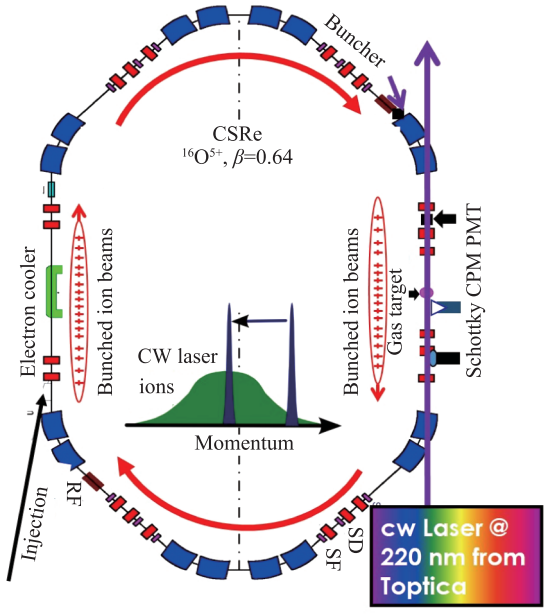
3 - 3 Preparation for Laser Cooling of Relativistic Li-like $^{16}O^{5+}$ Ion Beams at the CSRe*

Wen Weiqiang[1], Wang Hanbing[1,2], Huang Zhongkui[1,2], Zhang Dacheng[1], Hai Bang[1], Zhu Xiaolong[1], Zhao Dongmei[1], Yang Jie[1], Li Xiaoni [1], Li Jie[1], Mao Ruishi[1], Mao Lijun[1], Yang Jiancheng[1], Yuan Youjin[1] and Ma Xinwen[1]

([1]Institute of Modern Physics, Chinese Academy of Sciences, Lanzhou 730000, China;
[2]University of Chinese Academy of Sciences, Beijing 100049, China)

Laser cooling of relativistic heavy ion beams at storage rings is one of the most promising techniques to reach high phase-space densities and achieve a phase transition, an ordered beam, or even a crystalline beam. Compared with the established cooling schemes at storage rings, such as electron cooling and stochastic cooling, laser cooling rate is expected to be much higher and laser-cooled ion beams could reach ultra-low temperatures (∼mK). The preparation of laser cooling of 280 MeV/u $^{16}O^{5+}$ ion beams at the experimental cooler storage ring CSRe is in progress at the Institute of Modern Physics[1], Chinese Academy of Sciences. A schematic view of the experimental setup for laser cooling of relativistic ion beams at the CSRe is shown in Fig. 1 on the left, and the parameters relevant for the experiments are summarized in the table on the right. The experiment is to be performed in 2017, and $^{16}O^{5+}$ ion beam with an energy of 280 MeV/u will be the highest energy and highest charge state for laser-cooled ion beam until now. The space charge dominated regime are expected of the laser-cooled ion beams in the experiments. Laser cooling and precision laser spectroscopy of highly charged and relativistic heavy ions will also be performed at the future large facilities, such as High Intensity heavy ion Accelerator Facility (HIAF)[2].



CSRe parameters	
Circumference	128.80 m
Ion species	$^{16}O^{5+}$
Beam energy	280 MeV/u
Relativistic β, γ	0.64, 1.30
Revolution frequency	1.49 MHz
Transition energy γ_t	2.626
Splitting factor η	0.44
Harmonic number h	10, 15
Laser system	
Laser source	cw laser
Laser wavelength	λ_{laser} = 220 nm
Laser power	P_{laser}=40 mW
Scanning range	$\triangle f_{laser}$= 20 GHz
Cooling transition	
$2s_{1/2} \rightarrow 2p_{1/2}$	$\lambda_{rest} \approx$ 103.76 nm
$2s_{1/2} \rightarrow 2p_{3/2}$	λ_{rest} = 103.19 nm

Fig. 1 (color online) (Left) Schematic view of the experimental setup for laser cooling of 280 MeV/u Li-like $^{16}O^{5+}$ at the CSRe, the locations of a cw laser, laser beam transport, electron-cooler, RF-buncher, resonant Schottky pick-up, and UV-sensitive fluorescence detection systems are shown. (Right) The experimental parameters of laser cooling of $^{16}O^{5+}$ ion beams at the CSRe.

References

[1] H. B. Wang, W. Q. Wen, Z. K. Huang, et al., Nucl. Instr. Meth. B(2017), http://dx.doi.org/10.1016/j.nimb.2017.03.096

[2] X. Ma, W. Q. Wen, S. F. Zhang, et al., Nucl. Instr. Meth. B, (2017) http://dx.doi.org/10.1016/j.nimb.2017.03.129

* Foundation item: National Natural Science foundation of China (11504388), Youth Innovation Promotion Association CAS and BMBF