[2], Thomas E. Wall[2], Hendrick L. Bethlem[2], Sreekanth Mathavan[1], Corine Meinema[1], Tom Nijbroek[1], and Steven Hoekstra[1] — [1]University of Groningen, KVI, The Netherlands — [2]LaserLab, Department of Physics and Astronomy, VU University Amsterdam, The Netherlands

We present the deceleration and trapping of ammonia molecules using a travelling potential, and show our progress towards the deceleration and trapping of SrF molecules using this technique. The molecules are captured from a supersonic expansion by a trap that moves along with the molecules. The trap is created by applying oscillating potentials on a series of ring-shaped electrodes. By reducing the oscillation frequency this moving trap, with the molecules in it, is brought to a standstill. This method of deceleration allows a new class of molecular species to be decelerated and trapped, leads to larger numbers of trapped molecules, and makes new manipulation schemes possible.

MO 5.4 Mon 14:45 F 107

Stark deceleration of polar molecules with optimum efficiency — •Dongdong Zhang[1], Nicolas Vanhaecke[1,2], and Gerard Meijer[1] — [1]Fritz-Haber-Institut der Max-Planck-Gesellschaft, Faradayweg 4-6, 14195 Berlin, Germany — [2]Laboratoire Aimé Cotton, CNRS, Université Paris-Sud, 91405 Orsay, France

Over the last two decades, several techniques have been developed and have demonstrated their ability to produce slow, cold molecular ensembles. Among them, Stark deceleration has become one of the most successful and versatile methods to study and use cold molecules [1,2].

In this work we revisit the operation of the Stark decelerator and present a new, optimized operation scheme, which substantially improves the efficiency of the decelerator at both low and high velocities, relevant for trapping experiments and collision experiments, respectively. Both experimental and simulation results show that this new mode of operation outperforms the schemes which have hitherto been in use. This new mode of operation could potentially be extented to other deceleration techniques.

[1] H. L. Bethlem, G. Berden, and G. Meijer, Phys. Rev. Lett. 83, 1558 (1999).
[2] S. Y. T. van de Meerakker, H. L. Bethlem, N. Vanhaecke and G. Meijer, Chem. Rev. 112, 4828 (2012)

MO 5.5 Mon 15:00 F 107

Exciting polar molecules trapped on a chip — •Silvio Marx, Mark Abel, David Adu Smith, Gerard Meijer, and Gabriele Santambrogio — Fritz-Haber-Institut der Max-Planck-Gesellschaft, Faradayweg 4-6, 14195 Berlin, Germany

Over the last decade Stark decelerators have proven to be an important tool for the manipulation of external degrees of freedom of neutral polar molecules. Our chip-based Stark decelerators offer many advantages over macroscopic designs; among these advantages are relatively low voltage requirements, high field gradients, and tight spatial confinement of polar molecules. In addition, the simultaneous manipulation of internal degrees of freedom is necessary to gain full control over molecular motion. Here we demonstrate our ability in switching rotational and vibrational quantum states of CO molecules trapped above the chip. Moreover, we present the latest progress towards the direct spatial imaging of the trapped molecules.

MO 5.6 Mon 15:15 F 107

Towards Cold Chemistry with Magnetically Decelerated Hydrogen Atoms — •Katrin Dulitz[1], Michael Motsch[2], Nicolas Vanhaecke[3,4], and Timothy P. Softley[1] — [1]Department of Chemistry, University of Oxford, Chemistry Research Laboratory, Mansfield Road, Oxford, OX1 3TA, UK — [2]Laboratorium für Physikalische Chemie, ETH Zürich, Wolfgang-Pauli-Straße 10, 8093 Zürich, Switzerland — [3]Fritz-Haber-Institut der Max-Planck-Gesellschaft, Faradayweg 4-6, 14195 Berlin, Germany — [4]Laboratoire Aimé Cotton, CNRS, Université Paris-Sud, ENS Cachan, 91405 Orsay, France

Zeeman deceleration is an experimental technique which makes it possible to manipulate the velocity of open-shell atoms and molecules in a supersonic beam [1, 2]. The method is based on the Zeeman interaction between paramagnetic particles and time-dependent, inhomogeneous magnetic fields generated by pulsing high currents through an array of solenoid coils. Here, we present progress on the deceleration of hydrogen atoms in a 12-stage Zeeman decelerator that is being set up in Oxford. Results from previous Zeeman deceleration experiments [3] strongly suggest that nonadiabatic transitions, induced by a rapid reversal of the magnetic field direction, can lead to a significant loss of decelerated particles. Experiments to further quantify these effects are currently underway.

[1] N. Vanhaecke et al., Phys. Rev. A **75**, 031402 (2007). [2] E. Narevicius et al., Phys. Rev. A **77**, 051401 (2008). [3] S.D. Hogan et al., Phys. Rev. A **76**, 023412 (2007).

MO 5.7 Mon 15:30 F 107

Reaching for Ultracold Temperatures with Polyatomic Molecules — •Martin Zeppenfeld, Barbara G.U. Englert, Rosa Glöckner, Alexander Prehn, Martin Ibrügger, and Gerhard Rempe — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching, Germany

Many of the fascinating applications of cold and ultracold polar molecules require chemically diverse species. Here, optoelectrical Sisyphus cooling [1] presents a unique opportunity to even cool ensembles of polyatomic molecules. Using only a single infrared laser along with

additional microwave and radio frequencies, a wide range of molecule species stored in an electric trap [2] can be cooled. As a first result [3], we have achieved a temperature reduction by more than an order of magnitude to 29 mK of about a million CH_3F molecules. Present efforts to increase the cooling rate, reduce losses, and increase the number of detected molecules should allow sub-mK temperatures to be achieved with polyatomic molecules for the first time.

[1] M. Zeppenfeld *et. al.*, *Phys. Rev. A* **80**, 041401 (2009).
[2] B.G.U. Englert *et al.*, *Phys. Rev. Lett.* **107**, 263003 (2011).
[3] M. Zeppenfeld *et al.*, *Nature* **491**, 570-573 (2012).

MO 5.8 Mon 15:45 F 107

Towards parity violation measurements using ultra-cold SrF molecules — •Corine Meinema, Joost van den Berg, Sreekanth Mathavan, Tom Nijbroek, Klaus Jungmann, Lorenz Willmann, and Steven Hoekstra — University of Groningen, KVI, The Netherlands

We present our progress towards the creation of an ultra cold sample of SrF molecules. These molecules combine a high sensitivity for the detection of parity violation with favourable Stark shifts and good properties for laser cooling. By combining a supersonic expansion, a novel travelling wave stark decelerator and laser cooling we aim to create ultra cold molecules that we will use to test the Standard Model of particle physics.