Stationary plasma thruster plume simulation

Francesco Taccogna[*], Savino Longo[*+] and Mario Capitelli[*+]
[+]*IMIP-CNR, sect. Bari and* [*]*Department of Chemistry, University of Bari, Italy*

We present a PIC model of the plasma phase of the thruster SPT-100 plume. The model is based on a particle simulation of ions with a fluid, non isothermal model of the electron component. It also includes ion/neutral collisions by an TPMC model. The neutral flow field is determined by using a DSMC code. In the case considered the physical domain is 2D axisymmetric {r, z}. The grid (Fig. 1.a) is non uniform in both co-ordinates in order to adapt to the local plasma density. As regards boundary and injection conditions for the particle simulation, we have outflows on L_2, L_3 and L_4, axial symmetry on L_1, partial accomodation on S_2 and a shifted maxwellian source with parameters depending on r, on S_1. Ion flow source data are available for the SPT-100 in the form of two polinomial interpolation for the ion radial position probability P and the deflection angle vs. r on S_1. To connect the simulated particles to the grid the sampling used is exactly charge-density conservative and takes into account the cylindrical metrics of the co-ordinates. The electron density has been calculated by using the Boltzmann distribution, i.e. we assume a local equilibrium for the electron gas, justified at a phenomenological level by the faster relaxation processes. The electron temperature distribution is controlled by the adiabatic approximation (the electrons are assumed to act as an expanding fluid at isentropic conditions). When coupled to the electron component, the Poisson equation becomes a nonlinear one. Prior to discretizing on the mesh the equation we have linearized it by the Newton-Raphson technique. In order to solve the linearized Poisson equation on the grid we have used a relaxation technique (the electric potential is reported in Fig. 1.b). In order to move the ions for a time step we have used the leapfrog method with the Hockney condition fulfilled. We take into account the collisional kinetics of positive ions, including both elastic and charge exchange collisions. Our collision technique is an implementation of the TPMC method of Kitatani and Nanbu Basically the neutral target distribution function is sampled by virtual particles and the collision probability is evalued. The post-collision velocities are sampled fulfilling the conservation laws. The technique includes two distinct treatments, depending on the sampled value of the impact parameter b. If b is higher than a critical value, than the scattering process is treated exactly under the assumption of a polarisation potential. If the value of b is too low, we are in condition of orbital motion and a charge exchange scattering is possible with probability P=1/2 (the ion is given the velocity of the sampled target neutral).

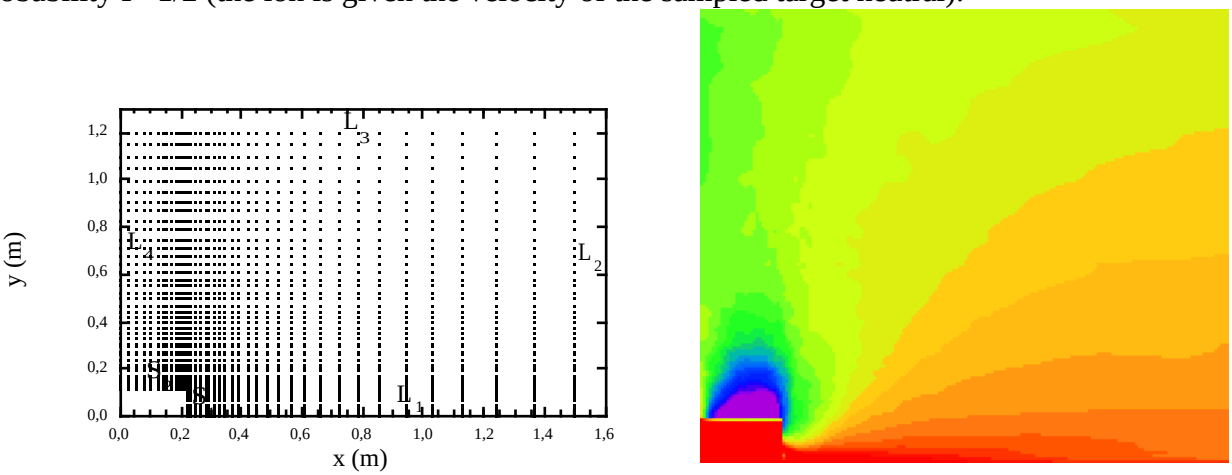

Fig. 1 - (a) Scheme of the simulation domain; (b) Equipotential lines at the steady state.