

## HETERONUCLEAR COLD MOLECULES (SYCM)

gemeinsam veranstaltet von den Fachverbänden  
Molekülphysik (MO) und  
Quantenoptik und Photonik (Q)

Martina Havenith  
Lehrstuhl für Physikalische Chemie II - NC 7/72  
Ruhr-Universität Bochum  
D-44780 Bochum  
E-Mail: Martina.Havenith@ruhr-uni-bochum.de

P.W.H. Pinkse  
Max-Planck-Institut für Quantenoptik  
Hans-Kopfermann-Str. 1  
D-85748 Garching  
E-Mail: Pepijn.Pinkse@mpq.mpg.de

### ÜBERSICHT DER HAUPTVORTRÄGE UND FACHSITZUNGEN (Hörsaal HU Audimax)

#### Hauptvorträge

SYCM 1.1	Sa	11:15	(HU Audimax)	<b>Molecular Spectroscopy as a Probe of Quantum Solvation</b> , <u>R. E. Miller</u>
SYCM 1.2	Sa	11:45	(HU Audimax)	<b>Synthese und Charakterisierung von Molekülen in Helium-Nanotröpfchen</b> , <u>F. Stienkemeier</u> , O. Bünermann, M. Mudrich, M. Weidemüller
SYCM 1.3	Sa	12:15	(HU Audimax)	<b>Spectroscopic tools for forming cold mixed alkali dimers</b> , <u>Eberhard Tiemann</u> , Asen Pashov, Ruvin Ferber, Maris Tamanis, Olga Docenko, Lena Zaharova
SYCM 1.4	Sa	12:45	(HU Audimax)	<b>Manipulation of polar molecules with electric fields</b> , <u>Gerard Meijer</u>
SYCM 2.1	Sa	14:30	(HU Audimax)	<b>Long-lived weakly bound molecules of fermionic atoms</b> , <u>Gora V. Shlyapnikov</u>
SYCM 2.2	Sa	15:00	(HU Audimax)	<b>Electrostatics in action: controlling cold collisions of polar molecules</b> , <u>John L. Bohn</u>
SYCM 2.3	Sa	15:30	(HU Audimax)	<b>Cold molecules for studying cold chemical reactions</b> , <u>Hansjürgen Loesch</u> , Ning-Ning Liu, Dirk Weber
SYCM 2.4	Sa	16:00	(HU Audimax)	<b>Mixture of ultracold lithium and cesium and photoassociation of cold LiCs</b> , <u>Matthias Weidemüller</u> , Stephan Kraft, Jörg Lange, Peter Staunum, Roland Wester

#### Fachsitzungen

SYCM 1	<b>Heteronuclear cold molecules</b>	Sa 11:15–13:15	HU Audimax	SYCM 1.1–1.4
SYCM 2	<b>Heteronuclear cold molecules</b>	Sa 14:30–16:30	HU Audimax	SYCM 2.1–2.4

Zusätzlich zum Symposium findet am Samstag vormittag von 8:30 Uhr bis 10:00 Uhr eine Fachsitzung „Heteronuclear Cold Molecules“ im Hörsaal HU 2091 statt, in der Kurzvorträge aus dem Symposium präsentiert werden. Die Fachsitzung ist im Programm unter MO 21 zu finden.

## Fachsitzungen

– Hauptvorträge –

### SYCM 1 Heteronuclear cold molecules

Zeit: Samstag 11:15–13:15

Raum: HU Audimax

#### Hauptvortrag

SYCM 1.1 Sa 11:15 HU Audimax

**Molecular Spectroscopy as a Probe of Quantum Solvation** — ●R. E. MILLER — Department of Chemistry, University of North Carolina, Chapel Hill NC 27599

Helium nanodroplets are being used to study quantum mechanical exchange in a finite system. These dynamical processes are probed by doping the droplets with a molecule, the spectroscopy of which is sensitive to the quantum solvent environment. Infrared laser spectroscopy is found to be an ideal method for probing the associated dynamics, providing detailed information on the rotational and vibrational motion of the solvated molecules and the nature of the coupling of these to the solvent. These nanodroplets also provide us with a unique method for forming clusters and nanoparticles with unique structures, resulting from the low temperature growth. A number of applications of this type will be discussed.

