Next-Generation Ion-Atom Hybrid Traps with Increased Control over Collision Energies

P. Eberle[1], A. Dörfler[1], R. Krishnamurthy[1], S. Willitsch[1], H. da Silva Jr.[2], M. Raoult[2], and O. Dulieu[2]

[1] *University of Basel, Switzerland*
[2] *Laboratoire Aime Cotton du CNRS, Paris, France*

Presenting Author: p.eberle@unibas.ch

Recent studies of chemical reactions at low collision energies using laser-cooled, co-trapped ions and atoms in hybrid traps showed the ability of such systems to be used for investigation of the quantum character of reactive collisions [1-4]. Details of the mechanism of chemical reactions and the nature of molecular interaction potentials can be studied. But so far, insufficient control over the collision energy magnitude and distribution impeded the study of effects with narrow dependencies on collision energy, such as shape resonances [5]. Here, we present results from the extension of our hybrid trap setup with increased control over the collision energies.

Our hybrid trap consists of a linear Paul trap for atomic and molecular ions overlapped with a magneto-optical trap for neutral rubidium atoms. Initial experiments focused on interactions between Ca^+ + Rb [1,2] and Ba^+ + Rb [3], in which both systems have been laser cooled. Recently, chemical reactions of sympathetically cooled N_2^+ molecular ions with Rb atoms have been studied as well [4].

In the original setup, changing the number of ions and shape of the ion crystal was the only control over the energy of the ion-atom collisions. Heating of the ions due to micromotion lead to large spreads of the collision energies averaging out the effect of narrow resonances. In a new approach, we use a modified magneto-optical trap which allows the use of a dynamic atom cloud. Radiation pressure differences in the cooling laser beams along one axis create atom clouds in off-center positions. On-resonance push beams accelerate the atoms through the ion crystal after which the atoms are recaptured in the opposite off-center position from where they are pushed back through the crystal. By carefully tuning the cooling and push beam sequence and intensities we are able to produce moving atom clouds with well-defined velocities in the lab frame. Using this approach with ion strings on the rf null line of the ion trap, the collision energy resolution could be greatly improved.

References

[1] F. H.J. Hall *et al.* Phys. Rev. Lett. **107**, 243202 (2011)
[2] F. H.J. Hall, P. Eberle *et al.*; Mol. Phys., **111**, 14-15, 2020-2032 (2013)
[3] F. H.J. Hall *et al.*; Mol. Phys. **111**, 12-13, 1683-1690 (2013)
[4] F. H.J. Hall *et al.*; Phys. Rev. Lett. **109**, 233202 (2012)
[5] H. da Silva Jr. *et al.*; New J. Phys. **17**, 045015 (2015)