P 11: Codes and Modelling

Time: Wednesday 14:00–15:30 Location: P-H11

P 11.1 Wed 14:00 P-H11

Modelling of streamer inception in pulsed-driven dielectric barrier discharges at atmospheric pressure — •Aleksandar P. Jovanović, Hans Höft, Detlef Loffhagen, and Markus M. Becker — Leibniz Institute for Plasma Science and Technology (INP), Felix-Hausdorff-Str. 2, 17489 Greifswald, Germany

A pulsed-driven dielectric barrier discharge (DBD) in a symmetric single-filament configuration with hemispherical electrodes is the object of interest of the analysis. The Townsend pre-phase and streamer propagation in Ar and N_2 with an admixture of 0.1 vol.% of O_2 have been investigated by a time-dependent, spatially two-dimensional fluid model. It consists of a set of balance equations for the particle number densities, the electron energy density, and the surface charge density, coupled with Poisson's equation for the determination of electric potential and field. The evolution of the spatial profiles of the electron number density and the electric field showed earlier streamer inception in Ar in comparison to the N_2-O_2 mixture, while qualitatively similar behaviour of the discharge during the streamer propagation was observed in both gases. The streamer propagation and consequently the current rise was slower in Ar (reaching a maximum streamer velocity of 0.43 mm/ns) compared to N_2-O_2 (1.23 mm/ns). An analysis of the electron particle and energy budget was performed to find out how the different gain and loss processes in these two gases affect the pre-phase and the streamer propagation.

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P 11.2 Wed 14:15 P-H11

Implementation and Validation of Guiding Centre Approximation into ERO2.0 — •Sebastian Rode[1], Juri Romazanov[1], Dirk Reiser[1], Sebastijan Brezinsek[1], Christian Linsmeier[1], and Alexander Pukhov[2] — [1]Forschungszentrum Jülich GmbH, Institut für Energie- und Klimaforschung - Plasmaphysik, Partner of the Trilateral Euregio Cluster(TEC), 52425 Jülich, Germany — [2]Institut für Theoretische Physik I, Heinrich-Heine-Universität Düsseldorf, Germany

The Monte-Carlo code ERO2.0 uses full orbit resolution to follow impurity particles throughout the plasma volume to determine the local erosion and deposition fluxes on the plasma-facing components of fusion devices. For this work, the theory of guiding centre approximation (GCA) was implemented into ERO2.0, enabling direct comparisons to other transport codes and accelerating the code. First, the implementation of GCA theory into the code is described in detail. Additionally, a hybrid simulation mode for ERO2.0 was developed, in which the advantages of both full orbit resolution and guiding centre approximation are used. The GCA implementation was tested in an inner-code benchmarking, using a plasma background corresponding to a deuterium limiter plasma used in JET pulse #80319. Analysing a multitude of output metrics of the code and comparing them between pure full orbit simulations and hybrid simulations, the quality of the GCA implementation was confirmed while a significant code speed up was measured in large scale simulations.

P 11.3 Wed 14:30 P-H11

Simulation results of a plasma lens as a capturing device for the ILC positron source — •Manuel Formela[1], Niclas Hamann[1], Gudrid Moortgat-Pick[1], Klaus Floettmann[2], and Gregor Loisch[2] — [1]Universität Hamburg — [2]DESY

The ILC is an ambitious international collaboration with its positron source especially being at the forefront of pushing technological boundaries. Part of this enterprise has to be the optical matching device responsible for capturing positrons exiting a target and transforming them from a highly divergent beam with a small effective cross-section to a wide, parallel beam to be appropriate for the succeeding accelerator section. For many years this problem has been approached by different types of sophisticated coils. Today considerations exist to utilize an electric current-carrying plasma. This so called plasma lens creates a magnetic field, which is potentially especially qualified for the usage as a so called optical matching device due to its pronounced azimuthal component in contrast to the radial component of conventional devices. Simulations of various tapered plasma lens designs have been conducted to find an optimal device for the ILC positron source. Designs with linear and quadratic tapering, but also with tapering growing with the square root have been examined. Furthermore, the parameter space for the optimization included a wide range of values for entrance and exit radius, length and electric current.

