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Physics with Cooled and Trapped Molecular Ions

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Modern techniques developed during the last decade have open several new opportunities to study low energy collision processes between molecular ions and electrons, such as dissociative recombination and electron impact excitation, with the help of fast molecular ion beams. The heavy-ion storage ring technique, together with cold electron beams produced by cryogenically cooled photocathode allow to reach center-of-mass resolution of the order of 500 μeV, permitting the observation of well separated Rydberg resonances in the recombination process. Also, manipulation and probing of the vibrational and rotational excitation of the stored molecular ions is now made possible with these tools. Observation of the molecular dynamics taking place during theses collisions can be made via three-dimensional imaging detectors. In this lecture, several examples will be shown which demonstrate the advantages of these techniques for simple molecular ions such as HD^+ and H_3^+. Comparison with recent theoretical calculations will be presented as well. Also, the next generation of experiments which will be performed by the end of this decade using the Cryogenic Storage Ring (CSR) will be described.