

## Q 71: Ultrakalte Moleküle I (gemeinsam mit MO)

Zeit: Freitag 10:30–12:45

Raum: 6B

## Fachvortrag

Q 71.1 Fr 10:30 6B

**Magnetic dichroism of alkali atoms and molecules on the surface of helium nanodroplets** — JOHANN NAGL, GERALD AUBÖCK, CARLO CALLEGARI, and •WOLFGANG E. ERNST — Institute of Experimental Physics, TU Graz, Petersgasse 16, A-8010 Graz, Austria

We measured laser induced fluorescence spectra of K and Rb atoms, dimers and trimers, on the surface of superfluid helium droplets, with and without a moderately strong external magnetic field ( $\approx 3$  kG). Atomic spectra (D lines) are saturated with a few hundred mW of laser power. In a magnetic field, and under saturation, we observe a greater signal for linear polarization but no difference between the two states of (circular) polarization of the exciting laser. We take this as evidence that the two spin sublevels of the ground-state alkali atoms are equipopulated, despite a Zeeman splitting comparable in magnitude to  $kT$  (at the temperature of the droplet,  $T = 0.38$  K). We estimate that the rate of spin relaxation induced by the droplet must be  $< 1000$ /s. We thus demonstrate that by selective depletion it is possible to create a beam of He droplets doped with spin-polarized alkali atoms.

Measurements on triplet dimers do show magnetic circular dichroism, indicating that, unlike atoms, molecules do undergo fast spin relaxation and do thermalize to the temperature of the droplet.

Q 71.2 Fr 11:00 6B

**Simulation der Dotierung von Heliumnanotröpfchen mit Alkaliatomen** — •OLIVER BÜNERMANN und FRANK STIENKEMEIER — Physikalisches Institut, Universität Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg

Heliumnanotröpfchen haben die Eigenschaft jegliche Teilchen über inelastische Stöße aufzusammeln. Dies kann zum Dotieren der Tröpfchen ausgenutzt werden: In einer Streuzelle wird ein entsprechender Dampfdruck des zu untersuchenden Materials eingestellt, die Tröpfchen passieren die Zelle und sammeln je nach Dampfdruck eine bestimmte Anzahl von Teilchen auf. Die Wahrscheinlichkeit  $P_k(p)$ , dass ein Tröpfchen  $k$  Teilchen aufgesammelt hat, ist poissonverteilt. Experimentell ermöglicht die Aufnahme von Dotierungskurven (Signal in Abhängigkeit vom Dampfdruck) einer gefundenen Absorption eine Komplexgröße zuzuordnen.

Im Experiment zeigen sich allerdings zum Teil starke Abweichung der Dotierungswahrscheinlichkeit von der Poissonverteilung. Insbesondere bei Alkaliatomen, -molekülen und -clustern kann man nicht mehr von einer Poissonverteilung sprechen. Eine Simulation des Dotierungsprozesses von Alkaliatomen wurde durchgeführt, die die Größenverteilung der Tröpfchen, die Tröpfchenschumpfung nach der Dotierung, die Desorption der dotierten Komplexe und den Impuls Eintrag auf die Tröpfchen berücksichtigt. Im Rahmen der Simulation erhält man eine gute qualitative Übereinstimmung mit dem Experiment. Es zeigt sich, dass die Wahl der Tröpfchenbedingungen einen entscheidenden Einfluss auf die Form der Dotierungskurven hat.

Q 71.3 Fr 11:15 6B

**Aggregation von HCl in Heliumnanotröpfchen** — •MARKUS ORTLIEB, ANJA METZELTHIN, MELANIE LETZNER und MARTINA HAVENITH — Physikalische Chemie II, Ruhr-Universität Bochum, Universitätsstr. 150, D-44780 Bochum

Wir untersuchen die Aggregation von HCl bei ultrakalten Temperaturen in Heliumnanotröpfchen im Bereich von 2820 bis 2940  $\text{cm}^{-1}$ . Die Messungen wurden mit einem leistungsstarken IR-OPO (cw: 2,9 W) durchgeführt. Anhand der Druckabhängigkeit der Signalstärken konnten die Linien dem HCl Monomer, Dimer und Trimer zugeordnet werden. Dabei zeigte sich, dass die Frequenzen des Trimers auf die Ausbildung einer linearen Kette aus HCl hinweisen.

