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An explicit algorithm in the quasi-static approximate PIC program QPAD

Plasma wakefield acceleration is a method that uses a driving particle beam or an intense laser to excite a wakefield in the plasma and uses the wakefield to accelerate another bunch of particles. In response to the need to simulate the plasma wakefield acceleration, large-scale parallel computing programs such as QuickPIC [1] and QPAD [2] have been developed. These programs use the quasi-static approximation PIC algorithm, while QPAD introduces the azimuthal Fourier decomposition on top of QuickPIC. Currently, both QuickPIC and QPAD use a predictor-corrector method to solve the field equations. In certain cases, multiple iterations are required to achieve convergence. Recently, T. Wang et al. [3] proposed a new explicit algorithm in the quasi-static approximation PIC code, thereby avoiding the need for iterative computation. We first developed an explicit algorithm within the azimuthal Fourier decomposition framework by analytically extracting implicit transverse magnetic terms from current derivatives using conserved quantities. In the explicit equation, the coefficients dynamically change during plasma solving, and their product with the transverse magnetic field quantity causes a modal nesting issue. The algorithm solves all-mode transverse magnetic equations via global matrix construction, enabling explicit quasi-static PIC with azimuthal Fourier decomposition.

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