Collisional cooling of trapped Rb^+ ions by Rb MOT[1]

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We present a combined ion-atom trap which consists of a linear Paul trap and a magneto optical trap. It traps rubidium ions and rubidium atoms simultaneously with spatial overlap, and enables us to study interaction between the trapped ions and cold atoms[2].

In conventional buffer gas-cooling techniques, there is no net change in ion temperature when the trapped ion and buffer gas have the same mass[3]. Nevertheless in the experimental configuration described above, cooling of ions can be unambiguously established. To explain why this occurs in our experiment, while being consistent with the traditional collisional cooling framework, we show that the localized MOT atom distribution leads to cooling of ions. The possibility of a single ion-atom glancing collision bringing a fast ion to a complete stop at the bottom of the ion trap, in a resonant charge exchange collision is discussed. The experimental conditions, when such collisions are favourable, are enumerated. The ion cooling processes are numerically computed and compared with experimental data. The temperature of the trapped cold ions is estimated after holding the ion atom system in contact for 180 sec. Finally the utility and future prospects of this method are discussed.

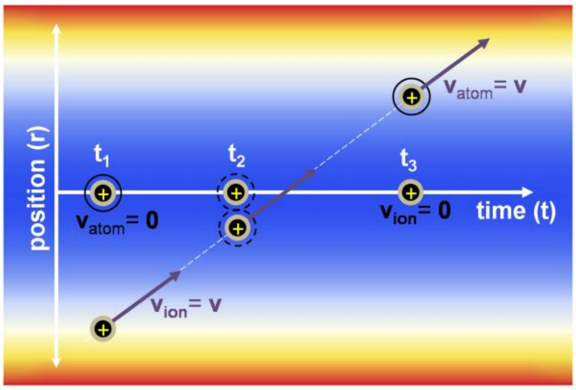

Fig.1. Ion cooling in a glancing, resonant charge exchange collision: atom with $v_{atom} = 0$ at $t = t_1$ collides with ion approaching with $v_{ion} = v$ at $t = t_2$. When a resonant charge exchange collision occurs at $t = t_2$, the valence electron from the atom transfers to the ion without any change in the dynamical state of the colliding particles. Therefore the ion comes to rest in the central (blue), low field region of the ion trap, and the atom moves away from the trap minima with $v_{atom} = v$.

References:
[1] K. Ravi, Seunghyun Lee, Arijit Sharma, G. Werth, and S. A. Rangwala, Appl. Phys. B 107, 971 (2012) doi 10.1007/s00340-011-4726-6 (2011)
[2] K. Ravi, Seunghyun Lee, Arijit Sharma, G. Werth and S. A. Rangwala, Nat. Commun. 3:1126 doi: 0.1038/ncomms2131 (2012)
[3] Major, F. G. and Dehmelt, H. G. Phys. Rev. **170,** 91–107 (1968).