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Molecular Dissociation Induced by Electron Collisions

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Free electrons can efficiently break molecules or molecular ions in low-energy collisions by the processes of dissociative recombination or attachment. These processes make slow electrons efficient chemical agents in many environments. For dissociative recombination, in particular, studies of the underlying reaction paths and mechanisms have become possible on a uniquely elementary level in recent years both for theory and experiment. On the experimental side, collisions can be prepared at resolved collision energies down to the meV (10 Kelvin) level, increasingly gaining control also over the initial molecular quantum level, and individual events are detected and kinematically analyzed by fast-beam coincidence fragment imaging. Experiments are reported from the ion cooler ring TSR in Heidelberg. Stored beams of molecular ions cooled in their external and internal degrees of freedom are collinearly merged with intense and cold electron beams from cryogenic GaAs photocathodes, recently shown to yield fast cooling of the center-of-mass motion also for heavy and correspondingly slow molecular ion beams. To reconstruct the molecular fragmentation events multiparticle imaging can now be used systematically with collision energies set a wide range, especially aiming at specific electron capture resonances. Thus, for CF^+ it is found that the electronic state of the C fragment (^3P or ^1D) switches resonantly when the collision energy is changed by only a small fraction. As a new powerful tool, an energy-sensitive multi-strip surface-barrier detector (EMU) has been set up to measure with near-unity efficiency the masses of all fragments together with their hit positions in high-multiplicity events. Among many uses, this device allows internal molecular excitations to be derived for individual chemical channels in polyatomic fragmentation. New results will be presented in particular on the breakup of the hydronium ion (D_3O^+).