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Boosted frame PIC simulations of LWFA: ultra-fast modeling of current experiments and first studies of acceleration towards the energy frontier[1]

SAMUEL MARTINS, GoLP, Instituto de Plasmas e Fusao Nuclear - Instituto Superior Tecnico, Lisbon, Portugal & University of California Los Angeles, Los Angeles, USA

The development of new laser systems, in the 10PW range, will push Laser Wakefield Accelerators (LWFA) to a new qualitative regime, for which theoretical scalings predict the possibility to accelerate electron bunches close to the energy frontier, with self-injected electrons in excess of 10 GeV, and above 50GeV bunches with externally injected electrons. As in the past, numerical simulations will certainly play an important role in testing, probing and optimizing the physical parameters and setup of these upscale experiments. The distances involved in these numerical experiments, however, are very demanding in terms of computational resources, so that three-dimensional fully kinetic simulations are not yet possible to (easily) accomplish. Following the work on optimized Lorentz frames by J.-L. Vay [PRL 98, 130405 (2007)], the Lorentz transformation for a boosted frame was implemented in OSIRIS [R. A. Fonseca et al, LNCS 2329, III-342 (Springer-Verlag, 2002)], leading to a dramatic change in the computational resources required to model LWFA. The critical implementation details will be described, and the main difficulties discussed. Quantitative benchmarks will be presented between boosted frame and laboratory frame simulations, and also with experimental results from Imperial College and Lawrence Livermore National Laboratory, with emphasis on the boosted frame scheme as a tool for faster design and modeling of current experiments. Finally, simulations for the scenarios possible with the next generation of laser systems will be presented, including the confirmation of electron bunch acceleration to the energy frontier.

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