Optimization of the Thickness of a Blurred Plasma Boundary for the Generation of Electron Bunches by a Ultrarelativistic Laser Pulse

Kuznetsov S V

Joint Institute for High Temperatures of the Russian Academy of Sciences, Izhorskaya 13 Bldg 2, Moscow 125412, Russia

shenau@rambler.ru

In one-dimensional geometry, the process of generation of an electron bunch during the interaction of a laser pulse with a semi-bounded rarefied plasma, which has a blurred interface with vacuum, has been analytically studied [1]. It is shown that the presence of a transition layer between the vacuum and the main plasma volume, which has a uniform electron concentration, significantly affects the process of electron bunch generation, because it shifts the start point of the process of electron self-injection into the wake wave closer to the plasma boundary. As a result, as the point of self-injection of electrons moves deeper into the plasma, the process of generating an electron bunch occurs under conditions of a decrease in the phase velocity of the wake wave. This intensifies the process of electron accumulation in the generated bunch and reduces the characteristic size of its head part, in which electrons with the highest energy are concentrated. The efficiency of this mechanism of energetic and spatial grouping of electrons depends on the thickness of the transition layer. It is found that the optimal thickness of the transition layer should exceed the amplitude of longitudinal electron oscillations, but not exceed such a value at which the start point of the bunch generation process goes beyond the plasma density plateau. The results obtained can be used to develop a subfemtosecond electron bunch injector.

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