Abstract *(paper not available)*

A Self –Consistent Numerical Code for High-Power Hall Thruster Plumes: Improvements, Validation, and Integration with Spacecraft Interactions Code

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The proposed Asteroid Robotic Redirect Mission (ARRM) could be the first deep-space mission to feature a Hall thruster-based solar electric propulsion (SEP) system. A critical factor in the design of the spacecraft is to understand (and mitigate if necessary) the interactions of the ion plume of high-power Hall thrusters (of up to 12.5 kW) with different surfaces, principally the solar arrays, and mechanical and communication subsystems that may be located in the vicinity of the propulsion system. The first step in understanding the spacecraft interactions of the thruster plume is to generate a “plume map” in which ion current densities and energies are plotted as a function of the distance and angle relative to the thrust axis. Distances of interest for spacecraft design span to 30 meters, with angles relative to the thrust axis in excess of 120 degrees. In this paper, we present a series of improvements introduced in the numerical code for the computation of the plume map presented in the 13th International Spacecraft Charging Technology Conference. This algorithm is largely based on the JPL in-house Hall thruster code, Hall2De. Hall2De is a hydrodynamics code specifically adapted for simulations of Hall thruster discharges whose computational domain comprises the acceleration channel, exact cathode location, and a large extent of the near plume up to tens of centimeters downstream of the channel exit. The plume map algorithm described here employs the time-averaged Hall2De result in the near plume to propagate the plasma solution to tens of meters away from the thruster. To this effect, a simplified set of equations (assuming that the magnetic field is negligible in the far plume) is solved to obtain plasma potential, electron temperature, neutral density and velocity, and ion density and velocity. The implemented algorithm allows for a non-isothermal far plume and the occurrence of charge exchange and ionization collisions. The background pressure in the code can be modified to enable the simulation of both in-space and test facility conditions. The improved algorithm has been extensively validated using plasma measurements of a 12.5 kW-Hall thruster obtained at multiple background pressures in a test facility. These plasma measurements include ion current densities, ion energy, and current fractions of each ion species at multiple angles and distances (up to 1.5 meters) from the thruster. After the validation process was successfully completed, an in-space plume map assuming vacuum conditions was generated for two distinct operating conditions of the thruster. The plume map results can be fed into a new spacecraft-plume interaction software, which has the capability of computing sputtering and redeposition rates on spacecraft surfaces, and parasitic current collection of the solar arrays.

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