Influence of the laser pulse steep rising front on ion acceleration

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The shaping of a time profile of the high-intensity laser pulse can substantially influence electron and ion dynamics in the irradiated target. It was shown that a steep time profile could mitigate the development of transverse short-wavelength instabilities with Rayleigh-Taylor-like features to use long-wavelength corrugation of the target for quasi-monoenergetic ion acceleration [1]. The steep rising front of the laser pulse can also enhance photon emission from under-dense targets [2].

One of the ways to produce the steep rising front is the use of the plasma shutter [3, 4, 5], a thin solid foil placed in front of the target. This approach is also beneficial for the mitigation of the prepulses accompanying the main laser pulse. Moreover, the intensity of the laser pulse can locally increase after burning through the plasma shutter [6]. The combination of these effects can increase the energy of ions accelerated from the target [7].

In this work, we study the effect of the steep rising front generated by the plasma shutter on ion acceleration from the target. We used 3D and 2D particle-in-cell simulations using code EPOCH [8]. In our simulations, we demonstrate an increase in the quality of accelerated ions. Namely, a substantial decrease in their divergence is observed when the steep-front laser pulse is used.

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