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An explicit algorithm for the quasi-static particle-in-cell program: QuickPIC

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Plasma wakefield acceleration is a mechanism that utilizes intense particle beams to excite large-amplitude plasma wakefield in plasma, thereby accelerating charged particles. Its acceleration gradient exceeds that of the most advanced radio frequency acceleration techniques by several orders of magnitude, reaching GeV/m level. This technology lays the groundwork for constructing ultra-compact accelerators and radiation sources, and also enables the development of plasma-based free electron laser devices and ultra-high-energy positron-electron colliders. The quasi-static approximation Particle-in-Cell (PIC) code QuickPIC[1,2] is a large-scale parallel computing program capable of efficiently simulating the physics processes of plasma wakefield acceleration. It employs a predictive iteration method to solve the electromagnetic field equations, which may require multiple iterations to converge. Recently, another quasi-static approximation PIC code, WAND-PIC[3], proposed a new explicit algorithm for solving the equations without an iterative process. We have integrated this method into QuickPIC. To solve the new explicit magnetic field equations, the original spectral method based on fast Fourier transform is no longer applicable. Therefore, we have introduced a finite difference method-based Poisson solver into QuickPIC. Finally, we show a comparison of the computational results between the iterative and explicit algorithms in QuickPIC.

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