#### Hauptvortrag

SYCM 1.2 Sa 11:45 HU Audimax

**Synthese und Charakterisierung von Molekülen in Helium-Nanotröpfchen** — ●F. STIENKEMEIER<sup>1</sup>, O. BÜNERMANN<sup>1</sup>, M. MUDRICH<sup>2</sup> und M. WEIDEMÜLLER<sup>2</sup> — <sup>1</sup>Fakultät für Physik, Universität Bielefeld, Universitätsstr. 25, 33615 Bielefeld — <sup>2</sup>Physikalisches Institut, Albert-Ludwigs-Universität Freiburg, Hermann-Herder-Straße 3, 79104 Freiburg

Durch Isolation von Atomen und Molekülen in Helium-Nanotröpfchen lassen sich spektroskopische Untersuchungen bei Temperaturen im Millikelvin-Bereich durchführen. Insbesondere erlaubt das sukzessive Beladen von einem Tröpfchen mit verschiedenen Atomen oder Molekülen die Synthese genau definierter Aggregate in der kalten Umgebung. Dies sind in unseren Experimenten zum einen hetero-nukleare Alkalimoleküle und -cluster [1], zum anderen halbleitende organische Nanostrukturen [2]. Bei Alkalimolekülen erhalten wir durch Laseranregung elektronischer Übergänge detaillierte Informationen über Wechselwirkungspotentiale. Andererseits lassen sich bei den organischen Systemen aber auch exzitonische Übergänge anregen und so Ladungstransfereigenschaften in größenbegrenzten Aggregaten studieren.

[1] Marcel Mudrich, Oliver Bünermann, Frank Stienkemeier, Olivier Dulieu, and Matthias Weidemüller, *Eur. Phys. J. D* (in press).

[2] M. Wewer and F. Stienkemeier, *Phys. Rev. B* 67, 125201 (2003); *J. Chem. Phys.* 120(3), 1239 (2004).

#### Hauptvortrag

SYCM 1.3 Sa 12:15 HU Audimax

**Spectroscopic tools for forming cold mixed alkali dimers** — ●EBERHARD TIEMANN<sup>1</sup>, ASEN PASHOV<sup>2</sup>, RUVIN FERBER<sup>3</sup>, MARIS TAMANIS<sup>3</sup>, OLGA DOCENKO<sup>3</sup>, and LENA ZAHAROVA<sup>3</sup> — <sup>1</sup>Universität Hannover, Institut für Quantenoptik — <sup>2</sup>Institute for Scientific Research in Telecommunications, Sofia/Bulgarien — <sup>3</sup>University of Latvia, Riga/LV

Up to now four different ways for obtaining ensembles of cold polar molecules are proposed and applied: photoassociation, Feshbach resonances, deceleration or selection of molecules with low translation energy by inhomogeneous electric fields and buffer gas cooling.

For a quantitative description of these processes a large amount of detailed spectroscopic data is needed which was not obtained in earlier work because its goal was concentrated on systematics of molecular structures.

We will open the view how to obtain needed molecular data for the regime of cold collisions and their resonance structure, of weakly bound systems and for transfer processes to long living states.

This should also give the base for the discussion of new applications of cold ensembles of polar molecules.

#### Hauptvortrag

SYCM 1.4 Sa 12:45 HU Audimax

**Manipulation of polar molecules with electric fields** — ●GERARD MEIJER — Fritz-Haber-Institut der Max-Planck-Gesellschaft, Faradayweg 4-6, Berlin, Germany

In this presentation I will give an overview of the various experiments that we have performed during the last few years to explore the possibilities of manipulating neutral polar molecules with electric fields. Arrays of time-varying, inhomogeneous electric fields have been used to reduce in a stepwise fashion the forward velocity of molecules in a beam. With this so-called 'Stark decelerator', the equivalent of a LINear ACcelerator (LINAC) for charged particles, one can transfer the high phase-space density that is present in the moving frame of a pulsed molecular beam to a reference frame at any desired velocity; molecular beams with a computer-controlled (calibrated) velocity and with a narrow velocity distribution, corresponding to sub-mK longitudinal temperatures, can be produced. These decelerated beams offer new possibilities for collision studies, for instance, and enable spectroscopic studies with an improved spectral resolution. These decelerated beams have been used to load ND<sub>3</sub> molecules and OH radicals in an electrostatic trap at a density of (better than) 10<sup>7</sup> mol/cm<sup>3</sup> and at temperatures of around 50 mK. Ground-state ND<sub>3</sub> molecules have been trapped in a novel AC electric field trap, slow beams of ND<sub>3</sub> molecules have been injected in an electrostatic storage ring, and, using microstructured electrode arrays, a switchable mirror for neutral molecules has been constructed and tested. The variety of schemes that we are pursuing to further increase the phase-space density of the trapped molecules will be discussed.

