Plasma shutter for improved ion acceleration by ultra intense laser pulses

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Plasma shutter [1,2,3] in the form of a thin solid membrane provides a way for improving laser pulse contrast by mitigation of prepulses accompanying the main laser pulse. Moreover, the intensity profile of the transmitted laser pulse can be improved during the interaction. This includes a local intensity increase and generation of a steep-front laser pulse.

In the first part of this work, we study the application of the plasma shutter in the interaction with a PW class laser with the help of 3D particle-in-cell simulations using code EPOCH [4]. In our simulations, we demonstrate a substantial increase of laser pulse intensity after burning through the plasma shutter [5] and subsequently increase of maximal energy of heavy ions accelerated from the additional main foil located behind the shutter [6]. The pre-expansion of the plasma shutter caused by prepulses is investigated using 2D hydrodynamic simulations [7]. A scheme using a double plasma shutter configuration (one filtering out the prepulses and other shaping the main pulse) is proposed [6].

In the second part, we utilize the generation of the steep front of the laser pulse, provided by the plasma shutter. In this case a structured double-layer target with interface modulation is irradiated by a 100 PW class laser pulse. The use of laser pulse with the steep front results in mitigation of short-wavelength instabilities in laser-matter interaction. Therefore, a long-wavelength Richtmyer-Meshkov like instability can develop resulting in generation of a collimated quasi-monoenergetic proton beam [8].

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