Rotational cooling and electron collisions of molecular ions at the Heidelberg cryogenic storage ring CSR

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The cryogenic electrostatic storage ring CSR has been set up to study atomic, molecular and cluster ions stored at kinetic energies between 20 and 300 keV and their interactions with photons, cold electrons and neutral particles. The CSR has demonstrated ion beam lifetimes of 1000 s and more [1]. While collision studies will also be possible also with heavy and complex molecular and cluster ions, we here focus on first results obtained for small hydride molecules. Near-threshold resonances of CH^+ pre-dissociating to C^+ and H could be observed for the lowest rotational levels (J = 0–2) of the ion [2]. The rotational relaxation cascade by far-infrared emission could be studied for OH^- probing single rotational levels by near-threshold photodetachment. This [3] confirmed radiative rotational cooling down to ~15 K and allowed natural lifetimes (A coefficients) of long-lived rotational levels to be measured with high precision (measured natural lifetime (A^{-1}) of 193(7) s for J = 1 in OH^-).
Recently, a storage-ring insertion with a collinear merged near-monoenergetic electron beam has been taken into operation, where electron collisions with the stored molecules are studied at tunable energies down to the order of 1 meV. Particle detectors perform event-by-event coincidence measurements of neutral products from molecular fragmentation. First measurements on low-energy dissociative recombination are under analysis. Moreover, the electron beam at kinetic energies reaching down to (so far) ~9 eV was used for phase-space cooling of the ion beam, observing reduced transverse beam sizes and shorter bunch lengths. Progress in these studies will be presented.

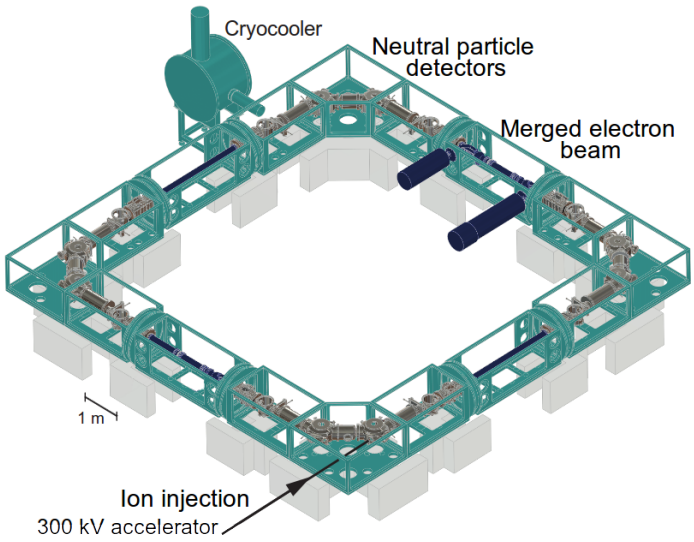

Figure 1: Scheme of the cryogenic electrostatic storage ring CSR with the recently added electron beam section.

References

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[2] A. O'Connor *et al.*, Phys. Rev. Lett. **116**, 113002 (2016).
[3] C. Meyer *et al.*, Phys. Rev. Lett. **119**, 023202 (2017).