

A Hybrid DSMC-PIC Model of The Near-Field Plume of a Hall Thruster

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Hall thrusters represent an efficient form of plasma electric propulsion for spacecraft. The two most active areas of Hall thruster research concern understanding and improving the thruster performance, and characterization of the plume far field to assess spacecraft integration issues. The near field plume of a Hall thruster is a physically complex and important region. The relatively high plasma density in the near field makes it accessible to a variety of experimental diagnostic techniques from probes to non-intrusive optical methods such as Laser Induced Fluorescence. Such data is much more difficult to obtain either inside the thruster or in the plume far field. Therefore, data obtained in the near-field often provide important glimpses of thruster and plume far field processes.

Computational models have been developed to simulate Hall thruster plumes. However, the level of physical modeling sophistication has been low precluding accurate simulation of the plume near field. In these models, the collisions and electro-static acceleration of heavy xenon ions and atoms are modeled using a combination of the direct simulation Monte Carlo method (DSMC) and the Particle-In-Cell technique (PIC). The electrons are treated as a fluid described by the assumption of quasi-neutrality and the Boltzmann relation.

In the present study, the near field plume of a 200 W class Hall thruster is modeled using a detailed DSMC-PIC-fluid hybrid approach. The new aspect of the model involves treating the electrons using a detailed fluid model constructed from the fundamental conservation equations for charge, momentum, and energy. The additional physics makes it possible to include the effects of the external cathode in the simulation as well as more accurate simulation of the variation in electron temperature and plasma potential. Full details of the model will be presented along with comparisons of results from the model with experimental measurements taken in the near field plume of the BHT-200 Hall thruster.