2nd Asia-Pacific Conference on Plasma Physics, 12-17,11.2018, Kanazawa, Japan

Stable laser ion radiation pressure acceleration

B. Qiao[1], X. F. Shen[1], X. T. He[1]

[1] Center for Applied Physics and Technology, School of Physics, Peking University

e-mail : bqiao@pku.edu.cn

Laser-driven ion acceleration is conceived to be one of the main applications of many powerful laser facilities that are being projected, built, or already in operation around the world. It opens a way for a future new generation of compact accelerators providing high-quality ion beams for many applications in medicine, industry, science and others. Among various acceleration schemes, radiation pressure acceleration (RPA) is regarded as one of the most promising schemes to obtain high-quality ion beams. Although RPA is very attractive in principle, it is difficult to be achieved experimentally. One of the most important reasons is the dramatic growth of the multi-dimensional Rayleigh-Taylor-like (RT) instabilities. Such instabilities lead to heating and loss of co-moving electrons in the accelerating plasma sheet, eventually result in Coulomb explosions of the plasma sheet and termination of ion effective acceleration. How to suppress the instability of RPA is currently one of the most challenging issues. In this talk, I shall report recent progresses on theoretical and numerical studies of stabilization of laser-driven ion RPA at Peking University (PKU). A novel scheme to achieve stable RPA [2,3] of ions from laser-irradiated ultrathin foils is proposed, where a high-Z material coating in front is used. The coated high-Z material, acting as a moving electron repository, continuously replenishes the accelerating ion foil with comoving electrons in the light-sail acceleration stage due to its successive ionization under laser fields with Gaussian temporal profile. As a result, the detrimental effects such as foil deformation and electron loss induced by the Rayleigh-Taylor-like and other instabilities in RPA are significantly offset and suppressed so that stable acceleration of heavy ions are maintained. Two- and three-dimensional particle-in-cell simulations show that a monoenergetic Al^{13+} beam with peak energy 3.8 GeV and particle number 10^{10} (charge > 20nC) can be obtained at intensity 10^{22} W/cm^2. This novel scheme will be experimentally verified by Petawatt laser in China.

References:

[1] B. Qiao et al., Phys. Rev. Lett. 108, 115002 (2012).
[2] X. F. Shen, B. Qiao* et al., Phys. Rev. Lett. 118, 204802 (2017).
[3] X. F. Shen, B. Qiao* et al., New. J. Phys. 19, 033034 (2017).
[4] W. L. Zhang, B. Qiao* et al., New. J. Phys. 18 093029 (2016).
[5] J. Kim, B. Qiao* et al., Phys. Rev. Lett. 115 054801 (2015).