Revisit of the Optimal Condition for Radiation Pressure Acceleration

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Laser-driven ion acceleration has the potential to be compact sources of energetic ions, which can be applied for proton radiography, tumor therapy, inertial fusion energy and warm dense matter [1]. Several acceleration mechanisms have been proposed, in which radiation pressure acceleration (RPA) promises higher scaling and laser-ion conversion efficiency and monoenergetic ion beams with the optimal condition $l_o = \frac{1}{\pi}\frac{n_c}{n_e}a_0\lambda$, with l_o, n_c, n_e, a_0 and λ the target thickness, the critical density, the electron density, the normalized laser amplitude and the laser wavelength [2]. However, experiments and simulations show that the pulse can punch through the target during the acceleration even under the optimal condition as various instabilities set in and grow nonlinearly with time and other parameters during the laser plasma interactions, which will terminate the acceleration early and reduce the conversion efficiency and beam quality [1, 3]. Through theoretical and simulation studies, we show that the optimal condition of RPA is related to the pulse duration, the ellipticity of the elliptically polarized laser pulse and the scale length of the preplasma. With the modified optimal condition, the acceleration can maintain stable until the pulse ends and the quality of ion beams is improved. Meanwhile, the conversion efficiency can be increased two times.

References

[1] A. Macchi, M. Borghesi, and M. Passoni, Rev. Mod. Phys. **85**, 751 (2013).

[2] B. Qiao, M. Zepf, M. Borghesi, and M. Geissler, Phys. Rev. Lett. **102**, 145002 (2009).

[3] X. F. Shen, B. Qiao, H. Zhang, S. Kar, C. T. Zhou, H. X. Chang, M. Borghesi and X. T. He, Phys. Rev. Lett. **118**, 204802 (2017).