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Sympathetic cooling and isotopic separation in a large Sr^+ Coulomb crystal

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Performing an accurate measurement on a physical system supposes a long observation time and a high sensitivity. The level of control demonstrated by the trapping and laser-cooling of few atomic ions led to extreme achievements such as long-lifetime high-fidelity quantum bits, or time/frequency measurements with an accuracy reaching the 17th decimal.

The electrostatic force between the trapped ions makes more challenging the trapping and laser-cooling of large ion ensembles, but leads to some interesting properties : at low temperature the system forms a long lifetime, self-organized, Coulomb crystal among which individual ions are optically resolved. The strong electrostatic coupling allows for using the laser-cooled atomic ions as a thermal bath for an other ionic specie. This opens the way to the quantum manipulation of unperturbed atoms or even molecules.

We have shown that extremely large ion crystals containing more than 10^6 Sr^+ ions can be formed in an electromagnetic linear Paul trap. Furthermore various isotopes (84, 86, 87, 88) can be trapped simultaneously, spatially separated, and sympathetically cooled [1,2]; a method for isotopic enrichment was demonstrated.

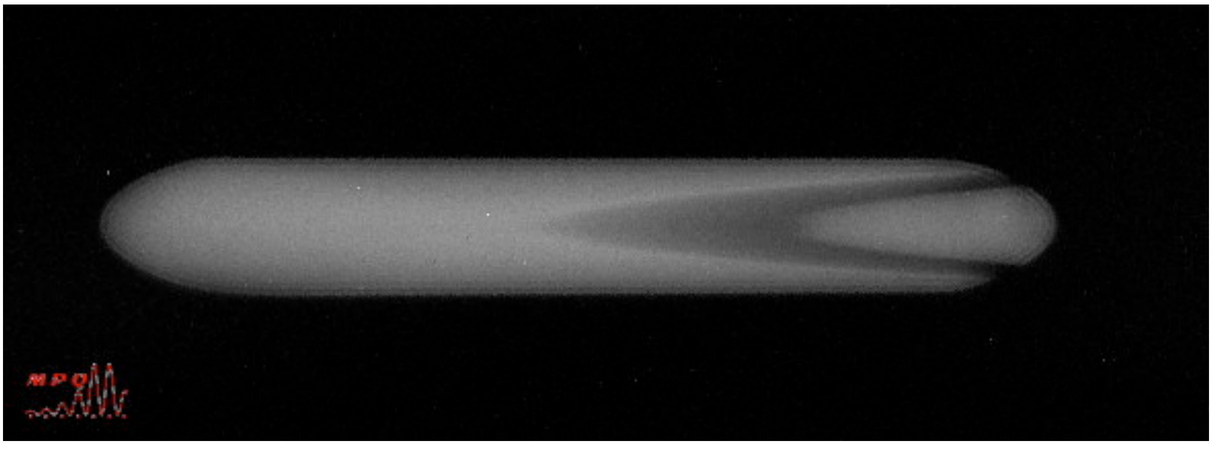

Fig. 1: *Fluorescence image of laser-cooled Sr+ ions in a linear Paul trap. The various natural isotopes are spatialy separated thanks to a mass-dependent trap stiffness and to the radiation pressure due to the opposite direction cooling lasers applied to $^{88}Sr^+$ and $^{86}Sr^+$. Among this very large Coulomb crystal, one can distinguish the ion slices due to the strong repulsive force between individual ions.*

Références

[1] S. Removille, R. Dubessy, B. Dubost, Q. Glorieux, T. Coudreau, S. Guibal, J-P. Likforman, L. Guidoni, Trapping and cooling of Sr+ ions: strings and large clouds, J. Phys. B: At. Mol. Opt. Phys. 42 154014, 2010

[2] S. Removille, Q. Glorieux, T. Coudreau, L. Guidoni, J.-P. Likforman, S. Guibal, Sympathetic cooling in a multi-isotope Sr+ Coulomb crystal, Proc. SPIE 7727, 2010, pp. 77270T