Beam lifetime measurement and longitudinal dynamics investigation for laser cooling at the CSRe

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Synopsis During the experiment for laser cooling of relativistic $^{12}C^{3+}$ ion beams with a pulsed laser, the individual lifetimes of the primary ions ($^{12}C^{3+}$) and the contaminate ions ($^{16}O^{4+}$) were measured and the longitudinal beam dynamics were investigated systematically. Although our results do not indicate laser cooling effect, a number of important prerequisites have been successfully tested for future laser cooling experiments.

We report on an experiment that was conducted in the preparation of laser cooling experiments with a pulsed laser [1] at the heavy-ion storage ring CSRe. During the experiment, the fluorescence signals were measured using a UV-CPM and two UV-PMT detectors. A non-destructive resonant Schottky pick-up was employed to measure the revolution frequency and the longitudinal momentum spread of the ion beams.

While the experimental results did not indicate laser cooling effects, a number of important prerequisites have been successfully tested for future laser cooling experiments. With electron-cooling, the signals of the $^{12}C^{3+}$ and $^{16}O^{4+}$ ions were successfully separated and clearly observed in the Schottky spectrum, as shown in figure 1. By analyzing Schottky noise signals, individual lifetimes of these two kinds of ions were measured to be 23.6 seconds and 17.8 seconds, respectively. The proportion of $^{12}C^{3+}$ ions in the stored ion beam was measured to be more than 70% [2]. Moreover, the longitudinal dynamics of the electron-cooled and RF-bunched $^{12}C^{6+}$ ion beams were investigated systematically, and the Schottky spectrum for longitudinal dynamics investigation is shown in figure 2.

A new laser cooling experiment for $^{16}O^{5+}$ ions with a CW laser is currently been prepared at the CSRe by the Laser-cooling Collaboration, and will be carried out in 2017.

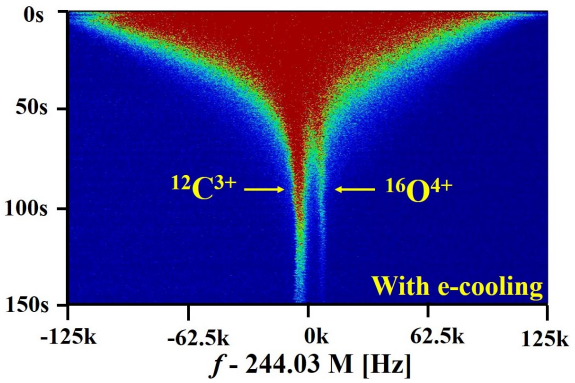

Figure 1. Schottky spectrum of coasting $^{12}C^{3+}$ and $^{16}O^{4+}$ ion beams under electron cooling.

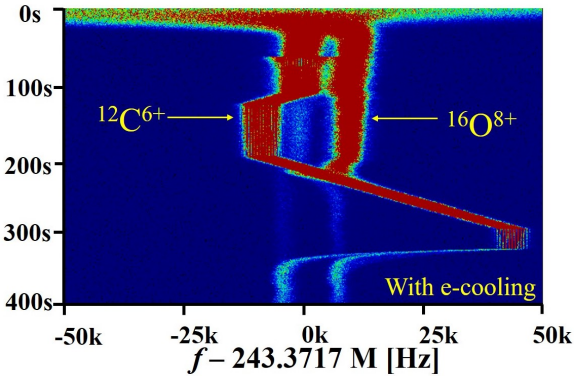

Figure 2. Schottky spectrum of $^{12}C^{6+}$ and $^{16}O^{8+}$ ion beams for longitudinal dynamics investigation.

References

[1] M. Siebold *et al.* 2016 *Laser Photonics Rev.* **10** 673
[2] H.B. Wang *et al.* 2017 submitted to *NIMB*

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