TRAPPING OF ELECTRONS FROM THE ELECTRON BUNCH IN A WAKE WAVE

Kuznetsov S.V.

JIHT RAS, Moscow, Russia
shenau@rambler.ru

The two-dimensional problem of trapping of electrons by the wakefield from the injected electron bunch has been studied analytically for an arbitrary ratio of the bunch dimensions to the characteristic dimensions of the wake wave generated in a plasma channel by a short laser pulse. The electrons are injected into the vicinity of the maximum of the wakefield potential with a velocity lower than the phase velocity of the wake wave. The process of the formation of a compact electron bunch in the trapping region due to the cutting out of electrons from the injected bunch has been considered. The parameters of the injection region in which the electrons are trapped and then accelerated by the wake wave have been determined. Formulas have been derived that allows one to accurately estimate the length of the trapped electron bunch and the number of electrons in it. It is shown that the influence of the transverse dimensions of the injected bunch on the length of the trapped electron bunch in the accelerating stage and its energy spread after acceleration is as important as the influence of its longitudinal size, because both of them can make comparable contributions to the length of the trapped electron bunch [1].

When a long wide electron bunch is injected into the wakefield, its dimensions do not enter into the formula for the length of the trapped bunch. In this case the length of the bunch is determined by the dimensions of the injection region, rather than by those of the injected bunch. The dimensions of the injection region depend on the electron injection energy. Thus, the length of the electron bunch in the accelerating stage can be controlled by varying the value of the injection energy.

The parameters (the energy spread, emittance, and spatial dimensions) of the accelerated electron bunches formed in the course of electron trapping by the wake wave from injected electron bunches with different ratios between their spatial dimensions and the characteristic dimensions of the wakefield have been compared by means of numerical simulations. It is shown that the mechanism of cutting out electrons from the injected electron bunch allows obtain bunches of accelerated electrons with energies of ~1 GeV, transverse emittances of 1–3 mm mrad, and relative energy spreads of several tenths of a percent.