

The GSI and FAIR laser cooling activities

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Stored and cooled relativistic heavy-ion beams have a small relative momentum spread ($\Delta p/p$) and a small emittance (ϵ) and are therefore ideally suited for high-precision experiments, such as laser and X-ray spectroscopy. At storage rings, cooling is typically achieved by means of electron and/or stochastic cooling, which yield cooling times of several seconds and $\Delta p/p \sim 10^{-5}$.

Laser cooling can, however, cool ion beams even faster and reach $\Delta p/p \sim 10^{-7}$. Furthermore, laser cooling becomes more effective at higher energies than electron cooling, and is – unlike stochastic cooling – not limited to low ion beam intensities. The future Facility for Antiproton and Ion Research (FAIR) will offer heavy-ion beams (as well as antiproton beams) with highest energies and intensities. The heavy-ion synchrotron SIS100 is (at) the heart of FAIR and stores, accelerates, and delivers the beams – initially provided by the GSI accelerators – to the FAIR experiments (i.e. the APPA, CBM, NUSTAR and PANDA collaborations). At the SIS100, laser cooling of bunched heavy-ion beams is our preferred method and is currently being prepared for [1,2]. Cooling is achieved by balancing the force from anti-collinear laser light exerted on the ions by the counter-acting force from the rf-bucket.

Calculations show that laser cooling at the SIS100 can be almost as effective as has been demonstrated at the ESR [3]. Furthermore, it should assist in making the SIS100 ion bunches – achieved by means of bunch compression (< 50 ns) – even shorter, thus offering world-wide unique possibilities. Because of the huge magnetic rigidity (100 Tm) of the SIS100, very large gamma factors (up to 13) and correspondingly large Doppler-shifts can be achieved, which should enable laser cooling (and laser spectroscopy) of a broad range of ion species. We will present the general concept of bunched beam laser cooling and provide an overview of the laser cooling pilot facility at the SIS100.

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