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On the self-forces of relativistic particles moving in vacuum in PIC codes XINLU XU, SLAC National Accelerator Labortaory, FEI LI, FRANK TSUNG, THAMINE DALICHAOUCH, WEIMING AN, HAN WEN, VIKTOR DECYK, University of California, Los Angeles, RICARDO FONSECA, Instituto Superior Tecnico, MARK HOGAN, SLAC National Accelerator Laboratory, WARREN MORI, University of California, Los Angeles — The particle-in-cell (PIC) method is widely used to model the self-consistent interaction between discrete particles and electromagnetic fields. It has been successfully applied to problems across plasma physics including plasma based acceleration, inertial confinement fusion, magnetically confined fusion, space physics, astrophysics, high energy density plasmas. In many cases the physics involves how relativistic particles (those with high relativistic gamma factors) are generated and interact with plasmas. However, when relativistic particles stream across the grid both in vacuum and in plasma there are many numerical issues may arise which can lead to incorrect physics. We present a detailed analysis of how numerical issues in PIC codes can lead to unphysical self-forces on particles that move at relativistic speeds across the grid. We analyze the fields on the grids excited by the relativistic particles and point out the numerical (unphysical) fields dominates especially for the electrical component along the drifting direction. Two representative solvers - the yee solver and the spectral solver are studied in details. Furthermore, a novel solver with $[k]_1 = [k_1]_t$ is proposed to eliminate the numerical EM fields and it has been implemented into the PIC code OSIRIS.

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