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Implicit PIC Development for Bounded Plasmas

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Particle-in-Cell (PIC) codes used to study plasma dynamics within ion sources typically use an explicit scheme. These methods can be slow when simulating regions of high electron density in ion sources, which require resolving the Debye length in space and the plasma frequency in time. Recent developments on fully-implicit PIC models in curvilinear geometries have shown that these spatial/time scales can be significantly decreased/increased respectively, allowing for notable speed-ups in simulation time, and thus making it a potential tool for studying the physics of ion sources. For this purpose, a charge and energy conserving implicit PIC code has been developed in 1D to show its potential for simulating bounded plasmas. In this paper, we use this model to simulate a 1D analytical benchmark of a bounded plasma with fixed power input and Maxwellian electron distributions. The results are shown to compare well to analytical theory and to the results using an explicit PIC code. We demonstrate the ability of the implicit PIC code to speed-up simulation time by nearly a factor of 10x compared to explicit PIC, which would correspond to a speed-up of up to 1000x in 3D.

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