

MO 14: Cold Molecules 2

Time: Wednesday 14:30–16:30

Location: PH/HS1

Group Report

MO 14.1 Wed 14:30 PH/HS1

Rotational cooling of trapped polyatomic molecules — ●ROSA GLÖCKNER, ALEXANDER PREHN, MARTIN IBRÜGGER, MARTIN ZEPPENFELD, and GERHARD REMPE — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching, Germany

Due to their anisotropic long range interaction and many internal states, cold or ultracold polar molecular ensembles offer manifold possibilities for studying many-body physics and quantum information or quantum controlled collisions and chemistry. A prerequisite for all applications in quantum optics is thereby to gain and maintain control over the internal and external degrees of freedom.

In this talk, I present rotational state cooling of CH₃F molecules via optical pumping. We exploit vibrational transitions to optically pump 16 *M*-sublevels of four rotational states into a single *M* level. With the combination of rotational and motional cooling [1,2] we are thus able to produce a trapped and cold (30mK) ensemble of CH₃F molecules with more than 70% of all molecules populating the same single *M* state. We expect this method to be applicable to a wide variety of molecular species, thus opening a route for quantum controlled experiments with polyatomic molecules.

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

[2] M. Zeppenfeld *et al.*, *Nature* **491**, 570-573 (2012).

MO 14.2 Wed 15:00 PH/HS1

Mikrosolvation of Phthalocyanine in superfluid Helium nanodroplets revisited — TOBIAS PREMKE, PHILIPP MEIER, and ●ALKWIN SLENCZKA — Universität Regensburg, 93053 Regensburg, Germany

Phthalocyanine was one of the first molecules investigated in superfluid Helium droplets by means of electronic spectroscopy [1, 2]. It became one of the best investigated organic dopant species. Inhomogeneous line broadening [3, 4], rotational fine structure [5], excited state life times [6], the Helium solvation layer [7-9], and the corresponding phonon wing [2, 10] have been studied by fluorescence excitation spectra and for some of the phenomena in combination with dispersed emission spectra. A recent resumption of electronic spectroscopy of Phthalocyanine in superfluid Helium droplets revealed new and unexpected results which put some of the previously reported results into question. Besides revisions of some particular details the recent study will be contrasted with the current understanding of microsolvation in superfluid Helium droplets.

[1] M. Hartmann, PhD Thesis, Göttingen, 1997. [2] M. Hartmann *et al.*, *Phys.Chem.Chem.Phys.*, **4** (2002) 4839. [3] A. Slenczka *et al.*, *J.Chem.Phys.* **115** (2001) 10199. [4] B. Dick, A. Slenczka, *J.Chem.Phys.* **115** (2001) 10206. [5] R. Lehnig *et al.*, *J.Chem.Phys.* **121** (2004) 9396. [6] D. Pentlechner *et al.*, *J.Phys.Chem.A*, **115** (2011) 7034. [7] R. Lehnig, A. Slenczka, *J.Chem.Phys.* **118** (2003) 8256. [8] R. Lehnig, A. Slenczka, *ChemPhysChem*, **5** (2004) 1014. [9] R. Lehnig, A. Slenczka, *J.Chem.Phys.* **120** (2004) 5064. [10] R. Lehnig *et al.*, *J.Phys.Chem.A*, **111** (2007) 7576.

MO 14.3 Wed 15:15 PH/HS1

Time resolved photoion/electron imaging spectroscopy of Rubidium atoms attached to Helium nanodroplets — ●JOHANNES VON VANGEROW, OLIVER JOHN, FRANK STIENKEMEIER, and MARCEL MUDRICH — Physikalisches Institut, Universität Freiburg, Hermann-Herderstr. 3, 79104 Freiburg, Germany

This presentation will focus on a metallic dopand, Rubidium, forming a bound surface state with a liquid Helium nanodroplet. In a femtosecond pump probe experiment, we trigger the desorption of the dopand via resonant excitation of the surface state, i.e. the 6P Σ and 6P Π states in the pseudodiatomic model approach.

By subsequent ionization of the dopand and time of flight mass detection up to 6.4 · 10⁴ amu, we observe solvation dynamics of the Rb⁺ occurring for delay times \leq 1 ps. Mass selected velocity map images of the desorbed Rb⁺ and RbHe⁺ photofragments show an increasing kinetic energy and anisotropy leveling out at $t \leq$ 10 ps for all excitation wavelengths. Vice versa, photoelectron images show a decreasing energy asymptotically reaching the corresponding atomic transition.

The experimental results will be compared to a semiclassical model particularly focusing on the RbHe⁺ formation dynamics involving assoziative photoionization.

MO 14.4 Wed 15:30 PH/HS1

High Resolution Infrared Spektropy and Semi-Experimental Structures of Silicon-Carbon and Germanium-Carbon Clusters — ●VOLKER LUTTER¹, SVEN THORWIRTH², JÜRGEN GAUSS³, and THOMAS GIESEN¹ — ¹Institut für Physik, Universität Kassel, Heinrich-Plett-Straße 40, Kassel — ²I. Physikalisches Institut, Universität zu Köln, Zùlpicher Straße 77, Köln — ³Institut für Physikalische Chemie, Johannes Gutenberg-Universität Mainz, Duesbergweg 10-14, Mainz

Gas-phase spectra of molecules and clusters comprising carbon and refractory elements like silicon and germanium are not well studied despite the relevance of these systems in various fields of research such as material sciences, nanotechnology, astrochemistry and theoretical chemistry. Especially for mixed polyatomic germanium-carbon molecules no high-resolution spectroscopic studies have been reported to date.

