PiAI Seminar Series: Physics informed AI in Plasma Science
9:30-10:30, 04 March 2024 (CET)
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Web Seminar

Towards a Machine-Learned Poisson Solver for Low-Temperature Plasma Simulations in Complex Geometries

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In electrostatic self-consistent low-temperature plasma (LTP) simulations, Poisson's equation is solved at each simulation time step, which can amount to a significant computational cost for the entire simulation. In this talk, we present the development of a generic machine-learned Poisson solver specifically designed for the requirements of LTP simulations in complex 2D reactor geometries on structured Cartesian grids. Here, the reactor setups can consist of various objects such as electrodes and/or dielectric materials. We leverage a hybrid CNN-transformer network architecture in combination with a highly randomized synthetic training dataset to ensure the generalizability of the learned solver to unseen reactor setups. To achieve the numerical accuracy of the solution required in LTP simulations, we refine the raw predictions with a GPU-based conventional iterative solver. This especially recovers the high-frequency features not resolved by the initial prediction. For large computational domains, the present approach is shown to reduce the solution time by up to 10–20% compared to a GPU-based conventional iterative solver alone. Finally, we conclude the talk by providing an outlook for future work.