A 3: Precision Spectrosocopy I - trapped ions (joint session A/Q)

Time: Monday 10:30–12:00 Location: K 1.016

Invited Talk A 3.1 Mon 10:30 K 1.016

Segmented ion traps with integrated solenoids for scalable microwave based QIP — •Michael Johanning, Timm F. Gloger, Peter Kaufmann, Hendrik Siebeneich, and Christof Wunderlich — Faculty of Science and Technology, Department of Physics, University of Siegen, 57068 Siegen, Germany

Segmented traps have proven to be an essential ingredient for quantum information processing (QIP) using cold trapped ions, as they allow to control the position and shape of ion crystals, even in a time dependent fashion, and can be used to relocate or reshape ion crystals for transport, splitting and merging operations and tune normal modes and distances, e. g. to create strings of equidistant ions.

On the other hand, microwave manipulation has shown to be a way for internal state manipulation with near unit fidelity without requiring sub-Doppler cooling. Additional position dependent fields allow for high fidelity addressing and create an effective spin-spin coupling that can be used to create entangled states. The combination of segmented traps and magnetic gradient induced coupling (MAGIC) allows for tuning of coupling constants, e. g. to create long distance entanglement and thus facilitates scalable quantum simulations.

We give an overview over our ongoing projects which combine segmented microtraps with micro-structured solenoids. Experimental results obtained in such traps include robust Hahn Ramsey interferometry, high fidelity transport of internal states, and single ion addressing.

A 3.2 Mon 11:00 K 1.016

Trapping of anions for laser cooling — •Pauline Yzombard, Alban Kellerbauer, and Giovanni Cerchiari — Max Planck Institut für Kernphysik, Heidelberg, Germany

There is only a very small number of anions candidates with an optical dipole-allowed transition between two bound states that are potentially suitable for Doppler laser cooling. Detailed spectroscopic studies were needed to identify a proper candidate [1].

According to our latest results, the La- ion seems promising [2]. But the narrow width of its bound-bound transition implies a long interaction time for the laser cooling to take place. We have developed two traps, a cryogenic Penning trap and a room-temperature linear Paul trap, to trap the anions long enough to apply laser cooling. As the efficient Doppler laser cooling of La- would require pre-cooling, we are currently developing an evaporative cooling step assisted by laser excitation.

One of the main motivations for this work is the importance of an ultra-cold negative plasma for antimatter experiments. The established technique for antihydrogen formation is based on merging antiproton and positron plasmas at low energy. The ability of sympathetically cooling the antiprotons with laser-cooled anions would open the path to new precision measurements with antihydrogen [3].

[1] U.Warring et al. PRL 102 (2009) 043001. [2] E. Jordan and al. PRL 115 (2015) 113001 [3] A. Kellerbauer New J. Phys. 8 (2006) 45. 2005

A 3.3 Mon 11:15 K 1.016

Sympathetic cooling of OH- by a laser-cooled buffer gas — •Jonas Tauch[1], Henry Lopez[1], Jan Trautmann[1], Bastian Höltkemeier[1], Eric Endres[1], Roland Wester[3], and Matthias Weidemüller[1,2] — [1]Physikalisches Institut, Universität Heidelberg, Deutschland — [2]University of Science and Technology of China, Shanghai Branch, Shanghai 201315, China — [3]Institut f. Ionenphysik und angewandte Physik, Universität Innsbruck, Österreich

Sympathetic cooling has become a powerful and universal method for preparing ultracold ions confined in radio frequency traps. In the past few year there has been a large debate about the limitations of this method. We recently 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 talk I present the recent results of our hybrid trap system, consisting of an 8-pole radio frequency trap and a dark spontaneous-force optical Rubidium trap. For probing the temperature of the ions, in particular OH-, we apply photodetachment tomography and time-of-flight detection of ions extracted from the trap. Via photodetachement spectroscopy we can also detect the energy distribution in the internal degree of freedom. We observe first evidence for sympathetic cooling and deviations from a thermal distribution of the ions, as predicted by our theoretical model.

A 3.4 Mon 11:30 K 1.016

Electronic coupling of laser-cooled ions stored in different traps — •Raúl A. Rica[1,2], Francisco Domínguez[1], Íñigo Arrazola[3], Javier Bañuelos[1], Manuel J. Gutiérrez[1], Lucas Lamata[3], Jesús J. del Pozo[1], Enrique Solano[3,4,5], and Daniel Rodríguez[1,2] — [1]Departamento de Física Atómica, Molecular y Nuclear, Universidad de Granada, 18071, Granada, Spain. — [2]Centro de Investigación en Tecnologías de la Información y las Comunicaciones, Universidad de Granada, 18071, Granada, Spain. — [3]Department of Physical Chemistry, University of the Basque Country UPV/EHU, Apartado 644, 48080, Bilbao, Spain. — [4]IKERBASQUE, Basque Foundation for Science, María Díaz de Haro 3, 48011, Bilbao, Spain. — [5]Department of Physics, Shanghai University, 200444 Shanghai, People's Republic of China.

A single laser-cooled ion stored in an ion trap can be used as an ultrasensitive detector of RF electric fields of diverse origin. One of the most appealing applications of such a detector considers its coupling to another oscillator. In this case, the ion can be used as a coolant for the second system, and even a quantum state transfer between them can be envisioned. In this contribution, we report on the evaluation of the sensitivity of a single Doppler-cooled ion in a Paul trap to external electric fields. We also present our progress in the implementation of a novel double trap system where two laser-cooled ions or clouds of ions can be coupled through the electric currents they induce on a common electrode.

A 3.5 Mon 11:45 K 1.016

Coulomb Coupling of Single Ions in a 2D Trap Array — •Frederick Hakelberg, Philip Kiefer, Sebastian Schnell, Matthias Wittemer, Jan-Philip Schroeder, Ulrich Warring, and Tobias Schaetz — University of Freiburg, Germany

Trapped ions present a promising system for quantum simulations [1]. Surface-electrode traps in contrast to conventional ion traps offer the advantage of scalability to larger system size and dimension while maintaining individual control: Dedicated radio-frequency electrode shapes allow the creation of two-dimensional trap arrays [2] while control electrodes allow localized manipulation of the trapping potential tuning motional frequencies and mode orientations [3,4]. The coupling between the individual ions, seen as harmonic oscillators, can be mediated via the Coulomb interaction, as has been demonstrated for one-dimensional traps [5].

In our experiment we trap Mg^+ ions in an equilateral triangle with $40\,\mu$m ion-ion distance. We present first experimental results for Coulomb coupling between ions in this two-dimensional trap array. Furthermore we investigate the effect of anharmonicities of the trapping potential on the exchange of large coherent states.

[1] T. Schaetz *et al.*, New J. Phys. **15**, 085009 (2013)
[2] R. Schmied *et al.*, Phys. Rev. Lett. **102**, 233002 (2009)
[3] M. Mielenz *et al.*, Nature Communications **7**, 11839 (2016)
[4] H. Kalis *et al.*, Phys. Rev. A **94**, 023401 (2016)
[5] Brown *et al.* & Harlander *et al.*, Nature **471**, 196-203 (2011)