light absorption and laser-triggered particle acceleration from semi-transparent overdense targets

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The laser-triggered charged particle (electrons and ions) acceleration is the hot topic in high-energy laser physics during the last 15 years. The progress in laser technologies and understanding of different mechanisms of particle acceleration constantly result in improvement of particle beam quality and increase of efficiency of laser-triggered acceleration. Particularly, it is clear now that significant ion energy increase can be due the use of semi-transparent dense targets (ultrathin foils). In spite of the mentioned progress and a lot of published papers on ion acceleration from ultrathin foils, there is still insufficient understanding of the dependence of laser light absorption and maximum ion energy on laser parameters. For instance, the different scalings for ion energy versus the laser energy which has been derived from 2D PIC simulations, theoretical models, and experiments demonstrate the ion energy behavior from squire root to linear dependence on laser energy.

In this paper, by using 3D PIC code MANDOR we have studied laser light absorption and acceleration of electrons and ions from thin foils of the optimum thickness interacting with short relativistically strong laser pulses. The laser energy was varying from several milli-joules to hundred joules. At first, we have been finding the optimum target thickness for given energy of the laser pulse and then we have been computing corresponding energy of the accelerated ions (protons). This allows one to derive for the first time a universal dependence of the maximum proton energy on laser energy for the optimum laser-foil interaction. The obtained dependence shows that for a wide range of laser intensities the energy of accelerated protons from the targets with high concentration of hydrogen scales as the laser energy to the 0.7 power. It has also been demonstrated that for moderate laser intensities there can be some increase in the ion energy with using of surface-structured targets.

We have studied field ionization effect on acceleration of electrons and ions with updated version of MANDOR which includes ionization of atoms by strong laser field. There has been demonstrated an important role of field ionization in formation of quasi-monoenergetic laser-accelerated electrons from ultra-thin targets.

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