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The cryogenic storage ring CSR for collision experiments with state-controlled and phase-space cooled molecular ion beams

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Synopsis The cryogenic storage ring (CSR) for positive and negative atomic, molecular and cluster ions is starting operation at the Max Planck Institute for Nuclear Physics in Heidelberg.

Cryogenic electrostatic storage devices are being realized with two main motivations: (a) very long storage times of ion beams with multi-keV kinetic energies in extremely rarified background gas and (b) suppressing radiative (blackbody) excitation of the stored ions. First operation [1, 2] and results of cryogenic electrostatic ion beam storage devices were reported. Among these new devices, the cryogenic storage ring CSR [3] is unique by its ion beam energy range up to 300 keVq and a wide range of instruments for merged and crossed beams collision studies. Merged velocity-matched electron beams will serve for translational (phase-space) cooling of the stored ions and for electron-ion collision studies down to meV kinetic energies [4]. The electrostatic storage strongly extends the ion mass range compared to magnetic storage rings. In combination, a new tool emerges for studying the fragmentation of complex molecular ions following many types of collisional or radiative interaction. Many new options open up for state controlled reaction studies of systems relevant for molecular astrophysics, where low internal temperatures of the collision partners often are of particular importance.

Construction of the cryogenic storage ring has been completed. A 35 m long beam pipe encloses the ion beam round-trip orbit, containing all beam optics and diagnostics within a separate extremely-low-pressure vacuum system. It is cooled to 10 K, cryopumps being kept at 2 K, and itself encapsuled in a large toroidal cryostat. Ion-optics cryogenic cooling [3] and room-temperature ion beam storage were separately demonstrated in previous work, while a campaign to perform first long-time storage of molecular anion and cation beams is in progress. Implementation of the merged electron beam device [4] and a setup for velocity-matched neutral atomic beams [5] are upcoming.

First experiments will focus on laser photodetachment and photodissociation of stored molecular anions and cations with sensitivity to individual rotational levels. A wide range of the CSR experimental equipment has either been created [6] or will be added in the near future. This includes multicoincidence detectors for neutral and charged fragments from in-flight fragmentation of the stored ions. They will be complemented by mass-sensitive calorimetric detectors for neutral fragments with promising properties revealed in recent studies [7]. The CSR facility also includes a 300 keV accelerator platform suitable to interface with a wide range of ion-chemistry and plasma-type sources for cations and anions [8]. Hence, many types of collision and radiation induced fragmentation of complex molecular and cluster ions can be investigated with particular emphasis to internal state definition as well as to the detailed analysis of all products.

References

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