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High-fidelity particle-in-cell simulations at multiple scales

Friday 16 September 2022 09:00 (45 minutes)

The particle-in-cell method is central to providing a kinetic description of the relativstic, nonlinear plasma dynamics – particularly when interacting with ultrashort laser pulses and particle beams. Its broad applicability ranges from advanced plasma accelerators of electrons or ions, warm dense matter to astrophysics. A major challenge to a better understanding is to integrate disparate spatial and temporal scales, as well as physics into consistent, predictive models that can be compared to experimental results. While the large-scale dynamics is often determined by hydrodynamic evolution, the microscale physics includes ionization, radiation processes from infrared to xrays, atomic physics, as well as QED effects. Interfacing and integrating domain-specific numerical codes, such as particle trackers, FEL codes, requires data standards for seamless data exchange. Based on recent examples from plasma accelerator research using the 3D3V particle-in-cell code PIConGPU, I will outline the state-of-the art and challenges of particle-in-cell simulations to and show current strategies of solving them in large-scale simulations on heterogenous high-performance computing environments.

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