Q 53: SYCM: Contributed posters for the Symposium Hot topics in cold molecules: From laser cooling to quantum resonances

Time: Thursday 16:30–18:30 Location: Empore Lichthof

Q 53.1 Thu 16:30 Empore Lichthof

Single-source merged-beam experiment for the study of reactive collisions — •Marco van den Beld Serrano, Frank Stienkemeier, and Katrin Dulitz — University of Freiburg, Hermann-Herder-Str. 3, 79104 Freiburg i. Br., Germany

We present an original merged-beam method for studying reactive collisions between two atomic or molecular species by the use of two gas pulses emerging from a single supersonic beam source. Our approach, which relies on the laser cooling and deceleration of a laser-coolable species inside a Zeeman slower, can be used for a wide range of scattering studies at thermal and at cold collision energies. A possible experimental implementation of the proposed method is outlined for autoionizing collisions between helium atoms in the metastable triplet state and a second, atomic or molecular species. Using numerical trajectory calculations, we provide estimates of the expected efficiency, the collision-energy range and the energy resolution of the approach. In addition to that, we have experimentally tested the feasibility of such an experiment by producing two gas pulses at very short time intervals, and the results of these measurements are detailed as well.

Q 53.2 Thu 16:30 Empore Lichthof

A buffer gas beam of AlF molecules and optical cycling — •Simon Hofsäss[1], Maximilian Doppelbauer[1], Sebastian Kray[1], Jesùs Pérez-Ríos[1], Boris Sartakov[2], Gerard Meijer[1], and Stefan Truppe[1] — [1]Fritz-Haber-Institut der Max-Planck-Gesellschaft, Berlin, Germany — [2]General Physics Institute, Russian Academy of Sciences, Moscow, Russia

We have recently identified the aluminium monofluoride (AlF) molecule as an excellent candidate for laser cooling and trapping at high densities and measured the detailed energy level structure of the electronic states relevant for these processes[1].

The first excited singlet state lifetime of 1.9 ns and the large photon recoil allow exerting a large cooling force to slow the molecules. The hyperfine structure in the excited state of the main cooling transition covers about 500 MHz, which allows slowing without chirping the laser frequency. The short excited state lifetime leads also to an exceptionally large capture velocity of a magneto optical trap, which is only limited by the available laser power in the UV.

Here we present the characterization of a cryogenic buffer gas molecular beam of AlF that will be used to load a magneto optical trap (MOT). Absorption and laser-induced fluorescence spectroscopy are used to determine the molecular flux. The velocity distribution is measured by combining optical pumping with a long time-of-flight. We investigate optical cycling and compare the measurements to a theoretical model.

[1] Truppe et al., Phys. Rev. A 100, 052513 (2019)

Q 53.3 Thu 16:30 Empore Lichthof

High-resolution optical spectroscopy of the $a^3\Pi$ and $b^3\Sigma^+$ states in aluminum monofluoride — •Maximilian Doppelbauer[1], Silvio Marx[1], Nicole Walter[1], Christian Schewe[1], Simon Hofsäss[1], Sebastian Kray[1], Boris Sartakov[2], Jesús Pérez-Ríos[1], Stefan Truppe[1], and Gerard Meijer[1] — [1]Fritz-Haber-Institut der Max-Planck-Gesellschaft, Faradayweg 4-6, 14195 Berlin, Germany — [2]General Physics Institute, Russian Academy of Sciences, Vavilovstreet 38, 119991 Moscow, Russia

Characterization of the triplet states of aluminum monofluoride (AlF) molecule is useful for laser cooling and trapping experiments[1].
The $b^3\Sigma^+$ - $a^3\Pi$ transition can be used for optical pumping, parity-selective detection of hyperfine levels in the $a^3\Pi$ state, and is a candidate for a triplet magneto-optical trap. The $A^1\Pi$ - $a^3\Pi$ transition is a possible loss channel for laser cooling on the $A^1\Pi$ - $X^1\Sigma^+$ transition. We present the results of spectroscopic investigations involving the $a^3\Pi$ and $b^3\Sigma^+$ states and discuss their relevance for laser cooling. Spectroscopic constants are determined to high precision. This makes AlF an ideal benchmark molecule for quantum chemical calculations.

