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Mesh refinement in QuickPIC

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The PWFA has emerged as a promising candidate for the accelerator technology used to build a future linear collider and/or light source. In this scheme witness beams are accelerated in the plasma wakefield created by a driver beam. The three-dimensional (3D) quasi-static (QS) particle-in-cell (PIC) approach, e.g., using QuickPIC, has been shown to provide high fidelity simulation capability and 2-4 orders of magnitude speedup over 3D fully explicit PIC codes. In some linear collider designs for the electron arm, the witness beam is accelerated in a wake excited in the blowout regime. In this regime the matched spot size of the witness beam can be 2 to 3 orders of magnitude smaller that spot size of the wakefield. To efficiently simulate such a disparity in length scales requires some mesh refinement capability. We describe a mesh refinement scheme that has been implemented into the 3D QS PIC code, QuickPIC. We use very fine (high) resolution in a small spatial region that includes the witness beam and a progressively coarser resolution in the rest of the simulation domain. A fast multigrid Poisson solver has been implemented for the field solve on the fine mesh. The code has been parallelized with both MPI and OpenMP, and the scalability has also been improved by using pipelining. The effects of the boundary between a course and fine mesh has been studied. We have also developed a preliminary adaptive mesh refinement algorithm for an evolving beam size. Several benchmark cases have been tested and it is found that the mesh refinement algorithm provides good agreement with previously published results and with simulations using a new quasi-3d QS PIC code called QPAD. For round beams QPAD operates as an 2D r-z code and we can use fine resolution throughout the entire simulation domain. Details of the algorithm and results on PWFA simulations will be presented.

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