Laser wakefield acceleration of a finite charge electron beam

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The interaction of a high-intensity femtosecond laser pulse with a rarefied plasma, the processes of wake wave generation and the acceleration of an externally injected electron beam in it are considered. The goal was to study the parameters of accelerated electrons, such as average energy, spread in energy, and acceleration length at which the minimum spread in energy is achieved, as well as to study the impact of the total charge of accelerated electrons on these parameters—the "loading effect".
For modeling, the developed WAKE-EXI code was used, which is a quasi-static cylindrically symmetric WAKE PIC code [1], modified to describe the acceleration of externally injected high-energy particles and the effect of their charge on the potential of the wake wave generated by an intense laser pulse.
The dependence of the before mentioned parameters of accelerated electrons on the electron injection energy is investigated. For test electrons (without taking into account the effect of the beam charge), good agreement with the theoretical estimate of the dependence of the optimal length on the electron injection energy is demonstrated. The dependence of these parameters on the value of the total charge of the electron beam is investigated. It was found that the electron beam charge is limited to a value of about 2 pC, provided that the relative energy spread should not exceed 2%.
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[1] Mora P and Antonsen Jr T M 1997 *Physics of Plasmas* **4** 217–229 (*Preprint* https://doi.org/10.1063/1.872134)