MO 6: Poster: Cold Molecules

Time: Monday 16:00–18:00 Location: P1

MO 6.1 Mon 16:00 P1

Using cold molecules to detect molecular parity violation — •Joost van den Berg, Samuel Hoekman Turkesteen, Klaus Jungmann, Eric Prinsen, and Steven Hoekstra — Kernfysisch Versneller Instituut, University of Groningen, The Netherlands

We combine novel experimental techniques to decelerate and cool heavy diatomic molecules, in order to detect and study molecular parity violation. Parity violation has so far never been observed in molecules. Parity-violating effects, originating from the weak interaction, are most pronounced in heavy molecules, and most accurately measured in cold samples of trapped molecules. Stark-deceleration and trapping of heavy molecules is more demanding compared to light molecules such as NH and OH. Using recent advances in Stark-deceleration we set out to decelerate and trap heavy alkaline-earth halide molecules. Initially we focus on the SrF molecule. We are currently working on a supersonic beam of SrF molecules, constructing a Stark-decelerator based on ring electrodes, and exploring the opportunities for molecular lasercooling. Possibilities to use RaF molecules are also being investigated. A new generation of precision measurements to probe fundamental interactions and symmetries is possible once such samples of sufficiently cold molecules are available.

MO 6.2 Mon 16:00 P1

A Centrifuge Molecular Decelerator — •Xing Wu, Sotir Chervenkov, Laurens D. van Buuren, Christian Sommer, Joseph Bayerl, Martin Zeppenfeld, and Gerhard Rempe — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Straße 1, 85748 Garching bei München

We present a new deceleration scheme for neutral polar molecules, which employs the centrifugal potential in a rotating frame. The idea is to launch a continuous beam of polar molecules into a centrifuge decelerator, and electrically guide the molecules [1] from the periphery to the center of the rotating frame along a spiral trajectory. Since the rotational speed is tunable, the centrifuge decelerator can be operated for a wide range of input velocities. The outcoming quasi-continuous, slow, and dense molecular beam is ideal for various applications requiring cold molecules, in particular for loading an electrical trap [2]. In combination with our cryogenic source [3], internally cold molecules will be decelerated. For this setup, simulations show that ammonia beams with velocities below 20 m/s and with fluxes of 10^9 molecules/s are feasible. We also present our efforts to further improve the flux of cold molecules from our cryogenic source.

[1] S.A. Rangwala *et al.*, Phys. Rev. A **67**, 043406 (2003)
[2] M. Zeppenfeld *et al.*, Phys. Rev. A **80**, 041401 (2009)
[3] L.D. van Buuren *et al.*, Phys. Rev. Lett. **102**, 033001 (2009), C. Sommer *et al.*, Faraday Discussions **142**, 203 (2009)

MO 6.3 Mon 16:00 P1

Progress Towards Optoelectrical Cooling of Polar Molecules — •Martin Zeppenfeld, Barbara G.U. Englert, Rosa Glöckner, Manuel Mielenz, Christian Sommer, Laurens van Buuren, Michael Motsch, and Gerhard Rempe — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching, Germany

We present progress towards the experimental realisation of optoelectrical cooling [1], a general laser cooling method for polar molecules. In addition to a microstructured electric trap for the molecules, we have been setting up a suitable IR laser and millimeter-wave system. Referencing the pump and signal of a CW OPO to a frequency comb allows for the generation of high-power IR light over a huge wavelength range from 2600 cm^{-1} to 4000 cm^{-1} with a linewidth and stability far below 1 MHz. This allows the fundamental C-H stretch mode of a large number of molecules to be addressed. Saturation spectroscopy is used to determine the frequencies of the most relevant rovibrational transitions of the test molecule CFH_3 (fluoromethane) to within $\sim$ 100 kHz.

Millimeter-wave radiation at $\sim$ 150 GHz is produced by frequency duodectupling (x12) the output of a microwave synthesizer. This allows the $J = 2$ to $J = 3$ transition of CFH_3 to be addressed. Both the IR as well as the millimeter-wave system have been used to perform depletion spectroscopy of cold molecules in the microstructured trap. Using the ability to tune the homogeneous electric fields inside the trap, Stark spectroscopy can be performed with individual M-sublevels being clearly resolved.

[1] M. Zeppenfeld *et al.*, Phys. Rev. A **80**, 041401(R) (2009)

MO 6.4 Mon 16:00 P1

Improvement of double resonance optical pumping in application of frequency stabilization * — •Yubing Yang — Department of Molecular and Optical Physics, Institute of Physics, Albert-Ludwigs-Universität Freiburg, 79104 Freiburg, Germany

The high-resolution spectrum for ^{87}Rb has been used in applications such as laser frequency stabilization, atomic clocks and laser cooling. A spectrum with a high signal-noise ratio and a narrow line width can be obtained by double resonance optical pumping (DROP) [1]. Compared with optical-optical resonance pumping, the DROP spectrum shows a much better signal-noise ratio and narrower spectral line width.

