A 27: Ultracold Atoms and Molecules II (joint session Q/A)

Time: Thursday 14:00–15:30 Location: Q-H10

Invited Talk A 27.1 Thu 14:00 Q-H10

Self-bound Dipolar Droplets and Supersolids in Molecular Bose-Einstein Condensates — •Tim Langen — 5. Physikalisches Institut and Center for Integrated Quantum Science and Technology, Universität Stuttgart, Germany

I will discuss the prospects of exploring quantum many-body physics with ultracold molecular gases.

On the theory side, I will present a numerical study of molecular Bose-Einstein condensates with strong dipole-dipole interactions. We observe the formation of self-bound droplets, and explore phase diagrams that feature a variety of exotic supersolid states. In all of these cases, the large and tunable molecular dipole moments enable the study of unexplored regimes and phenomena, including liquid-like density saturation and universal stability scaling laws for droplets, as well as pattern formation and the limits of droplet supersolidity.

On the experimental side, I will discuss progress in molecular laser cooling towards the ultracold regime. I will further present a realistic approach to realize both the collisional stability of ultracold molecular gases and the independent tunability of their contact and dipolar interaction strengths using a combination of microwave and DC electric fields.

Taken together, these results provide both a blueprint and a benchmark for near-future experiments with bulk molecular Bose-Einstein condensates.

A 27.2 Thu 14:30 Q-H10

Single-beam laser cooling using a nano-structured atom chip — •Hendrik Heine[1], Joseph Muchovo[1], Aaditya Mishra[1], Waldemar Herr[1,2], Christian Schubert[1,2], and Ernst M. Rasel[1] — [1]Institut für Quantenoptik, Leibniz Universität Hannover — [2]Deutsches Zentrum für Luft- und Raumfahrt e. V. (DLR), Institut für Satellitengeodäsie und Intertialsensorik, c/o Leibniz Universität Hannover, DLR-SI, Callinstr. 36, D-30167 Hannover, Germany

Matterwave interferometry with Bose Einstein Condensates (BEC) promises exciting prospects in inertial sensing and research on fundamental physics both on ground and in space. BECs can be efficiently created using atom chips and compact setups have already been shown. However, for transportable or space applications further reduction in complexity is desired in order to lower size, weight, and power demands.

I will present a nano-structured atom chip with results on magneto-optical trapping and sub-Doppler cooling using only a single beam of light. This reduces the overall complexity and promises greater long-term stability. We demonstrate state-of-the-art performance and magnetic trapping with the atom chip.

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A 27.3 Thu 14:45 Q-H10

Real-Time detection and feedback cooling of the secular motion of an ion — •Hans Dang[1,2], Martin Fischer[1], Atish Roy[1], Lakhi Sharma[1], Markus Sondermann[1,2], and Gerd Leuchs[1,2,3,4] — [1]Max Planck Institute for the Science of Light, Erlangen, Germany — [2]Friedrich-Alexander University Erlangen-Nürnberg (FAU), Department of Physics, Erlangen, Germany — [3]Department of Physics, University of Ottawa, Canada — [4]Institute of Applied Physics, Russian Academy of Sciences, Nizhny Novgorod, Russia

We report on the direct observation of the secular motion of a single ion by imaging it onto a knife-edge using a deep parabolic mirror. The unique misalignment functionals of the phase front of the light collected by the mirror together with its high collection efficiency[1] allow us to detect the motion in a time shorter than the coherence time of the harmonic motion of the ion. Using a known oscillation amplitude to calibrate the detection the temperature of the ion can be extracted from the rms voltage of the measured signal. By applying the phase-shifted and amplified signal to one of the compensation electrodes of the ion trap it is possible to dampen the amplitude of the harmonic oscillation and hence cool the ion. Prospects of expanding the detection to all three motional modes simultaneously will be discussed.

[1] R. Maiwald *et al.*, Physical Review A **86**, 043431 (2012)

A 27.4 Thu 15:00 Q-H10

Surface charge removal in a microstructured electrostatic trap for cold polyatomic molecules — •Jindaratsamee Phrompao, Michael Ziemba, Florian Jung, Martin Zeppenfeld, Isabel Rabey, and Gerhard Rempe — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Straße 1, 85748 Garching, Germany

Cold polar molecules are an excellent platform to explore fascinating research areas in both physics and chemistry, such as cold collisions, cold chemistry, and tests of fundamental physics. Motivated by these applications, techniques in the field are advancing rapidly with the overall goal of producing dense and cold molecular samples. To achieve these, electric trapping provides long trapping times and deep confinement of the molecules. In our electrostatic trap [1], we combine two parallel microstructured capacitor plates and a surrounding ring electrode to provide a tunable homogeneous electric control field and transverse confinement, respectively. By combining the various electrodes, polar molecules are confined within a boxlike potential. However, the trap depth is limited by high-voltage breakdown and surface charge accumulation, which possibly also induces early breakdown.

In this talk, we will present induced removal of charges by applying UV light and heating to test samples. We find that heating these to more than $200°C$ can remove the charge almost completely, but the characteristics are not reproducible. In contrast, charge removal by shining in UV light is more reliable and capable of providing rapid and complete charge removal.

[1] B.G.U. Englert et al., Phys. Rev. Lett. 107, 263003 (2011)

A 27.5 Thu 15:15 Q-H10

Creating an ensemble of cooled and trapped formaldehyde molecules in their ortho ground state — •Maximilian Löw, Martin Ibrügger, Martin Zeppenfeld, and Gerhard Rempe — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching

Direct cooling methods to produce polar molecules in the ultracold regime have improved significantly in recent years. Optoelectrical Sisyphus cooling is one of the most promising techniques in this field providing a large number of electrically trapped molecules at submillikelvin temperatures [1]. However, this method is not applicable to molecules in their absolute ground state.

Cooled ground state molecules can still be obtained by first applying Sisyphus cooling to formaldehyde (H_2CO) molecules in the rotational states $|J=3,K_a=3,K_c=0>$ and $|4,3,1>$. Afterwards, they are transferred to their ortho ground state $|1,1,0>$ by optical pumping via a vibrational transition. In a proof-of-principle experiment we thereby obtained trapped ground state molecules with a temperature of 65 mK and trapping times of several seconds. Colder temperatures should be easily achievable in the future.

As molecules in this state are stable against inelastic two-body collisions this fulfills an important requirement for evaporative or sympathetic cooling of formaldehyde in e.g. a microwave trap which takes us one step further on the envisioned road towards quantum degeneracy.

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