Rotational level specific dissociative recombination rate constants measured in a cryogenic storage ring

A Wolf [1], O Novotný [1], P Wilhelm [1], D Paul [1], A Kálosi [1], S Saurabh [1], K Blaum [1], M Grieser [1], R von Hahn [1], H Kreckel [1] and D Zajfman [2]

[1] *Max Planck Institute for Nuclear Physics, Heidelberg, Germany*
[2] *Weizmann Institute of Science, Rehovot, Israel*

Cryogenic electrostatic storage rings offer long-time storage for molecular cation and anion beams with multi-keV kinetic energy at low blackbody radiation intensity, reached by cooling the complete storage-ring structures down to around 10 K [1-3]. Hence, blackbody heating is strongly suppressed over beam storage times that were demonstrated to reach 10^2 to several 10^3 seconds. Among many options opened up by these new devices, collision studies become possible with molecular ions in the lowest rotational quantum levels. In particular, for hydride molecules, the populations of the lowest rotational levels evolve by radiative relaxation with a well-predictable temporal dependence to finally reach almost pure ground-level rotational population [4].

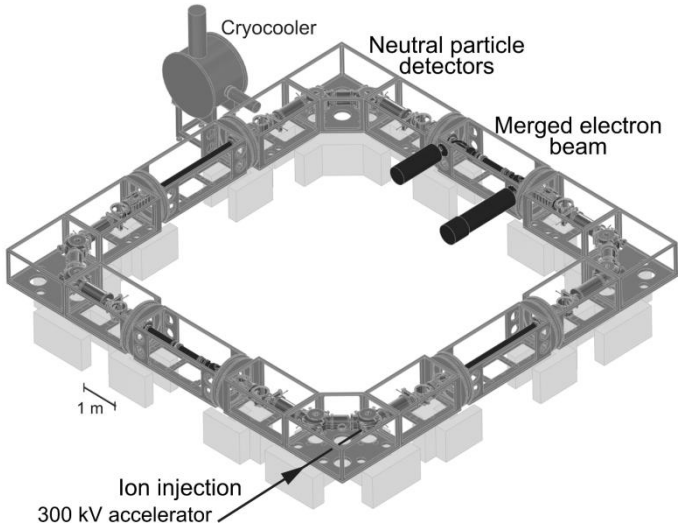

Figure 1: Schematic view of the cryogenic storage ring CSR [2] at the Max Planck Institute for Nuclear Physics, Heidelberg, and the merged electron beam device. The ring circumference is 35 m.

Using a recently completed merged electron beam device at the cryogenic electrostatic storage ring CSR (see Figure 1), dissociative recombination of electrons and molecular ions with such controlled internal excitation was studied at collision energies down to few milli-eV. With kinetic temperatures below 20 K in the photocathode-produced merged electron beam, rate coefficients could be determined for the radiatively relaxing rotational level populations and for the equilibrium with dominant ground-level rotational population. Time dependent measurements were analyzed to yield rotational level specific rate coefficients.

We present the facility and the first experimental results. The new rotational level specific rate coefficients yield improved laboratory data on dissociative recombination in cold plasma environments. Moreover, theoretical calculations on the rotational dependence of dissociative recombination via low-energy predissociating Feshbach resonances are challenged.

[1] H. T. Schmidt *et al.*, Rev. Sci. Instrum. **84**, 055115 (2013).

[2] R. von Hahn *et al.*, Rev. Sci. Instrum. **87**, 063115 (2016).

[3] Y. Nakano *et al.*, Rev. Sci. Instrum. **88**, 033110 (2017).

[4] C. Meyer *et al.*, Phys. Rev. Lett. **119**, 023202 (2017).