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Cold electron collisions with atomic and molecular ions in merged beams: high-resolution collision spectroscopy in storage rings

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Down to the lowest collision energies, free electrons efficiently react with atomic and molecular cations. Atomic ions can bind the colliding electrons by the emission of photons (radiative and dielectronic recombination), while molecular ions are efficiently broken up by slow free electrons without an energy barrier (dissociative recombination). For most atomic and molecular species, the cross sections for recombination and other inelastic cross sections show important resonances reflecting the energetic positions as well as the autoionization and pre-dissociation of quasibound intermediate states formed in the electron collision. High resolution experiments revealing such resonances as well as the underlying atomic and molecular properties and the rich dynamics are performed with merged beams of ions and electrons in ion storage rings, using event-by event counting and imaging methods. Recently, monochromatic electron impact energies down into the few-meV range have been realized by intense and cold merged electron beams from photocathode sources. Ion beam storage controls the internal vibrational and, to some extent, rotational state of the cation. Fast-beam multiparticle imaging is used to reconstruct the molecular fragmentation events and to monitor the initial ionic ro-vibrational state. Examples of recent measurements with multicharged atomic ions and with smaller molecules, from the hydrogen ions to di- and triatomic heavier species (such as CF^+ and CH_2^+) are presented.