Computer Simulation of Particle Acceleration in Thin Foils by Ultrashort Laser Pulses

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ABSTRACT

Generation of relativistic particles from the interaction of a laser pulse with a high density plasma foil, accompanied by an underdense preplasma in front of it, has been studied with 2D particle-in-cell (PIC) simulations. 2D PIC simulations with total number of particles 10^6 and 32 particles per cell were performed for linearly polarized laser pulses, propagating normally to a plasma target (hydrogen) in the x-direction of the $X — Y$ simulation plane. This target models a thin solid dense plasma slab having a rare plasma in front of it to model the blow-off plasma created by the laser prepulse which interacts with the foil before the main pulse reaches the target.

The primary mechanism responsible for electron acceleration is identified. Simulations show that the energy of the accelerated electrons has a maximum versus the pulse-duration for relativistic laser intensities. Electron acceleration with preplasma is different as compared to both extended homogeneous plasmas and dense plasma slabs with sharp boundaries. The most effective electron acceleration takes place when the preplasma scale length is comparable to the pulse-duration. Electron distribution functions have been found from PIC simulations. Their tails are well approximated by Maxwellian distributions with a hot temperature in the MeV range. Fast electron production is an origin of effective ion acceleration. Because ions are much heavier than electrons, long time is needed to accelerate them. The ion maximum energy saturates with the time at the value corresponds to hot electrons temperature.