Spacecraft Environment Analysis via Large Scale Plasma Particle Simulation

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Spacecraft charging simulation is becoming an important key-technology for upcoming era of future space development. We have developed 3-dimensional particle model spacecraft charging simulation code, NuSPACE. The major problems of large scale analysis of the spacecraft plasma environment are the difficulty of vectorization and parallelization of the poisson's equation solver and the numerical heating. Poisson's equation solver has played a fundamental part to obtain spacecraft potential in plasma particle simulation. By using rigorous charge conservation method, we have succeeded to develop a new simulation algorithm without the Poisson equation solver in addition to successful installation of the scheme to the vector-parallel supercomputers.

We have developed a new algorithm, charge conservation method (CCM), for solving the plasma current suitable for spacecraft charging simulation. We have shown sample simulation results using CCM implemented on the 3-dimensional plasma particle simulation code, NuSPACE. This algorithm enables us to simulate spacecraft plasma environment without solving the poisson's equation. Major advantages of this method are following,

1. Fully kinetic electromagnetic plasma particle simulation can be achieved.
2. Full vectorization and parallelization have been tested.
3. Easy to apply for the spacecraft charging simulation
4. Easy extension to the unstructured-grid spacecraft environment simulation code.

We have shown that the CCM achieves less numerical error than the conventional ASM. This level of the numerical error permits for us to avoiding the electric field correction by using the poisson's equation solver.

Full vectorization and parallelization of the CCM algorithm is technically important for future large scale simulations for the spacecraft plasma environment study. This technique enables us to apply our code to the supercomputer, such as the Earth Simulator. Full vectorization and parallelization have been tested for most supercomputers available for our simulation group.