Based on the $5S_{1/2}$-$5P_{3/2}$-$5D_{3/2}$ ladder-type atomic system, the effects of the combination of laser polarizations, laser power and alignment of the two lasers on the spectrum obtained by DROP are studied theoretically and experimentally. Furthermore, different coupling beam wavelengths and laser beam directions are investigated. In order to improve the spectrum, a new experimental setup of DROP is present and it is shown that this spectrum can be used to stabilize the laser frequency.

[1]H.S.Moon,L.Lee,andJ.B.Kim,J.Opt.Soc.Am.B,24,2157(2007) * supported by China Scholarship Council

MO 6.5 Mon 16:00 P1

Fourier Transform spectroscopy and potential energy curve of the ground state $X^1\Sigma^+$ of NaLi — •Michael Steinke, Horst Knöckel, and Eberhard Tiemann — Centre for Quantum Engineering and Space Time Research (QUEST) und Institut für Quantenoptik, Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover

Investigation of the spectra of diatomic alkali molecules and the spectroscopic observations on singlet and triplet ground states together with Feshbach resonances from cold collisions has turned out to be a useful toolbox for describing and predicting properties of such cold collisions. We report here on a revised description of the ground state $X^1\Sigma^+$ of NaLi. Compared to previous investigations (C.E. Fellows, J. Chem. Phys. 94, 5855 (1991)) we were able to extend the data set to levels closer to the atomic asymptote. In contrast, we were not successful finding excitations by which the triplet ground state could be accessed via fluorescence, mainly due to unfavorable Franck-Condon factors and small spin-orbit interaction of Li. Thus a combined modeling of singlet and triplet ground state is not yet possible. The state of the investigations will be presented.

MO 6.6 Mon 16:00 P1

Fourier Transform spectroscopy and improved potential energy curve of the ground state $X^1\Sigma^+g$ of Na_2 — •Michael Steinke, Horst Knöckel, and Eberhard Tiemann — Centre for Quantum Engineering and Space Time Research (QUEST) und Institut für Quantenoptik, Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover

Investigations of the spectra of diatomic alkali molecules and the spectroscopic observations on singlet and triplet ground states together with Feshbach resonances from cold collisions of trapped atoms have turned out to be the key ingredients for describing and predicting properties of such cold collisions. During our investigations of NaLi also strong Na_2 spectra were observed, which are used to enhance the set of experimental data available and which are valuable to eliminate remaining uncertainties in the description of the potential energy curve of the singlet ground state (C. Samuelis et al., Phys. Rev. A 63, 012710 (2000)). They can also help to improve the knowledge in the singlet scattering length. Known Feshbach resonances from cold collisions are mainly determined by the triplet state. The result of the combined analysis of singlet and triplet ground state will be presented.

MO 6.7 Mon 16:00 P1

Photodetachment and Reaction dynamics with cold trapped molecular ions — •Thorsten Best[1,2], Jonathan Brox[1], Stephanie Eisenbach[1], Sébastien Jézouin[1,3], Rico Otto[1], Sebastian Trippel[1,4], Alexander von Zastrow[1], and Roland Wester[1,2] — [1]Physikalisches Institut, Albert-Ludwigs-Universität, Freiburg — [2]Institut für Ionen- und angewandte Physik, Leopold-

Franzens-Universität Innsbruck — [3]École Normale Supérieure, Paris — [4]Center for Free Electron Laser Science, DESY, Hamburg

Trapping of molecular ions under well-controlled environmental conditions has become an important tool of molecular physics, with widespread fields of application.

We present recent experiments with molecular ions in our 22pole radio-frequency ion trap. Buffer gas cooling allows to prepare ensembles where only few internal states are populated. These systems allow to study inelastic ion-molecule collisions (e.g. reactions or clustering) in a well-controlled setting. For anions, the internal state distribution can be mapped out using photodetachment at threshold.

We also report on collision experiments with highly energetic atomic ions and charged water clusters held in a Paul trap at the ZERNIKE-LEIF facility.

MO 6.8 Mon 16:00 P1

Stark decelerated SO_2 for dissociation and collision studies — •Oleg Bucicov[1], Eberhard Tiemann[1], and Christian Lisdat[2] — [1]Institut für Quantenoptik, Leibniz Universität Hannover — [2]Physikalisch-Technische Bundesanstalt, Braunschweig

We present a Stark decelerator for low-field-seeking states with 326 stages, with which we succeeded in decelerating SO_2 molecules to the velocity of about 50 m/s [1]. With this decelerator it should be possible to bring the relatively heavy SO_2 molecules to a standstill and to trap them electrostatically.

The photodissociation experiments on the SO_2 molecule accomplished close to the nozzle, have confirmed the energetical position of the threshold of the state $\tilde{C}^1B_2$ for dissociating to SO($X^3\Sigma^-$, v=1) + O(^3P)[2]. Based on this, the experiments on photodissociation of the SO_2 molecule guided through the decelerator are underway. The predissociation at the threshold of decelerated SO_2 molecules, prepared in a state selective excitation by a frequency-doubled dye laser, results in the production of cold O in its ground state and cold SO fragments in few rotational levels of selected vibrational states in its lowest electronic state [3]. The detection of the molecular fragment SO by means of the (1+1) REMPI technique using a second frequency-doubled dye laser will enable measuring the velocity distribution of the both photofragments, SO and O.

