

Analytical and Numerical Studies of Underdense and Overdense Regimes in Plasma-Dielectric Wakefield Accelerators

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One of the advanced accelerator concepts is acceleration of particles by wakefields excited by relativistic electron bunches in dielectric structures. One problem of this method is the emittance growth of the accelerated beam due to its angular divergence. To focus the accelerated bunches, we suggest using a plasma that fills the vacuum channel of the dielectric unit.

The plasma-dielectric structure under investigation is a dielectric-lined circular waveguide that has a transport channel filled with isotropic plasma. In the linear theory approximation (overdense plasma) the total field is represented as a sum of the plasma wave, the eigen waves of the dielectric waveguide, and the quasistatic field of the bunch. It is shown that at a certain plasma density the superposition of the plasma wave and the dielectric waves allows the acceleration of the witness bunch by the field of the dielectric wave together with simultaneous focusing by the plasma wave. For the overdense plasma regime the results of analytical investigations coincide well with results of particle-in-cell simulations (PIC). Also, we carried out a PIC simulation of the underdense ("blowout") regime of wakefield excitation in the unit.

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