Weiterhin untersuchen wir das IR-Spektrum des Radikals NO in Heliumtröpfchen mit unserem Bleisalzdiolenlaser (Auflösung: 0,001  $\text{cm}^{-1}$ ). Der  ${}^2\Pi_{1/2}$  R(1/2) Übergang des  ${}^{15}\text{N}^{18}\text{O}$  Isotops konnte bei 1796,39  $\text{cm}^{-1}$  gemessen werden, was einer Verschiebung von 0,12  $\text{cm}^{-1}$  im Vergleich zur Gasphase entspricht.

Q 71.4 Fr 11:30 6B

**Spectroscopy of free radicals and radical containing entrance-channel complexes in superfluid helium nanodroplets** — •JOCHEN KÜPPER<sup>1,2</sup>, JEREMY M. MERRITT<sup>2</sup>, and ROGER E. MILLER<sup>2</sup> — <sup>1</sup>Fritz-Haber-Institut der MPG, Faradayweg 4-6, 14195 Berlin —

<sup>2</sup>University of North Carolina, Department of Chemistry, Chapel Hill, NC 27599, USA

The unique properties of superfluid helium nanodroplets, namely their low temperature (0.4 K) and fast cooling rates ( $\sim 10^{16}$   $\text{K s}^{-1}$ ), provide novel opportunities for the formation and high-resolution study of metastable structures or molecular complexes containing free radicals.

We discuss methods for the production of radicals and their applicability for embedding the radicals in helium nanodroplets. The spectroscopy of free radicals (i. e.  $\text{C}_3\text{H}_3$ ) and of radical containing entrance-channel complexes, for example  $\text{X}\cdots\text{HY}$  ( $\text{X}=\text{Cl}, \text{Br}, \text{I}, \text{CH}_3$ ;  $\text{Y}=\text{F}, \text{CN}$ ), embedded in helium nano-droplets is detailed. The observed complexes provide new information on the potential energy surfaces of several fundamental chemical reactions and on the intermolecular interactions present in open-shell systems. Prospects for further experiments of radicals embedded in helium droplets are discussed.

Q 71.5 Fr 11:45 6B

**Sub-megahertz infrared spectroscopy of trapped  $\text{HD}^+$  ions at millikelvin temperatures** — •JEROEN KOELEMELJ, BERNHARD ROTH, ANDREAS WICHT, INGO ERNSTING, and STEPHAN SCHILLER — Institut für Experimentalphysik, Universität Düsseldorf

We have performed an absolute frequency measurement of the ( $v' = 4, J' = 3$ )  $\leftarrow$  ( $v = 0, J = 2$ ) overtone transition at 1395 nm in the molecular  $\text{HD}^+$  ion with sub-megahertz accuracy. Trapped  $\text{HD}^+$  ions are sympathetically cooled to millikelvin temperatures by storing them together with  $\text{Be}^+$  ions, which are laser cooled to  $\sim 10$  mK using near-resonant 313 nm light. Vibrational overtone spectroscopy at 1395 nm is done using ( $1 + 1'$ ) resonance-enhanced multiphoton dissociation (REMPD), where a second photon at 266 nm selectively dissociates the  $\text{HD}^+$  ions in  $v' = 4$ . The loss of  $\text{HD}^+$  ions due to the REMPD process manifests itself as a change in the 313 nm  $\text{Be}^+$  fluorescence when the motion of the  $\text{HD}^+$  ions is resonantly driven by an ac electric field. The 1395 nm probe laser is a narrowband grating-enhanced diode laser with resonant optical feedback, which is locked to a femtosecond frequency comb. The comb is stabilized to a hydrogen maser which is referenced to GPS for long term stability. This allows tuning and measurement of the 1395 nm laser frequency with an accuracy better than 10 kHz. The 0.5 MHz uncertainty in our final result is due to measurement noise, Doppler broadening and, to a lesser extent, systematic uncertainties associated with external fields in the ion trap, and uncertainties in the *ab initio* data used for the spectral fit model.

