A 2: Ultra-cold atoms and molecules I (joint session A/MO/Q)

Time: Monday 10:30–12:15 Location: S HS 1 Physik

A 2.1 Mon 10:30 S HS 1 Physik

Quantum state-dependent reactive collisions of OH^- with ultracold Rubidium in a hybrid trap — •Saba Zia Hassan[1], Jonas Tauch[1], Eric Endres[1], Markus Nötzold[2], Henry Lopez[1], Bastian Höltkemeier[1], Roland Wester[2], and Matthias Weidemüller[1] — [1]Physikalisches Institut Heidelberg, INF 226, 69120 Heidelberg — [2]Institut für Ionenphysik und Angewandte Physik, Universität Innsbruck, 6020 Innsbruck

The study of ion-molecule reactions plays a vital role in cold chemistry, implying the need of well-controlled ion ensembles in a cold environment. The internal and external degrees of freedom of molecular ions, trapped in multipole radio frequency ion traps, can be cooled via collisions, with pre-cooled neutral atoms, to cryogenic temperatures of about 4 K. This lower temperature limit can be overcome using a laser-cooled buffer-gas localized at the center of the ion cloud.
In our hybrid atom-ion trap, the hydroxyl anions are stored in a 8-pole radio frequency wire trap and a dense cloud of ultracold rubidium is confined in a dark spontaneous-force optical trap (Dark-SPOT). The overlap of atoms and anions leads to elastic and inelastic collisions, cooling the external and internal degrees of freedom respectively. However, losses via associative detachment between OH^- and rubidium also occur, as predicted by ab-initio calculations. By varying the ratio of excited to ground state atoms, quantum state-dependent reactive collisions can be studied. Accurate measurements of these reactions can allow us to probe into the effective core potentials used in theoretical studies. In this contribution the latest results will be presented.

A 2.2 Mon 10:45 S HS 1 Physik

State-to-state chemistry in a magnetic field — •Joschka Wolf, Markus Deiss, Shinsuke Haze, and Johannes Hecker Denschlag — Institut für Quantenmaterie and Center for Integrated Quantum Science and Technology IQ^{ST}, Universität Ulm, 89069 Ulm, Germany

State-to-state chemistry describes the determination of the quantum states of the final products given the quantum state of reactants. We have developed and demonstrated a method to probe diatomic molecular product states of reactive processes both qualitatively and quantitatively [1]. Using the given method, we have investigated the recombination of three neutral rubidium atoms in an ultracold atomic gas. We have extended the scheme of [1], to also resolve the magnetic quantum number of molecular product states. In this talk, we present the measurements of product molecules for different reactant states as a function of the magnetic field. We find a propensity rule that the magnetic quantum number of the two reactants forming the molecule is conserved.

J. Wolf *et al.*, Science 358, 921 (2017)

A 2.3 Mon 11:00 S HS 1 Physik

Sisyphus Optical Lattice Decelerator (SOLD) — •Rodrigo Gonzalez Escudero, Chun-Chia Chen, Shayne Bennetts, Benjamin Pasquiou, and Florian Schreck — Van der Waals - Zeeman Institute, Institute of Physics, University of Amsterdam

In this talk, we present our implementation of a novel deceleration scheme that slows and cools atoms without using radiation pressure [1]. This scheme can enhance the efficiency of standard laser cooling techniques, requiring fewer photons to bring fast atoms to rest, making it a good decelerator candidate for exotic species [2] and molecules.

The SOLD works by having atoms selectively excited to an electronic state whose energy is spatially modulated by an optical lattice. Excited Atoms decelerate solely by climbing the conservative potential landscape created by the lattice. The ensuing spontaneous decay brings atoms to the ground state, and completes one Sisyphus cooling cycle.

This deceleration method might prove useful for our attempt to create a steady-state strontium atom laser machine [3], breaching the gap from the currently achieved, and unprecedented steady-state phase-space density of near unity to the first steady-state Bose-Einstein condensate from which a continuous atom laser can be outcoupled.

[1] C-C.Chen et al., arXiv:1810.07157 (2018).
[2] S. Wu et al., Phys. Rev. Lett. 106, 213001 (2011).
[3] S. Bennetts et al., Phys. Rev. Lett. 119, 223202 (2017).