### SYCM 2 Heteronuclear cold molecules

Zeit: Samstag 14:30–16:30

Raum: HU Audimax

#### Hauptvortrag

SYCM 2.1 Sa 14:30 HU Audimax

**Long-lived weakly bound molecules of fermionic atoms** — ●GORA V. SHLYAPNIKOV — Laboratoire Physique Théorique et Modèles Statistique, Université Paris Sud, Bâtiment 100, 91405 Orsay Cedex, France — Van der Waals-Zeeman Instituut, Universiteit van Amsterdam, 1018XE Amsterdam, The Netherlands

Recent remarkable achievements in the physics of ultracold Fermi gases attracted a lot of attention and draw fascinating prospects for future studies. One of the most profound results is the creation and Bose-Einstein condensation of weakly bound bosonic molecules of fermionic

atoms. I will discuss prospects related to heteronuclear molecules which are supposed to be formed in mixtures of different fermionic atoms. One of the aspects will be their polarization and thus the creation of dipolar Bose gases which are predicted to exhibit novel physics in the regime of quantum degeneracy.

#### Hauptvortrag

SYCM 2.2 Sa 15:00 HU Audimax

**Electrostatics in action: controlling cold collisions of polar molecules** — ●JOHN L. BOHN — JILA, University of Colorado, Boulder, CO 80309

One of the most impressive developments to come out of the study of ultracold atomic gases is the ability to influence scattering by applying a suitable magnetic field. In this talk I will describe how ultracold heteronuclear molecules will afford even greater opportunities to control scattering, because of their dipole moments. Indeed, applying combined electric and magnetic fields can alter collision cross sections and branching ratios by orders of magnitude. I will show how this is important to the basic problem of creating and handling cold molecules, as well as to applications such as control over chemical reactions.

### Hauptvortrag

SYCM 2.3 Sa 15:30 HU Audimax

**Cold molecules for studying cold chemical reactions** —  
•HANSJÜRGEN LOESCH, NING-NING LIU, and DIRK WEBER —  
Fakultät für Physik, Universität Bielefeld, Universitätsstraße 25,  
D-33615 Bielefeld

Elementary chemical reactions form an important and attractive field of application for cold molecules. Detailed experimental information about these processes at low collision energies deepens the insight into their dynamics and is crucial e.g. for a better understanding of the molecule formation mechanisms in cold interstellar gas clouds. Theoretical studies predict interesting quantum phenomena such as tunnelling and resonances. Candidates for first investigations are the three centre reactions of the type  $A+BC \rightarrow AB+C$ . There are now very efficient meth-

ods available to cool down the reagent atoms (A) and new techniques are being developed to produce cold molecules (BC). In this talk a novel technique for the formation of cold molecules is introduced. It is based on reactive collisions between metal atoms (K) and hydrogen-halide molecules (HBr) in the course of which cold salt molecules (KBr) are formed. So far, a significant flux of slow molecules ( $<30$  m/s) has been observed. In addition, the rotating-nozzle-technique for the generation of cold molecules is briefly discussed and results obtained with our improved set-up are presented. To date, quasi-continuous beams of atoms and molecules with peak velocities near 30 m/s have been created.

### Hauptvortrag

SYCM 2.4 Sa 16:00 HU Audimax

**Mixture of ultracold lithium and cesium and photoassociation of cold LiCs** — •MATTHIAS WEIDEMÜLLER<sup>1</sup>, STEPHAN KRAFT<sup>1</sup>, JÖRG LANGE<sup>1</sup>, PETER STAANUM<sup>1,2</sup>, and ROLAND WESTER<sup>1</sup> —  
<sup>1</sup>Physikalisches Institut der Universität Freiburg, 79104 Freiburg —  
<sup>2</sup>Institut für Quantenoptik, Universität Hannover, 30167 Hannover

We trap a mixture of ultracold lithium and cesium atoms in a quasi-electrostatic trap formed by the focus of a CO<sub>2</sub> laser beam. Elastic and inelastic processes between the two different gases are studied in detail. Possible routes to the formation of cold heteronuclear molecules in low vibrational states will be discussed and the status of the experiment will be presented.