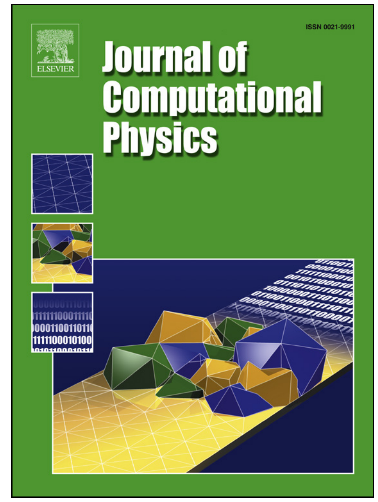
Accepted Manuscript



CHAOS : An octree-based PIC-DSMC code for modeling of electron kinetic properties in a plasma plume using MPI-CUDA parallelization

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PII: S0021-9991(18)30460-1
DOI: https://doi.org/10.1016/j.jcp.2018.07.005
Reference: YJCPH 8130

To appear in: *Journal of Computational Physics*

Received date: 23 October 2017
Revised date: 21 June 2018
Accepted date: 4 July 2018

Please cite this article in press as: R. Jambunathan, D.A. Levin, CHAOS : An octree-based PIC-DSMC code for modeling of electron kinetic properties in a plasma plume using MPI-CUDA parallelization, *J. Comput. Phys.* (2018), https://doi.org/10.1016/j.jcp.2018.07.005

Highlights

- Linearized Morton Z-ordered forest of octrees are used to discretize the domain based on the local Debye length for the PIC simulations. Fast bit-wise Morton encoding is exploited to map ions and electrons to the grid.
- A 2:1 criterion is implemented on the PIC octree to accurately solve the electrostatic Poisson's equation using multiple GPUs.
- A communication link is set-up between processors that share the partitioned Z-boundary to transfer the electric potential of the boundary leaf nodes, using MPI-CUDA communications.
- The Poisson's equation was transformed into a set of linear equations, $Ax = b$, such that, the matrix A is symmetric, positive-definite. The sparse matrix, A, was iteratively inverted using the preconditioned conjugate gradient method, by employing multiple CPUs and GPUs.
- Comparison of the 2:1 octree simulations results with analytical and uniform grid results demonstrate the accuracy of the solver for canonical test cases with known ion charge density distributions.
- The strong-scaling studies showed near-ideal speedup with 128 GPUs.
- For the proton plasma plume with co-located electron and ion source, the electrons were trapped by the ion beam and the electron temperature was found to be anisotropic.
- When the ion mass was increased, the plume structure was more confined compared to the proton plasma. This resulted in electron trapping within a smaller region, resulting in a larger thermal spread in their near-Maxwellian velocity distributions.
- Finally, when the electron source location was shifted, electron oscillations were observed at early times. As the plume evolved, the electrons were trapped by the ion beam and as a result the oscillations were damped. This was inferred from the transition of the bi-modal electron velocity distribution at early times to a single peak distribution at later times, and an increase in the electron charge density within the ion beam.