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Astrochemistry in TSR and CSR Ion Storage Rings

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Dissociative recombination (DR) of molecular ions plays a key role in controlling the charge density and composition of the cold interstellar medium (ISM). Experimental data on DR are required in order to understand the chemical network in the ISM and related processes such as star formation from molecular clouds. Needed data include not only total reaction cross sections, but also the chemical composition and excitation states of the neutral products. Utilizing the TSR storage ring in Heidelberg, Germany, we have carried out DR measurements for astrophysically important molecular ions. We use a merged electron-ion beams technique combined with event-by-event fragment counting and fragment imaging. The count rate of detected neutral DR products yields the absolute DR rate coefficient. Imaging the distribution of fragment distances provides information on the kinetic energy released including the states of both the initial molecule and the final products. Additional kinetic energy sensitivity of the employed detector allows for identification of fragmentation channels by fragment-mass combination within each dissociation event. Such combined information is essential for studies on DR of polyatomic ions with multi-channel breakup. The recently commissioned Cryogenic Storage Ring (CSR) in Heidelberg, Germany, extends the experimental capabilities of TSR by operation at cryogenic temperatures down to ˜6 K. At these conditions residual gas densities down to ˜100 cm^{-3} can be reached resulting in beam storage times of several hours. Long storage in the cold environment allows the ions to relax down to their rotational ground state, thus mimicking well the conditions in the cold ISM. A variety of astrophysically relevant reactions will be investigated at these conditions, such as DR, electron impact excitation, ion-neutral collisions, etc. We report our TSR results on DR of HCl^+ and D_2Cl^+. We also present first results from the CSR commissioning experiments.