Negative ion relaxation and reactions in a cryogenic storage ring

H. T. Schmidt[1], S. Rosén[1], G. Eklund[1], M. Ji[1], P. K. Najeeb[1], M. K. Kristiansson[1], E. K. Anderson[1], P. Löfgren[1], P. Reinhed[1], A. Simonsson[1], A. Källberg[1], M. Blom[1], M. Björkhage[1], W. D. Geppert[1], S. Mannervik[1], M. H. Stockett[1], J. D. Alexander[1], R. D. Thomas[1], D. Hanstorp[2], H. Zettergren[1], and H Cederquist[1]

[1]*Stockholm University, Department of Physics, 10691 Stockholm, Sweden*
[2]*University of Gothenburg, Department of Physics, 41296 Gothenburg, Sweden*

The cryogenic double electrostatic ion-storage ring, DESIREE, in Stockholm is now fully operational and here a report is given on recent studies of molecular relaxation and mutual neutralization (MN) processes. The low temperature at which DESIREE is operated leads to a remarkably low density of residual gas of the order of one or a few molecules per cubic mm. This in turn means that ions can be stored with keV energies for very long times up to the order of one hour. Long-time storage in such environments implies that the internal degrees of freedom for infrared active molecular ions will approach equilibrium with the cryogenic surrounding so that effectively single or few quantum states are populated in the stored beams after tens of minutes of storage [1]. Similarly, for atomic ions, the populations of metastable states has been monitored as a function of time by a selective photodetachment technique revealing the intrinsic – very long – lifetimes [2].

Using the unique double-ring structure of DESIREE allows the study of MN processes in merged beams of positive and negative ions. Control of the CM energy of interacting ions has been demonstrated down to the order of 10 meV. The two neutral atoms formed in the MN process are detected in coincidence. From their mutual distance in all three dimension when passing the plane of the detector, the amount of kinetic energy released in the MN process can be determined with sufficient precision that the final fragment quantum states can be resolved. This is demonstrated in the figure for Li^++D^- MN reactions at 0 eV initial CM energy.

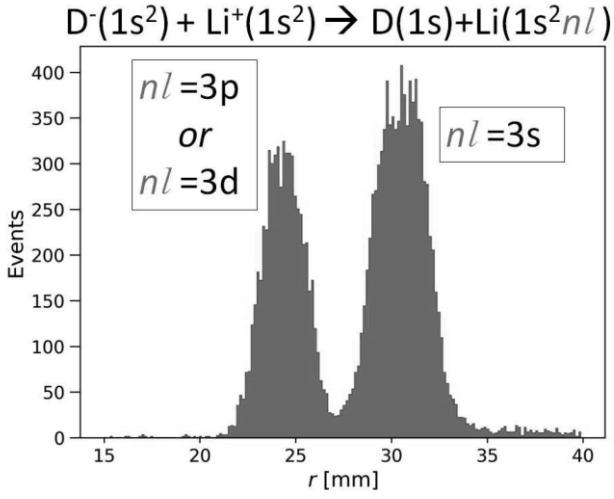

Figure 1: Histogram of the distribution of distances in all three dimensions of pairs of neutral atoms formed in Li^++D^- mutual neutralization reactions when they reach the detector plane.

[1] Schmidt H T *et al* 2017 *Phys. Rev. Letters.* **119** 073001
[2] Bäckström E *et al* 2015 *Phys. Rev. Letters.* **114** 143003