CSR: Status and Outlook

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Since the early 1990s electron cooler ion storage rings – besides their original applications in nuclear and particle physics – have provided significant experimental input to the fields of atomic and molecular physics [1]. The traditional realisations of such devices are medium-sized magnetic storage rings of several tens of meters of circumference, like CRYRING in Stockholm, ASTRID in Aarhus, or TSR in Heidelberg. However, rising scientific interest in molecular ions with ever lower charge-to-mass ratios has led this first generation of electron cooler storage rings to their technical limits. As residual-gas-induced loss cross-sections rise at low ion velocity, beams of high rigidity can be stored only for short times in existing machines, with lifetimes often shorter than the required electron cooling times. In addition, large molecular ions are characterised by a high number of internal degrees of freedom that are energetically accessible through the infrared black body radiation from room-temperature vacuum chamber walls. Emerging interest in heavy, singly charged molecular and cluster ions has led to the development of compact electrostatic storage rings [2], which allow mass-independent ion storage and which can be cooled to cryogenic temperatures more easily than full-size magnetic storage rings [3]. However, existing electrostatic devices operate at too low energy to achieve efficient electron cooling for heavy ion beams [4].

The Cryogenic Storage Ring (CSR), presently under construction at MPIK, is designed to combine the advantages of traditional electron cooler storage rings with those of electrostatic storage devices [5]. The electrostatic beam optics of the CSR can store particles of up to 300 keV kinetic energy per unit charge, independent of their mass. A low-energy electron cooler [6] will allow phase-space cooling of ions of up to 160 atomic mass units per elementary charge. The all-cryogenic design of the storage ring will provide unprecedented vacuum conditions [7] and assure long storage times of even very slow ion beams. In addition, it suppresses the black body radiation background of the vacuum chamber. In combination with electron cooling and dedicated cold ion sources, this will provide experiments with both kinematically and internally cold stored ions. The internal cooling will reduce initial state multiplicities and allow precision studies of even complex systems, under environmental conditions similar to those found e.g. in cold interstellar media. The ability to store and cool very heavy ions opens up new research opportunities, including electron-ion recombination reactions of large molecular systems in the electron cooler, and fast ion-neutral collisions in a crossed-beam gas target backed by a reaction microscope. Furthermore, slow ion-neutral reactions at tunable velocities and ion-photon experiments are planned. Access to ambient temperatures down to ~10 K will allow investigations of processes depending on thermal excitations, such as thermionic decays of clusters and large molecules [8].

We give an overview of the present status of the CSR project, including the ongoing construction of the electrostatic beam line and the injector platform. Construction of the low-energy electron cooler has started and is projected to be finished by the time the ring lattice is complete. Concepts for particle detectors operating in the cryogenic environment of the ring are presently being elaborated and we give an outlook on possible first experiments after the commissioning phase of the CSR.

References

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