Electron-ion collision experiments with merged beams in storage rings: General aspects and research at the cryogenic electrostatic storage ring CSR

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The role of experiments in strengthening application-oriented knowledge on atomic and molecular collision processes is twofold: (a) to directly determine rate constants and (b) to verify the theoretical assumptions and methods required to predict rate constants from many-body quantum calculations. In both cases, it is important that measurements define as precisely as possible the projectile and the target regarding chemical composition, charge state, internal structure and internal excitation state. Moreover, studies with angular resolution or in external fields can be important for additional benchmarking of the theory and for enabling predictions in anisotropic environments.

For studies of this type, beam experiments with well-defined collision energy and geometry, as well as with stored and state-controlled targets are particularly powerful.

In our laboratory we apply the technique of merged electron and ions beams using a collinear electron-ion interaction zone in an ion storage ring. The cryogenic electrostatic storage ring CSR was designed and taken into operation for this purpose recently. Long storage times in extreme vacuum allow the relaxation of internal excitation for many atomic and molecular ions, as well as measurements with good control of the internal excitation during the relaxation process. Through electrostatic ion storage and by suitable ion sources, electron collisions can be also studied for complex atomic ions and heavy di- and polyatomic molecular ions.

Measurements of low-energy recombination between electrons and small molecular ions under rotational-level control were performed recently at the CSR. The study of atomic ions with complex configurations (singly and multiply charged systems) is soon to start. The planned projects will involve collaboration with other laboratories. First electron collision results with the Heidelberg CSR will be presented. Regarding recombination studies for complex atomic ions, the status of scientific understanding as well as the perspectives for measurements at the existing ion storage ring facilities will be discussed.