Q 71.6 Fr 12:00 6B

**Buffer-gas cooling of CrH and MgH in a cryogenic magnetic trap for paramagnetic molecules** — •MICHAEL STOLL<sup>1</sup>, TIM STEIMLE<sup>2</sup>, GERARD MELJER<sup>1</sup>, and ACHIM PETERS<sup>3</sup> — <sup>1</sup>Fritz-Haber-Institut der Max-Planck-Gesellschaft — <sup>2</sup>Department of Chemistry and Biochemistry, Arizona State University — <sup>3</sup>Humboldt Universität zu Berlin, Institut für Physik

The buffer gas loading and subsequent magnetic trapping of neutral molecules is a powerful tool for it can provide samples of cold molecules with very high densities. We report on the buffer-gas cooling of CrH and MnH radicals to a temperature of below 1 K, using a dilution refrigerator. We also present data on the first attempts to trap CrH and discuss inelastic scattering with the Helium background gas as a possible loss mechanism preventing effective trapping.

Further experiments using CrD, MnH and MnD should give additional information on the exact role of inelastic scattering processes. First estimations indicate that trapping of MnH should in principle be feasible in our current setup, whereas trapping of CrH would require substantial modifications to our cryogenic system.

Q 71.7 Fr 12:15 6B

**UV photodissociation studies of polyatomic molecular ions at milli-Kelvin temperatures** — •DAVID OFFENBERG, CHAOBO ZHANG, BERNHARD ROTH, and STEPHAN SCHILLER — Institut für Experimentalphysik, Heinrich-Heine-Universität Düsseldorf

Photodissociation spectroscopy is a commonly used tool to investigate molecular properties. The spectral resolution can be enhanced by reducing the molecules' thermal energy [1], as recently demonstrated on diatomic molecular ions [2]. Here, we present our initial advances towards photodissociation spectroscopy of polyatomic molecules.

As a first model system we use translationally cooled, singly protonated molecules of Glycyrrhetic Acid (GA) – a biomolecule of mass 471 amu consisting of 80 atoms. In our apparatus, the molecular ions are generated by an electrospray ionization source, transferred to and stored in a radio-frequency trap together with laser-cooled barium ions. Due to their Coulomb interaction with the atomic coolant, they cool down from ambient temperature to the hundred milli-Kelvin range and can be kept and investigated under these low-temperature and nearly collisionless conditions for more than one hour [3]. We have measured the photodissociation rate of GA ions using a single-frequency cw-laser at 266 nm. In further studies we plan to investigate the feasibility of resonance enhanced two-photon dissociation with additional tunable IR lasers.

[1] O. Boyarkin et al., J. Am. Chem. Soc. 128, 2816 – 2817 (2006)

[2] B. Roth et al., Phys. Rev. A 74, 040501(R) (2006)

[3] A. Ostendorf et al., Phys. Rev. Lett. 97, 243005 (2006)

Q 71.8 Fr 12:30 6B

**Preparation of single molecular ions for time resolved electron diffraction** — ●STEFFEN KAHRA, GÜNTHER LESCHHORN, AXEL

FRIEDENAUER, HECTOR SCHMITZ, ERNST FILL, and TOBIAS SCHÄTZ — Max-Planck-Institut für Quantenoptik, 85741 Garching

We present a scheme for the preparation of isolated single molecular ions. The ions will be confined in a linear Paul-trap. This allows besides for excellent spacial positioning with accuracy of only a few micrometers also for application of common sympathetic cooling techniques. Since the ions are accessible to manipulation by laser and electron beams, for example, a wide range of experimental opportunities arises. Investigation of one of the most intriguing realms in nature comes into reach when we combine our tool with the recent and foreseeable developments made in the field of short electron pulse generation. Doing electron or X-ray diffraction (100 fs) on isolated species in a time resolved manner, might provide us with direct information about the electronic motion inside the charged molecule. Hence, observing the molecule by means of diffraction and taking spectroscopic knowledge into account is expected to help us understand how the dynamic structure of an excited molecule on the few femtosecond timescale really evolves.

Supported by: IMPRS, MAP, MPG