Development of a Parallel Multi-Physics Modeling Platform: Rigorous Advanced Plasma Integration Testbed (RAPIT)

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Many important and challenging science and engineering problems require modeling of complex plasma and flow physics applying hybridization of different continuum- and/or particle-based solvers. Examples may include plume analysis of reaction control thrusters on upper-stage rocket and satellite in orbit, rocket plume analysis at high altitude, ion thruster plume analysis, and plasma distribution in etching and thin-film deposition chambers, to name a few. These studies often utilize independent solvers developed previously and integrate them in a non-selfconsistent approach, which makes their applications and future extension highly inflexible. Thus, a highly flexible simulation platform, which allows easy addition and integration of different solvers with a self-consistent approach while maintaining efficient computations, is strongly needed to tackle problems with complex physics, such as flow/plasma in space related technology. In this paper, we report the development of a new C++ object-oriented multi-physics simulation platform named Rigorous Advanced Plasma Integration Testbed (RAPIT) using unstructured meshes with parallel computing using MPI (message passing interface). The proposed RAPIT can easily accommodate continuum- and/or particle-based solvers with some proper hybridization algorithm in a self-consistent way. For the former, it may include, but not limited to, the Navier-Stoke (NS) equation solver for general gas flow modeling and the plasma fluid modeling code for general low-temperature plasma modeling. For the latter, it may include the particle-in-cell Monte Carlo collision (PIC-MCC) and the direct simulation Monte Carlo (DSMC) solvers. Some preliminary results of DSMC, PIC-MCC and NS equation solvers based on RAPIT are presented in this paper.