A High Power Ion Thruster Plume Model

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Proposed future missions, such as those being evaluated under Project Prometheus, will use ion thrusters that are much more powerful, much larger, and have much greater specific impulse than state of the art thrusters. For this purpose, new generation of ion thrusters, HiPEP and NEXIS, are being developed that will operate at much higher accelerator voltages than previous thrusters, such as NSTAR. To accommodate these thrusters on spacecraft, it is essential to be able to predict how the ion thruster plumes will behave in space, and what the details of plasma environment generated by the thrusters.

Previous models of the thruster plumes were for beam ion energies of one thousand volts and below. Future engines may have beam ion energies of 5000 eV or greater. At these higher ion energies, the trajectories of ions are dominated by the electric fields in grid apertures, and the angular spread of ions in individual beamlets, rather than by density gradient forces in the bulk beam, as is the case in lower voltage ion thrusters. The other major difference is that at the high ion energies, ions scattered at large angles will have sufficient energies to cause sputtering. As a result, initial angles, such as those due to grid dishing, now play a greater role.

The model is of a single thruster plume and includes the initial angular spread in individual beamlets, the effect of bulk plasma density gradient forces, elastic scattering with slow neutrals, and charge exchange collisions. The model will be able to model chamber background gas density and will be validated with laboratory measurements of the NEXIS thruster plume. The intent of the model is to provide thruster plume descriptions to the EPIC electric propulsion spacecraft interactions code for spacecraft configuration studies.