[1] Truppe et al., Phys. Rev. A 100, 052513 (2019)

Q 53.4 Thu 16:30 Empore Lichthof

Feshbach resonances in half-collisions between para/ortho H_2^+ and He — •Karl P. Horn[1], Daniel M. Reich[1,2], Arthur Christianen[3], Gerrit C. Groenenboom[3], Ad van der Avoird[3], Prerna Paliwal[4], Yuval Shagam[4], Nabanita Deb[4], Edvardas Narevicius[4], and Christiane P. Koch[1,2] — [1]Theoretical Physics, Universität Kassel, Germany — [2]Theoretical Physics, Freie Universität Berlin, Germany — [3]Theoretical Chemistry, IMM, Radboud University, Nijmegen, Netherlands — [4]Department of Chemical Physics, Weizmann Institute of Science, Rehovot, Israel

Imaging the final states of cold He-H_2^+ half-collisions reveals significant differences in the rotational distributions when using either para or ortho H_2^+ as a collision partner. We provide an explanation of the observed disparity in terms of the dominating influence of Feshbach resonances in the vibrationally excited states of the two spin isomers. To this end, we numerically simulate the half-collision process, utilising a state of the art potential[1] and full coupled channels calculations[2]. We substantiate our analysis by studying the difference in behaviour under interchange of either one or both hydrogen atoms with deuterium.

[1] M. Meuwly et al., Phys. Chem. Chem. Phys., 2019,21, 24976-24983
[2] S. N. Vogels et al., Science, 350. 787-790 (2015)

Q 53.5 Thu 16:30 Empore Lichthof

Designing a microwave trap for ultracold polar molecules — •Maximilian Löw, Martin Ibrügger, Martin Zeppenfeld, and Gerhard Rempe — Max-Planck-Institut für Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching

Ultracold polar molecules are promising candidates for many different applications because of their rich internal structure and long-range dipole-dipole interactions. Optoelectrical Sisyphus cooling provides a high number of molecules at sub-millikelvin temperatures as we demonstrated with formaldehyde (H_2CO) in the past [1]. However, the electric trap used in the experiment prevents us from reaching high phase-space densities due to its large volume.

For this reason, we are designing a microwave trap as the next stage in our experiment. Working at a frequency of 50 GHz it acts as a red-detuned dipole trap on the rotational transition $|J,K_a,K_c\rangle = |211\rangle \leftarrow |110\rangle$ of formaldehyde. We present our progress in developing a high-finesse open mm-wave resonator to achieve trap depths of several mK with reasonable input power while maintaining optical access. We also show that we can prepare cooled formaldehyde in its ortho rotational ground-state $|110\rangle$. The microwave trap will enable us to further reduce the molecule temperature using evaporative or sympathetic cooling and allows us to aim for the regime of quantum degeneracy.

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

Q 53.6 Thu 16:30 Empore Lichthof

A new experimental setup to investigate cold molecule-Rydberg atom interactions — •Shreyas Gulhane and Martin Zeppenfeld — Max-Planck-Institut fuer Quantenoptik, Hans-Kopfermann-Str. 1, 85748 Garching, Germany

Due to their large electric dipole moments, interactions between polar molecules and Rydberg atoms extend over large distances, allowing for applications in quantum science. In the past, we have investigated such interactions at room temperature, allowing the observation and investigation of Förster resonant energy transfer between these two systems [1].

Extending this work to cold molecules and cold Rydberg atoms provides new opportunities. In this contribution, we present the experimental setup. Slow molecules produced by velocity filtering via a quadrupole electric guide interact with Rydberg atoms excited from cold atoms inside a magneto-optical trap (MOT). We present the laser system for the MOT, a 780nm tappered amplifier diode laser locked to a rubidium vapor cell. This is combined with a 480nm frequency doubled diode laser for two-photon excitation of rubidium Rydberg states. In addition, we present our vacuum setup. This includes in-vacuum MOT coils and a carefully designed electrode arrangement for precise electric field control. [1]. F. Jarisch *et al.*, New J. Phys. **20**, 113044 (2018).