In this contribution, we present the first high-resolution gas-phase measurements of jet-cooled linear Ge₂C₃ (Ge=C=C=C=Ge). The rovibrational spectrum of the antisymmetric C-C-stretching mode ν_3 has been observed at 5.2 μm and found to exhibit a complex pattern due to the presence of a sizable number of abundant isotopologs. Our study is complemented by high-level quantum-chemical calculations of Ge₂C₃ at the CCSD(T) level of theory. The data analysis allows for direct comparison of theoretical and experimental results of selected molecular parameters.

MO 14.5 Wed 15:45 PH/HS1

Zeeman deceleration of metastable helium and nitrogen atoms — ●KATRIN DULITZ, JUTTA TOSCANO, ATREJU TAUSCHINSKY, and TIMOTHY P. SOFTLEY — Department of Chemistry, University of Oxford, Chemistry Research Laboratory, 12 Mansfield Road, Oxford, OX1 3TA, UK

Zeeman deceleration is an experimental technique in which strong inhomogeneous magnetic fields inside an array of solenoid coils are used to manipulate the velocity of a supersonic beam of paramagnetic atoms or molecules [1,2].

We present experimental results that demonstrate, for the first time, the Zeeman deceleration of helium atoms in the metastable 2³S₁ state and nitrogen atoms in the metastable 2²D_{5/2} state. Using an electron-impact source and a short, 12-stage Zeeman decelerator, we achieve an up to 40% decrease in the kinetic energy of the metastable helium beam [3]. In a proof-of-principle experiment with metastable nitrogen atoms, we achieve deceleration from 460 m/s to 410 m/s. We also show that the pulse duration for electron-impact excitation needs to be matched to the acceptance of the decelerator in order to obtain a good contrast between the decelerated and undecelerated parts of the beam.

[1] N. Vanhaecke *et al.*, *Phys. Rev. A* **75**, 031402 (2007). [2] E. Narevicius *et al.*, *Phys. Rev. A* **77**, 051401 (2008). [3] K. Dulitz, A. Tauschinsky, T. P. Softley, *submitted*.

MO 14.6 Wed 16:00 PH/HS1

Photo-ejection of biomolecular ions from helium droplets — ●JENNY PESTEL, DOO-SIK AHN, ANA ISABEL GONZALEZ FLOREZ, and GERT VON HELDEN — Fritz-Haber-Institut der MPG, Berlin, Germany

Superfluid helium droplets are an ideal environment to investigate ions at cryogenic temperatures. By (photo-)excitation the ion can get ejected from the helium droplet. This process is not completely understood yet. Our goal is to characterize the photo-ejection process and shed more light on the underlying mechanism.

We have developed an experimental setup [1] where biomolecular ions are brought to the gas-phase via electrospray ionization. Subsequently they are mass/charge selected in the quadrupole mass filter and accumulated in a linear ion trap. A pulsed beam of helium droplets picks up the ions as they traverse the trap. From here the doped droplets can be accelerated and measurements as a function of flight time allow us to determine the ejection efficiency on size distributed droplets [2].

With this approach we can study the ion ejection for different dopants on the pre-defined helium droplet sizes. This makes it possible to analyze and report recent results using both ultraviolet as well as infrared light for photo-excitation.

- [1] F. Bierau et al., *Phys. Rev. Letter.* 105, 133402 (2010)
[2] F. Filsinger et al., *PCCP*, 1-8 (2012)

MO 14.7 Wed 16:15 PH/HS1

Low energy scattering of Stark-decelerated OH radicals with ortho- and para-H₂ molecules — •H.C. SCHEWE¹, X. WANG¹, S. Y. T. VAN DE MEERAKKER², G. MEIJER^{1,2}, Q. MA³, J. KLOS³, P. J. DAGDIGIAN³, M. H. ALEXANDER³, A. V. D. AVOIRD², and N. VANHAECKE^{1,4} — ¹Fritz-Haber-Institut der Max-Planck-Gesellschaft, Faradayweg 4-6, 14195 Berlin, Germany. — ²Radboud University Nijmegen, Institute for Molecules and Materials, Heijendaalseweg 135, 6525 AJ Nijmegen, the Netherlands. — ³Department of Chemistry and Biochemistry and Institute for Physical Science and Technology, University of Maryland, College Park, MD 20742-2021, USA. — ⁴Laboratoire Aime Cotton, CNRS, Universite Paris-Sud, 91405 Orsay,

France.

The crossed beam scattering is an important experimental method to investigate molecular interactions, which can lead to energy transfer or chemical reactions. The Stark deceleration technique yields control over both the internal and external degrees of freedom of polar molecules in a molecular beam. The combination of these techniques opens up deeper investigations of molecular scattering processes as a function of the collision energy with a very high energy resolution.

Results on inelastic scattering of ortho- or para-H₂ with Stark-decelerated OH(*X* ²Π_{3/2}, *J* = 3/2, *f*) at collision energies between 60-150 1/cm are presented. The main difference in the scattering process of ortho- and para-H₂ is seen in the relative cross sections, originating from the different multipole interactions involved and are compared with theory.