A 2.4 Mon 11:15 S HS 1 Physik

Sympathetic cooling of molecular anions by a localized laser-cooled buffer gas — •Jonas Tauch[1], Saba Zia Hassan[1], Eric Endres[1], Markus Nötzold[3], Henry López[1], Bastian Höltkemeier[1], Roland Wester[3], and Matthias Weidemüller[1,2] — [1]Physikalisches Institut Heidelberg, INF 226, 69120 Heidelberg — [2]University of Science and Technology of China, Shanghai Branch, Shanghai, China — [3]Institut für Ionenphysik und Angewandte Physik, Technikerstrasse 25/3, 6020 Innsbruck

Sympathetic cooling has become a powerful and universal method for preparing ultracold ions confined in radio frequency traps. This technique enables the study of cold molecular ions, as precision spectroscopy and chemistry at temperatures near to the absolute zero. In the past few years there has been a large debate about the limitations of this method, due to the mass ratio between the ions and the coolant. We developed a theoretical description which predicts that this limitations can be overcome by a localized buffer gas cloud and/or a higher order radio frequency trap. In this contribution I will present recent results of our hybrid atom-ion trap system, consisting of an 8-pole radio frequency wire trap and a dark spontaneous-force optical Rubidium trap. First signs of translational and rotational cooling of the trapped hydroxyl anions are observed. To probe the translational energy distributions of the anions, their time-of-flight is measured after extraction from the trap. The internal degrees of freedom are probed via near threshold photodetachment, revealing an increase of the population in lower rotational states. Thus cooling of the internal degrees of freedom.

A 2.5 Mon 11:30 S HS 1 Physik

Using a Quartz Crystal Micro-Balance for the characterization of a Zeeman Slower — •A. Chavarria Sibaja[1,2], A. Godinez Sandi[1,2], K. Hernandez Jimenez[1,2], S. Thiel Pizarro[1,2], M. Guevara Bertsh[3], and O.A. Herrera Sancho[1,2,4] — [1]Escuela de Física. University of Costa Rica — [2]CICIMA. University of Costa Rica — [3]Institut fur Quantenoptik und Quanteninformation. University of Innsbruck — [4]CICANUM. University of Costa Rica

We present here the developement of an experimental apparatus that consists of a Gd atoms source and 1 m-long multi-layer solenoidal Spin-Flip Zeeman Slower, and the propose of an alternative method to measure the atoms velocity, based on using of a Quartz Crystal micro-balance (QCM), which is normally used in thin film deposition process in solid-state physics. We observed that the measurement of the perturbations induced in the natural frequency of the QCM by the deposition mass process and the momentum exchange of the particles when they hit the crystal surface, allow to determine the change in the kinetic energy of Gd atoms. In this experiment, we focus a 447,2 nm laser into a counter-propagating beam of Gd atoms in order to drive the strongest dipole atomic transition from the ground 9D 0 state to the exited state 9D. Additionally we measure the variations of velocity of the atoms at the end of our Zeeman-Slower with a QCM,in order to characterize the effectiveness of our apparatus, as part of the future developement of magneto-optical trap system. We obtain preliminary results of 39% of reduction of the velocity of the Gd atoms respect to their initial velocity using a current of 3 A.

A 2.6 Mon 11:45 S HS 1 Physik

Locking of multiple Lasers to a Frequency Comb — •Benjamin Sprenger[1], Dag Schmidt[1], Ronald Holzwarth[1,2], Bastian Hacker[2], Dominik Niemietz[2], and Gerhard Rempe[2] — [1]Menlo Systems GmbH, Am Klopferspitz 19a, 82152 Martinsried — [2]Max-Planck Institut für Quantenoptik, Hans-Kopfermann-Straße 1, 85748 Garching bei München

Cold atom experiments usually require a whole set of lasers with different and precisely defined optical frequencies. A frequency comb offers the possibility to stabilize all lasers in the visible and near IR part of the spectrum (and even far beyond in the IR regime if needed) to the same reference, thereby providing the same stability and accuracy as well as mutual coherence to all lasers. We present a setup in which a frequency comb is used to stabilize more than 20 CW Lasers in 7 different laboratories. The comb light is distributed via optical fibers from the central comb laboratory to all other labs. Many applications, like quantum information experiments with single atoms and photons

or molecular spectroscopy can be simplified with this setup and allows for reliable operations with improved accuracy.

A 2.7 Mon 12:00 S HS 1 Physik

Improved Setup for Optoelectric Sisyphus Cooling of Formaldehyde Using a Detection Scheme Based on Laser Induced Fluorescence — •Martin Ibrügger, Maximilian Löw, Alexander Prehn, Martin Zeppenfeld, and Gerhard Rempe — Max-Planck-Institut für Quantenoptik, Hans-Kopfermannstr. 1, 85748 Garching

Ultracold molecules are ideal systems for the investigation of fundamental physics with applications ranging from quantum simulation over high-precision spectroscopy to ultracold chemistry. We showed in the past that optoelectrical Sisyphus cooling is one of the most promising techniques to provide the high number of molecules and the temperatures required for those applications [1]. We now implemented a new detection scheme for formaldehyde based on laser induced fluorescence (LIF), thereby increasing the signal by up to a factor of 30 compared to the previously used quadrupole mass spectrometer, and furthermore allowing state selective detection of the molecules.

Here, we present the current status of the experiment. In particular, we investigate trap dynamics of individual rotational M-sublevels which were previously hard to resolve. Results are very promising for the development of an improved cooling sequence which will pave the way for exciting applications such as high-precision spectroscopy and collisional studies of trapped formaldehyde.

[1] A. Prehn *et al.*, *Phys. Rev. Lett.* **116**, 063005 (2016).