Fast transport and accumulation of cold ion clouds in a multi-zone RF-trap

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Transporting charged particles between multiple traps has become an important feature in quantum information, high-precision spectroscopy, cold chemistry or frequency metrology experiments. In this work, we study experimentally the transport and accumulation of a large ion sample in a multi-zone trap. Our trapping device is composed of two quadrupole (first and second zone) and an octupole (third zone) linear trap mounted inline.

Our transport protocol consists in the variation of the potential barrier between two trap zones following a hyperbolic tangent gate [1]. The result shows that, for some well identified transport parameters, the transport efficiency from the first to the second zone (distance 23 mm) is independent of the ion number as long as this number is larger than 2000 ions and can reach 90% in such case. For clouds smaller than 2000 the efficiency is higher and can reach 100% in 100μs [2] (see figure 1).

The number of leaving ions depends strongly on the duration of the transport protocol, alternating between 0 and 100% several times before these oscillations are damped. This oscillation of the fraction of leaving ions is not symmetric. Under certain experimental conditions, ions are transported from the first to the second part, but do not return from the second zone for the same set parameters. This asymmetry can be use used to accumulate ions in the second trap [3]. This technique allows to create very large ion clouds in the trap by accummulation. As the transport efficiency to the octupole is low, we use the described accumulation process to create a large ion sample in octupole trap.

In the ideal case, the cold ion cloud in a linear octupole trap organizes in a hollow structure, formed of concentric tubes. However, in our octupole trap we observe some local harmonic potential wells where the ions samples organize themselves into very prolate strings or zigzag structures and to ellipse structures for large samples. This feature can be due to a defect in the geometry of the RF-electrodes. We exploit this observed structures to verify the theoretical laws for string, zigzag or ellipse structures.

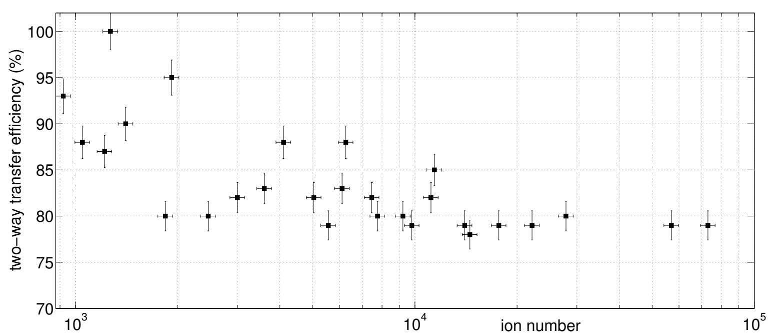

Figure 1: *Ratio of the number of ions after shuttling back and forth from trapping zone 2 with two identical transport protocols, versus the initial number of ions*

References

[1] J. Pedregosa-Gutierrez, C. Champenois, M. R. Kamsap and M. Knoop;Ion transport in macroscopic RF linear traps International Journal of Mass Spectrometry; doi:10.1016/j.ijms.2015.03.008 (2015).
[2] M.R. Kamsap, J. Pedregosa-Gutierrez, C. Champenois, D. Guyomarc'h, M. Houssin, and M. Knoop ; Fast and efficient transport of large ion clouds; Submitted (2015).
[3] M.R. Kamsap, C. Champenois, J. Pedregosa-Gutierrez, M. Houssin and M. Knoop ; Fast accumutation of ion in dual trap; submitted (2015).