DYNAMIC OF SELF-INJECTED BUNCHES AT LASER WAKEFIELD ACCELERATION IN AN INHOMOGENEOUS PLASMA

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At the moment, one of the urgent problems of high-energy physics is research in the field of creating an Advanced Linear International Collider (ALIC). This collider is based on the methods of advanced and novel accelerator (ANA), among which one of the most efficient is laser wakefield acceleration [1]. Advanced LinEar collider study GROup (B. Cros, P. Muggli et al.) proposed as a long-term goal the design of an e+/e-/gamma ALIC collider with up to 30 TeV [2].

The wakefield acceleration method is a modern method based on the excitation of a wave in plasma as a result of the action of the ponderomotive force of a laser pulse [3]. The wakefield allows achieving acceleration gradients of up to several teravolts per meter [4]. Self-injected electron bunches can be formed in plasma and accelerated to high energies, but their parameters can only be controlled indirectly, in particular by using inhomogeneous plasma profile.

In this study, the acceleration and focusing process of a self-injected electron bunch in laser wakefield acceleration was investigated using 2D numerical simulation with the OSIRIS code [5].The aim of this study was to investigate the dynamics and parameters of self-injected bunches depending on the plasma density, taking into account that the plasma is inhomogeneous. Clear advantages of using longitudinally and transversely inhomogeneous plasma were shown. Three profiles were considered: 1) homogeneous; 2) radial profile parabolically increasing from the axis of the system with a uniform area along the axis; 3) inhomogeneous profile that linearly increasing along the axis.

The results of the studies demonstrated that the use of longitudinally inhomogeneous plasma leads to an increase of the stay time of the bunch in the acceleration phase (250.8 fs in comparison of 159.4 fs in the homogeneous case). In the homogeneous case, the maximum field observed at the end of the acceleration phase is 0.156 TV/m, in the inhomogeneous case the maximum field increases by 2.38 times. In addition, 2 times increase in the longitudinal momentum value is observed.

In the case of transverse inhomogeneity, a waveguide effect is observed relative to the laser pulse. In addition, the parabolic inhomogeneous transverse distribution leads to transverse stabilization of the bunch at more duration - 297.5 fs.

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