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Laser wakefield based particle accelerator and radiation sources at SJTU

Min Chen, Li-Ming Chen, Nasr Hafz, Zheng-Ming Sheng, and Jie Zhang

[1] Key Laboratory for Laser Plasams (MOE), Department of Physics and Astronomy, Collaborative Innovation Center of IFSA (CICIFSA), Shanghai Jiao Tong University, China

E-mail: minchen@sjtu.edu.cn;

Laser wakefield acceleration has great potential for the next generation of compact radiation sources due to its three orders of magnitude larger accelerating gradient than traditional ones. Currently both the acceleration and radiation part should be improved for high quality electron beam and radiation source. In this talk we will focus on these in the first part by using ionization injection mechanisms and on the last radiation part by using plasma channel based plasma undulators.

To get low energy spread electron beam, two injection schemes are proposed here. By use of certain initially unmatched laser pulses, the electron injection can be constrained to the very front region of the mixed gas target, typically in a length of a few hundreds micro meters determined by laser-driven bubble deformation, and energy spread is largely reduced [1]. By using this method, electron beam with FWHM energy spread less than 5% and peak energy around 500MeV is demonstrated by simulations. We will show some recent experimental demonstration of this scheme at Laboratory for Laser Plasmas at Shanghai Jiao Tong University [2]. In a second scheme, we suggest to use two-color beat wave to control the injection length [3]. When two laser pulses with fundamental frequency and high harmonics co-propagate with each other, a beat wave is generated and the highest electric field due to the overlapping of the two peaks of the two laser waves can ionize the internal electrons and trigger the ionization injection. Due to the phase velocity difference of the two color pulses, the ionization distance is very limited which then lowers the injection length. We demonstrate electron beam with ultralow energy spread less than 1% percent and central energy of 400MeV can be obtained by using ω and 3ω laser pulses in a gas.

To make a compact radiation source, we propose an all-optical synchrotron-like radiation source based on laser-plasma acceleration either in a straight or in a curved plasma channel. With the laser pulse off-axially injected in a straight channel, the centroid oscillation of the pulse causes a wiggler motion of the whole accelerating structure including the trapped electrons, leading to strong synchrotron-like radiations with tunable spectra [4,5]. It is further shown that a ring-shaped synchrotron is possible in a curved plasma channel. Due to the intense acceleration and bending fields inside plasmas, the central part of the sources can be made within palm size. With its potential of high flexibility and tunability, such compact light sources once realized would find applications in wide areas and make up the shortage of large synchrotron radiation facilities.

References:

[1] M. Zeng, M. Chen, Z.M. Sheng et al., Phys. Plasmas, 21, 030701 (2014).
[2] M. Mirzaie, et al., Sci. Rep. 5, 14659 (2015).
[3] M. Zeng, M. Chen, L.L. Yu et al., Phys. Rev. Lett. 114, 084801 (2015).
[4] M. Chen, J. Luo, F.Y. Li, et al, Light: Science & Applications, 5, e16015 (2016).
[5] J. Luo, M. Chen, et al., Sci. Rep. 6, 29101 (2016).