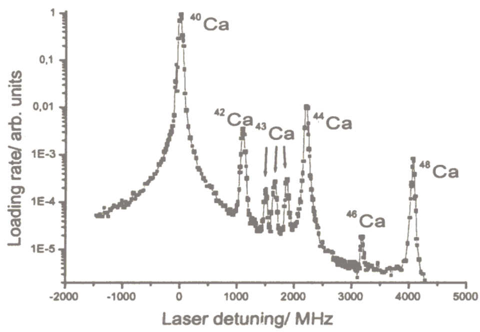
Isotope selection for ion quantum information processing

A. Mortensen[1], J. Lindballe, I. S. Jensen, D. Voigt, and M. Drewsen
Institute of Physics and Astronomy, University of Aarhus, 8000 Aarhus C, Denmark

Laser-cooled ions in RF traps has several interesting applications in the field of quantum information. Strings of crystallized ions are considered to be promising candidates for scalable quantum information processors[1], while large two-species ion crystals are interesting as storage mediums of quantum states of light[2]. Isotope-selective resonance-enhanced photo-ionization is an extremely effective tool for loading ions into traps used for such experiments[3, 4]. For realizing a quantum computer, this technique makes it very easy to load a specific number of ions, even in cases where several isotopes would be desirable in the same string. This accounts for the situation where one ion-species sympathetically cool another species that constitutes the qubits as well as the case where each qubit is represented by a specfic isotope. For the proposed quantum memory of light[2], where the storage medium consist of ions sympathetically cooled by other laser-cooled ions, isotope-selective loading, possibly in combination near-resonant charge transfer processes, will be ideal.

Previously, we have shown that it is possible to resonantly photo-ionize ^{40}Ca via excitation of the $4s5p\,^1P_1$ state, using CW laser light at 272 nm[3]. Here, we report on the isotope-selective loading of an ion trap applying this resonant two-photon ionization process. More specifically, *all* the natural abundant calcium isotopes including ^{46}Ca$^+$ ions has been produced and trapped. This is evident from the figure below where the loading rate (arb. units) as a function of the detuning of the ionizing laser from the resonance of ^{40}Ca is presented.

Besides loading the various isotopes, from the spectrum shown as well as similar laser scans, we have, furthermore, determined the previously unknown isotopeshift of the $4s^2\,^1S_0 \rightarrow 4s5p\,^1P_1$ transition, the hyperfine splitting of the $4s5p\,^1P_1$ state for ^{43}Ca, as well as an upper bound of the lifetime of $^1P_1$ state.



References

[1] J. I. Cirac and P. Zoller, Phys. Rev. Lett. **74**, 4091 (1995)

[2] M. Drewsen in *non-neutral plasma physics IV*, edited by F. Anderegg, L. Schweikhard, C. F. Driscoll, AIP Conf. Proc. 606 (AIP,New York,2002), p. 135; M. D. Lukin, S. F. Yelin and M. Fleischhauer, Phys. Rev. Lett. **84**, 4232 (2000).

[3] N. Kjærgaard *et al.*, Appl. Phys. B **71**, 207 (2000).

[4] S. Gulde *et al.*, Appl. Phys. B **73**, 861 (2001).

[1]Email: andersvm@ifa.au.dk