[1] O. Bucicov, Eur. Phys. J. D 46 463 (2008).
[2] C. Braatz, E. Tiemann, Chem. Phys. 229 93 (1998).
[3] S. Jung, J. Phys. B 39 S1085 (2006).

MO 6.9 Mon 16:00 P1

High resolution spectroscopy of Rb_2 triplet molecules, experimental techniques and effective Hamiltonians — •Christoph Strauss[1,2], Tetsu Takekoshi[2], Florian Lang[2], Klaus Winkler[2], Rudolf Grimm[2,3], Marius Lysebo[4], Leif Veseth[4], Eberhard Tiemann[5], and Johannes Hecker Denschlag[1] — [1]Universität Ulm, Institut für Quantenmaterie, Albert-Einstein-Allee 45, D-89081 Ulm, Germany — [2]Institut für Experimentalphysik und Zentrum für Quantenphysik, Universität Innsbruck, A-6020 Innsbruck, Austria — [3]Institut für Quantenoptik und Quanteninformation der Österreichischen Akademie der Wissenschaften, A-6020 Innsbruck, Austria — [4]Department of Physics, University of Oslo, 0316 Oslo, Norway — [5]Gottfried Wilhelm Leibniz Universität Hannover, D-30167 Hannover, Germany

In this poster we present details and background information on our spectroscopic analysis of the triplet ground state $a^3\Sigma_u^+$ and the first excited triplet state $(1)^3\Sigma_g^+$ of Rubidium 87 discussing its vibrational, rotational, hyperfine and Zeeman structure. This includes information that cannot be given in our talk "High resolution spectroscopy of Rb_2 triplet molecules". In brief, we perform laser spectroscopy on ultracold Feshbach molecules to obtain precision data with a typical resolution of a few tens of MHz. With model Hamiltonians we can describe and understand the experimental spectra quite well. As a result we obtain optimized $a^3\Sigma_u^+$ and the $X^1\Sigma_g^+$ Born Oppenheimer potentials within a coupled channel model.

MO 6.10 Mon 16:00 P1

Fourier-transform spectroscopy of the mixed alkali - alkaline earth molecule LiCa — Milena Ivanova[1], Alexander Stein[2], Asen Pashov[1], Horst Knöckel[2], and •Eberhard Tiemann[2] — [1]Department of Physics, Sofia University, 5 James Bourchier Blvd., 1164 Sofia, Bulgaria — [2]Centre for Quantum Engineering and Space Time Research (QUEST) und Institut für Quantenoptik, Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover

The mixed alkali - alkaline earth molecules gain importance for ultracold molecules because ultracold ensembles of alkali atoms and alkaline earth atoms are produced in several international labs. However, the spectroscopic information is almost completely missing. We succeeded in producing and observing the molecule LiCa in a wide range of vibrational and rotational quantum numbers with Fourier transform spectroscopy .

The modelling of the experimental data is complicated through the fine structure of the doublet ground state $X^2\Sigma^+$ and we will present the current interpretation of this structure. Its understanding and the derived potential energy curve of the ground state are the essential prerequisites for modeling cold collisions in mixed ultracold ensembles of alkali and alkaline earth atoms. The potential curve of the excited state is also derived.

MO 6.11 Mon 16:00 P1

Low-energy scattering of Stark-decelerated OH radicals with He atoms at high energy resolution — •H. Christian Schewe, Moritz Kirste, Xingan Wang, Ludwig Scharfenberg, Janneke Blokland, Gerard Meijer, and Sebastiaan Y.T. van de Meerakker — Fritz-Haber-Institut der Max-Planck-Gesellschaft, Faradayweg 4-6,14195 Berlin, Germany

For precise collision studies of molecules, a Stark decelerator offers the advantage that it produces beams of cold neutral polar molecules with a tunable velocity. Crossed or merged with a second beam of atoms or molecules, scattering can be studied at collision energies down to few wavenumbers.

We present future experiments in which the inelastic scattering of Stark-decelerated and state-selected OH($X^2\Pi_{3/2}$, J=3/2) radicals with Helium atoms will be studied (Kirste et al. Phys. Rev. A **82**, 042717, (2010)). To reach collision energies down to 10 cm^{-1} a pulsed valve of the Even-Lavie type (Hillenkamp et al. J. Chem. Phys. **118**, 8699, (2003)) is mounted on a Helium cryostat. The translational velocity and the speed ratio of a pure Helium beam have been characterized and its dependence on the temperature, the stagnation pressure and the opening time of the valve have been determined. Simulations will be presented to show how the resolution of the collision energy can be optimized such that theoretically predicted scattering resonances of the inelastic cross section can be resolved.