Fast Particle-in-Cell simulations-based method for the optimisation of a laser-plasma electron accelerator

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A method for the optimisation and advanced studies of a laser-plasma accelerator electron source [1] is presented. In the following we focus on the specific case of a laser-plasma injector based on ionisation injection [4, 5, 6] for high quality beam production. We use the Particle-in-Cell (PIC) SMILEI code [2] with envelope approximation [3] for the laser and a low number of particles per cell allowing to reach computation time performances enabling the production of a large number of data set. Various operation mode of the laser-plasma injector are identified and the stability around specific working points is investigated. The generated phase space particle distribution data can be used to perform start to end simulation of the complete accelerator. The presented method can be first considered as an approach to generate a data set to reduce the space of accelerator parameters to be later finely optimised using higher fidelity PIC simulations. In addition, it allows for the construction of a simple first model of laser-plasma injector parameters control such as adjusting the charge keeping a constant energy distribution, or the reverse for example. The use of deep learning techniques can extend the optimisation process. All data generated are left open to the scientific community for further study and optimisation.

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