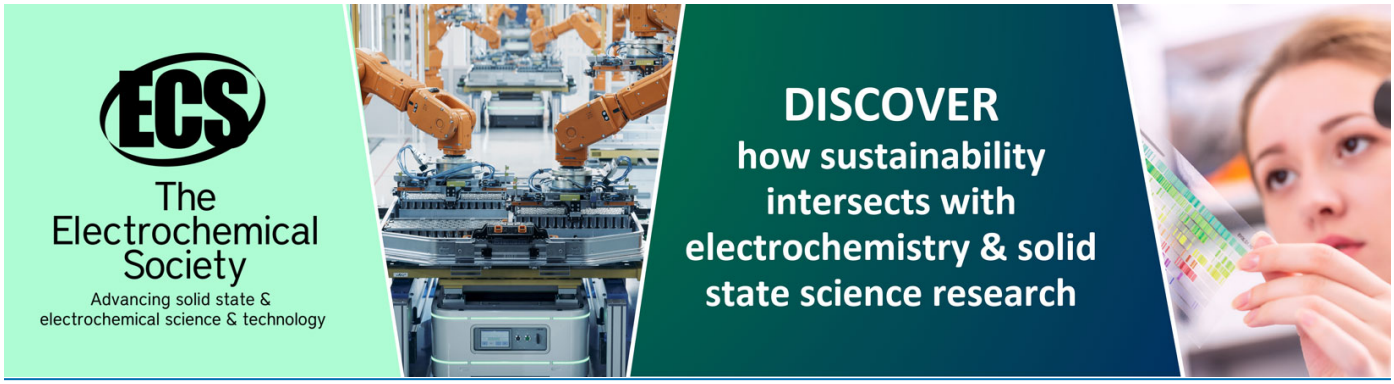
Progress of laser cooling of $^{12}C^{3+}$ ions at the CSRe



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Progress of laser cooling of $^{12}C^{3+}$ ions at the CSRe

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Synopsis We have performed a test run for laser cooling experiments with $^{12}C^{3+}$ ion beams at an energy of 122 MeV/u at the CSRe with a pulsed laser. During this beamtime a lot of progress have been made. This was the first time we could successfully separate the $^{12}C^{3+}$ ions and $^{16}O^{4+}$ ions in the Schottky spectrum with the help of electron cooling. And our newly installed CPM detector worked well during the experiment. We tried to see effects from the interaction of the pulsed laser light with the stored $^{12}C^{3+}$ ion beams, but no cooling effects could yet be observed.

Laser cooling is the most promising method to achieve high phase-space densities or even crystalline beams for relativistic heavy ion at storage rings [1]. In order to achieve laser cooling at the CSRe in IMP, we performed a test run for a laser cooling experiment with $^{12}C^{3+}$ ion beams at an energy of 122 MeV/u at the CSRe with a pulsed laser in September 2014.

During this beamtime we have made a lot of progress and managed to get a large part of the experiment under control. Firstly, we could successfully separate $^{12}C^{3+}$ ions and $^{16}O^{4+}$ ions in the Schottky spectrum with the help of electron cooling for the first time (Figure 1). Secondly, the new CPM (Channeltron photomultiplier) detector which was used to detect the fluorescence from the (laser excited) $2p_{1/2}$ and the $2p_{3/2}$ states was tested systematically. With the laser off, the CPM detector was also used to determine the lifetime by recording fluorescence due to charge-changing collisions between $^{12}C^{3+}$ ions and the residual gas. The lifetime was about 20 seconds, which is much longer than it was during the last beam time. Thirdly, we tried to see effects from laser cooling with the pulsed laser, and the beam and laser widths were measured using the scrapers and a wire scanner to make sure they were overlapped. Moreover, the dynamics of the electron-cooled and RF-bunched ion beams were investigated systematically by longitudinal modulation of sinusoidal, square and barrier bucket waveforms.

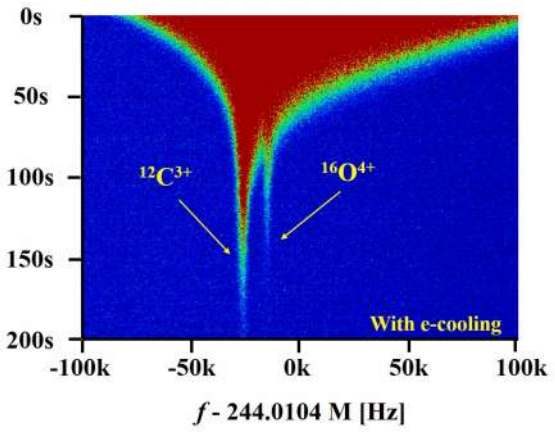

Figure 1. Schottky spectrum of $^{12}C^{3+}$ and $^{16}O^{4+}$.

We tried to see effects from the interaction of the pulsed laser with the stored $^{12}C^{3+}$ ion beams. But unfortunately, we did not find any evidence for effects from the interaction in the Schottky spectrum or the count rate of the CPM detector. We attribute this to the background and the low repetition rate of the laser. Therefore, we will repeat the experiment in 2015 using a laser system with a higher repetition rate.

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References

[1] U. Schramm *et al* 2004 *Progress in Particle and Nuclear Physics* **53** 583-67

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