AKBP 10: New Accelerator Concepts

Zeit: Mittwoch 11:00–12:30 Raum: HS 8

AKBP 10.1 Mi 11:00 HS 8

Stability analysis of Laser-Plasma accelerators using quasi-cylindrical PIC simulations — •Sören Jalas, Jannis Neuhaus-Steinmetz, Manuel Kirchen, and Andreas R. Maier — Center for Free-Electron Laser Science (CFEL) and Hamburg University

Particle-in-Cell (PIC) codes have proven to be a vital tool in the developement of plasma based accelerators. For example, the process of electron injection due to wave breaking and with that the beam charge and phase space is currently not quantitively described by analytical theories. Therefore, studies on the impact of fluctuating experimental parameters in this case lean on numerical simulations. For reliable quantitive results numerical convergence of these simulations is paramount. However, the computational demand of full 3D PIC simulations hinders extensive convergence and stability studies for many problems. The use of quasi-cylindrical PIC codes can greatly improve this by reducing the computational cost to that of a few 2D simulations. Here we present the results of extensive convergence and physical parameter studies of laser plasma accelerators using the quasi-cylindrical PIC code FBPIC. With the ultimate goal of using PIC codes for plasma accelerators just like tracking tools are used for conventional accelerators, we study the feasibility of wide range, high statistics parameter studies in terms of computational cost, when also quantitive precision is a key factor.

AKBP 10.2 Mi 11:15 HS 8

FBPIC - A spectral, quasi-3D, multi-GPU Particle-In-Cell code for plasma accelerators — •Manuel Kirchen, Soeren Jalas, Jannis Neuhaus-Steinmetz, and Andreas R. Maier — Center for Free-Electron Laser Science & Department of Physics, University of Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

Plasma accelerators are compact high-energy particle sources allowing to accelerate charged particles to relativistic energy levels on mm length scales. Modelling the complex acceleration process requires computationally demanding Particle-In-Cell codes. These codes self-consistently solve the electromagnetic particle interaction inside the plasma. We present the latest features of FBPIC - a highly parallel Particle-In-Cell code featuring a spectral electromagnetic solver that eliminates numerical instabilities common to traditional field solvers, a quasi-3D geometry that greatly reduces the computational costs and the Lorentz-boosted frame technique that scales down the required simulation time by orders of magnitude.

AKBP 10.3 Mi 11:30 HS 8

Approaching predictive capabilities for LWFA experiments with PIConGPU — •Richard Pausch[1,2], Jurjen Couperus Cabadağ[1], Marco Garten[1,2], Axel Huebl[1,2], Alexander Köhler[1,2], Thomas Kurz[1,2], Susanne Schöbel[1,2], Ulrich Schramm[1,2], Klaus Steiniger[1], René Widera[1], Omid Zarini[1,2], Arie Irman[1], Michael Bussmann[1], and Alexander Debus[1] — [1]HZDR — [2]TU Dresden

State-of-the-art particle-in-cell simulations are becoming faster in terms of time to solution by utilizing modern hardware accelerators like GPUs and more accurate by improving the underlying algorithms. However, in order to model experiments, methods to include realistic laser pulses and gas distributions as well as efficient techniques to predict experimental observables, so-called synthetic diagnostics, need to be included in these simulations.

In this talk, we present extensions to the particle-in-cell code PIConGPU that were essential to accurately model LWFA experiments based on self-truncated ionization injection performed at HZDR. We discuss the significant impact of the implementation of higher order laser modes on the plasma dynamics and the resulting acceleration process. Furthermore, we discuss in detail the advantage of efficient in situ data analysis on the example of studying electron phase space evolution and of predicting spectrally and directionally radiation emission by all particles.

These improvements set the stage for quantitatively predicting the results of experiments in the near future.

