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Astrochemistry in an Ion Storage Ring[1]

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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 and reliable predictions based on a good knowledge on the underlying quantum mechanisms 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 are carrying out DR measurements for astrophysically important molecular ions. TSR is unique for being the only storage ring in the world currently capable of such DR studies. We use a merged electron-ion beams technique to generate high-quality phase-space cooled, stored ion beams. This is 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 details of the reaction dynamics are given by the pattern of the fragment positions. A recently introduced energy- and position-sensitive detector combines these two basic approaches and, in addition, 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 multi-fragment breakup. We report recent DR results on D_3O^+, $DCND^+$, D_2Cl^+ and other systems.

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