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Electron cooling of trapped highly charged ions

HITRAP is a facility for deceleration of large bunches of highly charged ions (HCI) produced online by the GSI accelerator. It consists of an ion transport beamline from the accelerator, an IH-structure and an RFQ for deceleration down to several keV/q, as well as a Penning-Malmberg trap for ion cooling down to sub-eV energies.

The linear deceleration stages reduce the ion energy from 4 MeV/u to 500 keV/u and to 6 keV/u respectively, resulting in a slow, but hot ion bunch mixed with non-decelerated components. Customized detectors separate then the energy components, while an electrostatic beamline guides the slow ions to the ion trap, which is the final cooling stage.

The trap is operated in a nested configuration, where the electrons are stored simultaneously with the HCI. The ions transfer their energy by Coulomb interaction to the electrons, which in turn continuously dissipate energy by synchrotron radiation from their circular motion in the trap's magnetic field. The alignment of the ion trap was achieved by projecting the magnetron motion of the stored electron plasma onto a position sensitive detector, which proved to be a crucial step.

Recently, the cooling process was demonstrated by storing about 10^5 highly charged argon ions together with about 10^9 electrons. The HCI were produced by an EBIT and transported at 4 keV/q, while the electrons came from a photocathode source with an initial energy of 200 eV. Depending on parameters such as ion energy, electron density and trap configuration, the ions transferred most of their energy to the electrons within a few seconds of storage.

In addition to describing the first electron cooling of HCI, this talk will also present the status of the HITRAP facility and some of the associated experiments.

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