P 11.4 Wed 14:45 P-H11

Surrogate Modeling of Ion Acceleration in the Near-Critical Density Regime with Invertible Neural Networks — •Thomas Miethlinger[1,2], Marco Garten[1,2], Ilja Gothel[1,2], Nico Hoffmann[1], Ulrich Schramm[1], and Thomas Kluge[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf, 01328 Dresden, Deutschland — [2]Technische Universitat Dresden, 01069 Dresden, Germany

The interaction of near-critical plasmas with ultra-intense laser pulses presents a promising approach to enable the development of very compact sources for high-energetic ions. However, current records for maximum proton energies are still below the required values for many applications, and challenges such as stability and spectral control remain unsolved to this day. In particular, significant effort per experiment and a high-dimensional design space renders naive sampling approaches ineffective. Furthermore, due to the strong nonlinearities of the underlying laser-plasma physics, synthetic observations by means of particle-in-cell (PIC) simulations are computationally very costly, and the maximum distance between two sampling points is strongly limited as well. Consequently, in order to build useful surrogate models for future data generation and experimental understanding and control, a combination of highly optimized simulation codes (we employ PIConGPU), powerful data-based methods, such as artificial neural networks, and modern sampling approaches are essential. Specifically, we employ invertible neural networks for bidirectional learning of parameter and observables, and autoencoder to reduce intermediate field data to a lower-dimensional latent representation.

P 11.5 Wed 15:00 P-H11

Application of surrogate models for tokamak edge plasma simulations — •Stefan Dasbach and Sven Wiesen — Forschungszentrum Jülich GmbH, Institut für Energie-und Klimaforschung - Plasmaphysik, 52425 Jülich, Germany

The effect of operational parameters on the exhaust in a tokamak can be adequately simulated by plasma edge codes like SOLPS-ITER. These simulations suffer from two main limitations: a) due to their complexity these transport codes suffer from long convergence times, and b) each simulation yields only a result for a single tokamak scenario with fixed parameters. However for rapid design studies of future fusion power plants systems codes require fast simplified models for the exhaust in many different scenarios (machine size, field, heating, etc.). Promising candidates for such surrogate models are machine learning models trained on simulation data. The development of such surrogate models is however limited by the high computational requirements for creating a sufficient training database. This work discusses several different pathways of how this limitation might be overcome and shows first steps in their implementation. The approaches shown include the generation of a simulation database based on less numerically demanding fluid neutral simulations and first trials on a surrogate model only replacing the numerically more demanding kinetic neutral part of SOLPS-ITER.

P 11.6 Wed 15:15 P-H11

Atomic Physics for Transient Relativistic Plasmas — •Brian Edward Marre[1,2], Sergei Bastrakov[1], Axel Huebl[3], Marco Garten[1,2], Pawel Ordyna[1,2], Rene Widera[1], Michael Bussmann[4], Ulrich Schramm[1], and Thomas Kluge[1] — [1]Helmholtz Zentrum Dresden-Rossendorf — [2]TU Dresden — [3]Lawrence Berkley National Laboratory — [4]Center for Advanced Systems Understanding

Experiments for laser-driven ion acceleration create extreme states of matter, in particular relativistic solid-density plasmas undergoing transient, non-equilibrium physics. Especially the formation of such plasmas is heavily influenced by collisional and radiative effects. However, state-of-the-art simulations do not model transitions to and from excited atomic states self consistently. As these transitions are now becoming experimentally accessible on fs-nm scales, e.g. at HIBEF at the European XFEL, modelling can be improved by including excited states dynamics in simulations.

We are developing such an extension for the Particle-In-Cell(PIC) simulation code PIConGPU, to model atomic state distributions self consistently in transient plasmas. This extension is based on a reduced atomic state model directly coupled to the existing PIC-simulation, for which the atomic rate equation is solved explicitly in time.

Via the prediction of atomic state populations, this will allow us to predict plasma self-emission and XFEL probing, and improve our understanding of isochoric heating processes and plasma expansion.