Simulation of plasma expansion under the action of a pre-pulse for effective acceleration of charged particles

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When selecting optimal density gradients of the pre-plasma, a significant increase in the efficiency of converting laser energy into proton energy is observed. In this paper the effect of a nanosecond laser pre-pulse on the parameters of a plasma target was considered in order to further search for the optimal parameter of the plasma density gradient.

Plasma expansion modeling was carried out using the hydrodynamic code FRONT [1]. In the course of calculations, laser pulses were used with an intensity from $I = 10^{10}$ W/cm^2 to $I = 10^{13}$ W/sm^2, the duration varied from 2 ns to 5 ns. Carbon, aluminum, and titanium were considered as target materials.

The pre-plasma density profile can be roughly represented as the sum of two exponentials, one of which describes the plasma near the target, and the other describes the sub-critical plasma.

The conducted studies have shown that the characteristic gradient of plasma density, close to critical, reaches saturation with an increase in energy consumption. While the characteristic gradient of the low-density plasma continues to increase. It is also calculated that for the considered parameters of laser pulses at energy densities exceeding 10^4 J/cm^2, the density profiles of the scattered plasma are weakly dependent on the target material due to rapid ionization.

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