AKBP 10.4 Mi 11:45 HS 8

Stand-alone laser system for off-harmonic optical probing of high intensity laser interaction with cryogenic hydrogen jet targets — •Constantin Bernert[1,2], Markus Loeser[1], Lieselotte Obst-Hübel[1,2], Martin Rehwald[1,2], Mathias Siebold[1], Karl Zeil[1], Tim Ziegler[1,2], and Ulrich Schramm[1,2] — [1]Helmholtz-Zentrum Dresden - Rossendorf, Bautzner Landstraße 400, 01328 Dresden, Germany — [2]TU Dresden, Zellescher Weg 19, 01069 Dresden, Germany

The availability of high-intensity short-pulse lasers in the Peta-Watt regime drives the development of new and compact accelerator schemes like for example the generation of multiple 10 MeV proton beams from high-density targets. Particularly cryogenic hydrogen jet-targets offer the benefit of being debris-free and capable of high-repetition rate applications. Together with spatially and temporally resolved optical probing techniques this target is most suitable for a comparison to numerical particle-in-cell simulations. However, the strong plasma self-emission often masks the laser-target interaction point and thus complicates the data analysis.

Here we show the performance of a probe-laser-system operating at a central wavelength of 1030nm far off the fundamental wavelength of the drive laser at 800nm. The application in an experimental campaign dedicated to laser-proton acceleration together with cryogenic hydrogen jet-targets showed a significant improvement of imaging quality for the laser-target interaction concerning the plasmas self-emission.

AKBP 10.5 Mi 12:00 HS 8

High-power laser grating deformation and resulting spatio-temporal couplings — •Vincent Leroux[1,2], Manuel Kirchen[1], Sören Jalas[1], Philipp Messner[1,3], Paul Winkler[1,2], Matthias Schnepp[1], Timo Eichner[1], Christian Werle[1], and Andreas R. Maier[1] — [1]Center for Free-Electron Laser Science, Hamburg, Germany — [2]DESY, Hamburg, Germany — [3]Max-Planck Institute for the Structure and Dynamics of Matter, Hamburg, Germany

Laser-plasma accelerators are driven by hundreds terawatt or up to petawatt laser systems, at a few Hz repetition rates. Furthermore, as the laser technology pushes forward the average power limit, the absorbed heat into the gold-coated in-vacuum compressor gratings increases. This heat leads to deformations of the grating surface which changes the spatial and temporal properties of the laser beam during high-power operation, which can in turn drastically decrease the peak intensity on target, as well as degrade the quality of the accelerated electron beams.

We previously investigated the impact of the grating deformation on the compressed laser wavefront, and we now report on the simulation of the spatio-temporal couplings stemming from the same causes. We then draw conclusions on the overall decrease of the peak intensity in the focal plane due to both the increase in pulse duration and beam size.

AKBP 10.6 Mi 12:15 HS 8

Probing the transient fields of the plasma accelerators with an ultrashort electron beam — •Pardis Niknejadi[1], Kristjan Poder[1], Richard D'Arcy[1], Lucas Schaper[1], Alexander Knetsch[1], Simon Bohlen[2], Martin Meisel[2], and Jens Osterhoff[1] — [1]Deutsches Elektronen-Synchrotron DESY, Notkestraße 85, 22607 Hamburg, Germany — [2]Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

FLASHForward, the exploratory FLASH beamline for Future-ORiented Wakefield Accelerator Research and Development, is a European pilot test bed facility for plasma-wakefield acceleration (PWFA) experiments. The goals of these experiments are to produce, in a few centimeters of ionized gas, beams of GeV energy with high quality, develop diagnostics for such beams, and evaluate their application in the fields of high energy physics and future compact light sources. Several conventional and novel diagnostics tools, capable of characterizing ultra-short plasma-wakefield accelerator beams, are under development in the FLASHForward diagnostic test laboratory. Notably, the Femtosecond innovative RelativistiC Electron (FiRCE) is a probe designed for investigation of plasma interaction region. Therefore, the FiRCE probe will aid in the understanding of the processes of electron trapping and acceleration in PWFA through the mapping of transient electric fields. In this contribution, a summary of the research and development related to the FiRCE probe, such as the parameter regime and set up requirements, is discussed.