

## A Parallelization of Full-Particle and Fluid-Particle Hybrid Plasma Simulations with the OhHelp Load Balancer

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This paper presents a parallel implementation of full-particle and fluid-particle hybrid plasma simulations with our load balancing method OhHelp. This method simply and equally partitions the space domain so that each partitioned subdomain is assigned to each computation node for scalable simulation with respect to the domain size. Load balancing and thus scalability in terms of the particle populations are accomplished by making each node help another node having a densely populated subdomain. A part of particles in the densely populated subdomain is assigned to the helper node together with duplicated field data associated to grid points in the subdomain, which assures that no nodes have too many particles.

We have applied the OhHelp method to two kinds of representative PIC simulations: the full-particle and fluid-particle hybrid plasma simulations. Then for both applications, we have obtained good scalability even in case of a severely non-uniform particle distribution[1][2], which confirms high applicability of the method to general particle simulation methods. Also, the OhHelp load balancing algorithm and several useful functions for domain-decomposed simulations are provided as the OhHelp Library, which will help people applying the OhHelp method to their own particle simulation codes.

Meanwhile, we should take care of several key points about difference between the full-particle and hybrid simulations in an aspect of computational cost. For example, in hybrid simulation, the cost to simulate the progress of electromagnetic field is more significant than that in full-particle simulation. Thus we should consider the issue of the cost balance between computation and communication, especially in a sub-cycling for solving the electromagnetic field. We will report some practical aspects of the OhHelp implementation in plasma particle simulations using the OhHelp Library.

[1] H. Nakashima et al., OhHelp: A Scalable Domain-Decomposing Dynamic Load Balancing for Particle-in-Cell Simulations, In ICS'09, 2009.

[2] J. Akiyama et al., A Parallelization of Particle-Fluid Hybrid Plasma Simulation with the OhHelp Load Balancer, In IPSJ Tech. Rep. 2010-HPC-124, 2010.

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