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Implementation of a Mesh refinement algorithm into the quasi-static PIC code QuickPIC

Plasma-based acceleration (PBA) has emerged as a promising candidate for the accelerator technology used to build a future linear collider and/or an advanced light source. In PBA, the witness beam needs to be matched to the focusing forces of the wakefield (WF) to reduce the emittance growth. In some linear collider designs, the matched spot size of the witness beam can be 2 to 3 orders of magnitude smaller than the spot size (and wavelength) of the WF. Such an additional disparity in length scales is ideal for mesh refinement where the WF within the witness beam is described on a finer mesh than the rest of the WF. We describe a mesh refinement scheme that has been implemented into the 3D QS PIC code, QuickPIC. A fast multigrid Poisson solver has been implemented for the field solve on the refined meshes and a Fast Fourier Transform (FFT) based Poisson solver is used for the coarse mesh. A series of intermediate meshes are used to improve accuracy. The code has been parallelized with both MPI and OpenMP, and the parallel scalability has also been improved by using pipelining. An adaptive mesh refinement technique is implemented to optimize the computational time for simulations with an evolving witness beam size. Several test problems are used to verify that the mesh refinement algorithm provides accurate results. The results are also compared to highly resolved simulations with near azimuthal symmetry using a new hybrid QS PIC code QPAD.

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Primary authors: SU, Qianqian (University of California, Los Angeles); LI, Fei (Tsinghua University); AN, Weiming (Beijing Normal Univeristy); DECYK, Viktor (University of California, Los Angeles); ZHAO, Yujian (University of California, Los Angeles); HILDEBRAND, Lance (University of California, Los Angeles); DALICHAOUCH, Thamine (UCLA Physics and Astronomy Department); ZHOU, Shiyu (Tsinghua University); ALVES, Eduardo (University of California, Los Angeles); ALMGREN, Ann (Lawrence Berkeley National Laboratory); MORI, Warren (University of California Los Angeles)

Presenter: SU, Qianqian (University of California, Los Angeles)

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