MO 16: Cold Molecules II

Time: Wednesday 14:30–16:00 Location: BAR Schön

MO 16.1 Wed 14:30 BAR Schön

A Molecular Synchrotron — •Peter C. Zieger[1], Sebastiaan Y. T. van de Meerakker[1], Hendrick L. Bethlem[2], André J. A. van Roij[3], and Gerard Meijer[1] — [1]Fritz-Haber-Institut der Max-Planck-Gesellschaft, Berlin, Germany — [2]Laser Centre Vrije Universiteit, Amsterdam, The Netherlands — [3]Institute for Molecules and Materials, Radboud University Nijmegen, Nijmegen, The Netherlands

With a Stark decelerator it is possible to produce beams of cold neutral polar molecules with a tunable velocity that are well suited for molecular beam scattering studies. One can load these beams into a molecular synchrotron; this offers particularly interesting prospects for these kinds of scattering experiments. In principle, a storage ring allows for the confinement of multiple packets of molecules that repeatedly interact in a circle, thereby, significantly increasing the sensitivity of molecular collision experiments. We present a molecular synchrotron consisting of 40 straight hexapoles that allows the simultaneous confinement of multiple packets moving clockwise and counter clockwise. We will explain the operation principle of the synchrotron and present our latest experiment, where multiple molecular packets are confined over a flight length of one mile [1]. Recently a second Stark decelerator beamline was built to enable the injection of multiple counter-propagating packets in the synchrotron. These measurements epitomize the level of control that can now be achieved over molecular beams and brings a low-energy molecular collider within close reach.

[1] P.C. Zieger, S.Y.T. van de Meerakker, C.E. Heiner, H.L. Bethlem, A.J.A. van Roij, G. Meijer, PRL 105, 173001 (2010)

MO 16.2 Wed 14:45 BAR Schön

Millimeter wave control over neutral molecules in a Stark decelerator — •Mark Abel[1], Gabriele Santambrogio[1], Samuel Meek[1], Liam Duffy[2], and Gerard Meijer[1] — [1]Fritz-Haber-Institut der Max-Planck-Gesellschaft, 4-6 Faradayweg, 14195 Berlin — [2]Department of Chemistry and Biochemistry, University of North Carolina at Greensboro, Greensboro NC, 27402, USA

Stark- and Zeeman-based decelerators have shown much promise as a route to the full quantum state control of cold neutral molecular samples. Here, we combine Stark deceleration and trapping using a microstructured electrode array with internal state control using a coherent millimeter-wave source. The millimeter wave radiation is coupled to the molecules only microns from the trap electrodes, switching their quantum state. Such on-chip manipulations constitute an important step for future chip-based molecular devices.

MO 16.3 Wed 15:00 BAR Schön

Focusing metastable CO molecules with an elliptical electrostatic mirror — •Ana Isabel González Flórez, Gabriele Santambrogio, Samuel A. Meek, Horst Conrad, and Gerard Meijer — Fritz-Haber-Insitut der Max-Planck-Gesellschaft, Faradayweg 4-6, D-14195 Berlin, Germany

Focusing optics for polar molecules finds application in shaping, steering and confining molecular beams. Here we present an elliptical mirror for polar molecules consisting of an array of microscopic gold electrodes deposited on a glass substrate. Alternating voltages applied to the electrodes create a repulsive potential for polar molecules in low field seeking states. The equipotential lines are parallel to the substrate, which is bent in an elliptical shape, allowing to focus the molecules from one focal point into the other. The reflectivity of the mirror depends on the voltages applied, on the quantum state of the molecules, and on their velocity. The dependence of the focusing properties of the mirror on these three variables was studied and the results agree with our numerical simulations.

MO 16.4 Wed 15:15 BAR Schön

Multistage Zeeman Deceleration of Metastable Neon — •Michael Motsch, Alex W. Wiederkehr, Stephen D. Hogan, and Frédéric Merkt — Laboratorium für Physikalische Chemie, ETH Zürich, CH-8093, Switzerland

Multistage Zeeman deceleration exploits the interaction between paramagnetic atoms or molecules and pulsed magnetic fields to slow a supersonic beam of these particles in a phase-stable manner. We start by exciting Ne atoms to the metastable $^3P_2$ state with a DC discharge in the expansion region behind a pulsed gas nozzle. Using 91 deceleration solenoids, we slow Ne* atoms to velocities as low as 120 m/s, thereby removing up to 95 % of the initial kinetic energy. We characterize the cold sample of Ne* atoms with a time-of-flight technique, investigate the efficiency of the deceleration process, and discuss the possibility to extend the technique to other species.

MO 16.5 Wed 15:30 BAR Schön

The alternating-gradient m/μ-selector — •Stephan Putzke[1], Frank Filsinger[1], Jochen Küpper[1,2,3], and Gerard Meijer[1] — [1]Fritz-Haber-Institut der MPG, Berlin — [2]Center for Free-Electron Laser Science, DESY, Hamburg — [3]Universität Hamburg

Over the last years we have developed and applied methods for the manipulation of the motion of large and complex molecules. Because all states are high-field seeking at the relevant field strengths, alternating gradient (dynamic) focusing has to be applied [1]. Polar molecules in different quantum states or conformers, exhibiting a sufficently different Stark effect, can be filtered selectively. This method has been succesfully used for the conformer selection of 3-aminophenol in a m/μ-selector [2]. The resolution can be improved by changing the duty-cycle of the half-periods in the switching cycle [3].

Here we present results obtained with a newly set up second generation AG guide. We investigate the transmission of individual rotational quantum states of benzonitrile (C_7H_5N), a prototypical large polar molecule. The transmission and the m/μ-resolution are considerably improved by the new setup. It employs both, longer electrodes – allowing more switching cycles – and an improved alignment. It now becomes possible to filter almost all quantum states out of the beam and to prepare a nearly pure ground-state sample of benzonitrile.

[1] D. Auerbach et al., J. Chem. Phys. **45**, 2160 (1966); H. L. Bethlem et al., J. Phys. B **39**, R263 (2006)
[2] F. Filsinger et al., Phys. Rev. Lett. **100**, 133003 (2008)
[3] F. Filsinger et al., Phys. Rev. A **82**, 052513 (2010)

MO 16.6 Wed 15:45 BAR Schön

Microwave lens: Focusing properties and potential losses — •Simon Merz[1], Claudia Brieger[1], Gerard Meijer[1], and Melanie Schnell[2] — [1]Fritz-Haber-Institut der Max-Planck-Gesellschaft, D-14195 Berlin — [2]Max-Planck Advanced Study Group at CFEL, D-22607 Hamburg

To manipulate the motion of polar molecules in high-field-seeking states, which is important for molecules in their ground states and for basically all larger and more complex molecules, time-dependent methods such as AC focusing and trapping and alternating-gradient (AG) deceleration have to be employed. Besides electric fields, electromagnetic radiation can be used, such as laser and microwave fields.

We have recently demonstrated a microwave lens for polar molecules in high-field-seeking states [1] that can be used to focus molecules. We investigated the focusing properties as a function of the microwave mode structure, the microwave input power, the detuning and the molecules' velocity, and also studied some potential loss mechanisms. A detailed understanding is necessary for future experiments on microwave deceleration and trapping using an open Fabry-Pérot type resonator.

[1] H. Odashima et al. Microwave Lens for Polar Molecules. *Phys. Rev. Lett.*, 104:253001, 2010