Q 61: SYCM: Contributed talks for the Symposium Hot topics in cold molecules: From laser cooling to quantum resonances

Time: Friday 14:00–15:15 Location: e415

Q 61.1 Fri 14:00 e415

Towards laser cooling and trapping of AlF molecules — •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]Faradayweg 4-6

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].

Here we report the characterization of a cryogenic buffer gas molecular beam of AlF that will be used to load a magneto optical trap (MOT). Spectroscopic techniques are applied to determine properties of the beam source such as molecular flux, velocity distribution and beam divergence. We investigate the optical cycling process on the rotationally closed Q lines of the main cooling transition and compare the measurements to a theoretical model.

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

Q 61.2 Fri 14:15 e415

Towards sympathetic cooling of the ultracold SrF molecule — •Maciej Kosicki[1], Masato Morita[2], Piotr Zuchowski[1], and Timur Tscherbul[2] — [1]Institute of Physics, Faculty of Physics, Astronomy and Informatics, Nicolaus Copernicus University in Toruń, Poland, 87-100 — [2]Department of Physics, University of Nevada, Reno, NV, 89557, USA

Sympathetic cooling is a method that can allow transferring molecules into a single partial-wave regime. This process is based on cooling species by immersion in a gas of coolant atoms. The method relies on elastic collisions to transfer momentum between the hot molecules and the coolant atoms. Inelastic collisions are detrimental to the cooling process as they release the internal energy of trapped molecules, leading to undesirable heating and trap loss. In addition, the inelastic collisions might also lead to final states that are no longer trappable. By providing numerical results, we show that the ultracold SrF molecule (recently laser-cooled into the microkelvin regime) is a promising candidate to be sympathetically cooled by collisions with Rb atom in the presence of a magnetic field. A key step into this direction has been an evaluation of the ratio between elastic and inelastic collisions for the spin-polarized SrF and Rb complex. In particular, the state-of-the-art ab initio calculations have been employed to obtain molecular properties and the potential energy surface in the lowest triplet state. Next, the scattering parameters have been obtained using the converged close-coupling calculations based on the total angular momentum representation in the body-fixed coordinate frame.

Q 61.3 Fri 14:30 e415

Spectroscopic studies on the lowest triplet states of AlF — •Nicole Walter[1], Silvio Marx[1], Maximilian Doppelbauer[1], Jesús Pérez-Ríos[1], Boris Sartakov[2], Sebastian Kray[1], Simon Hofsäss[1], Christian Schewe[1], Stefan Truppe[1], and Gerard Meijer[1] — [1]Fritz-Haber-Institut der Max-Planck-Gesellschaft, Faradayweg 4-6, 14195 Berlin — [2]General Physics Institute, Russian Academy of Sciences, Vavilovstreet 38, 119991 Moscow, Russia

Aluminum monofluoride (AlF) is an excellent candidate for laser cooling. The spin-forbidden $a^3\Pi$ - $X^1\Sigma^+$ transition can be used to achieve final temperatures in the low μK range.

The metastable a-state allows high spectral resolution due to its long lifetime ($\sim$ 1 ms). Using a jet-cooled, pulsed molecular beam, rf-transitions between opposite parity Λ-doublet levels are measured. We observe Rabi-lineshapes narrower than 1.5 kHz. By increasing the interaction time of the molecules with the rf-field, lines narrower than the natural linewidth can be obtained.

The parity selective detection of AlF in the a-state is done by resonant ionization via the $b^3\Sigma^+$ or $c^3\Sigma^+$-state. For this, we measure rotational-resolved spectra of all the involved states. Furthermore, the predicted lifetimes of the a, b and c-states are experimentally verified.

Q 61.4 Fri 14:45 e415

Spectroscopic studies of spin-forbidden transitions in aluminum monofluoride — •Maximilian Doppelbauer[1], Silvio Marx[1], Simon Hofsäss[1], Nicole Walter[1], Sebastian Kray[1], Christian Schewe[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

Aluminum monofluoride (AlF) is an excellent candidate for laser cooling on any Q-line of the $A^1\Pi$ - $X^1\Sigma^+$ transition and trapping at high densities[1]. Narrow-line laser cooling on the spin-forbidden $a^3\Pi$ - $X^1\Sigma^+$ transition can be used to reduce the temperature further. The $A^1\Pi \rightarrow a^3\Pi$ decay channel can lead to losses from the optical cycle.
Prior to cooling and trapping experiments, it is necessary to measure the detailed energy level structure in the $X^1\Sigma^+$ electronic ground state, in the $A^1\Pi$ state and in the metastable $a^3\Pi$ state as well as the strength of the transitions between these states.
Here, we report on our investigations of the $a^3\Pi$ - $X^1\Sigma^+$ and $A^1\Pi$ - $a^3\Pi$ transitions of aluminum monofluoride.

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

Q 61.5 Fri 15:00 e415

P,T-Violting effects in polyatomic molecules – An electronic structure perspective — •Konstantin Gaul and Robert Berger — Fachbereich Chemie, Philipps-Universität Marburg,Hans-Meerwein-Straße 4, 35032 Marburg

"New physics" beyond the standard model, such as supersymmetry, can imply larger simultaneous violations of parity (P) and time-reversal (T) symmetry and therewith predict more pronounced non-vanishing permanent electric dipole moments (EDMs) than the standard model. In polar molecules electronic structure enhances such P,T-odd effects and thus low-energy high-precision experiments on these molecules can give access to the TeV energy-regime[1]. With the proposal of laser-cooling of polyatomic molecules[2] and its experimental evidence[3], new possibilities to improve molecular searches for P,T-violation employing the advantages of polyatomic molecules were demonstrated[4].

In this contribution the electronic structure enhancement of P,T-odd effects in laser-coolable polyatomic molecules including vibrational effects will be discussed. Scaling behavior with respect to nuclear charge numbers and disentanglement of different sources of P,T-violation are highlighted.

[1] D. DeMille, Physics Today 68, 34 (2015).
[2] T. A. Isaev, R. Berger, Phys. Rev. Lett. 116, 063006 (2016).
[3] I. Kozyryev et. al., Phys. Rev. Lett. 118, 173201 (2017).
[4] I. Kozyryev, N. R. Hutzler, Phys. Rev. Lett. 119, 133002 (2017).
[5] K. Gaul, R. Berger, Phys. Rev. A accepted for publication, (2019), arXiv:1811.05749 [physics.chem-ph].