Research of electron distribution function traits in discharge chamber of ion thruster using "Particle-in-cell" simulation

D.A. Kravchenko A.G. Tarasov

SSC FSUE Keldysh Research Centre, Moscow, Russian Federation
dmitry1204@gmail.com

A non-stationary kinetic PIC simulation allows taking into consideration trajectories of particles, their collisions and interaction with plasma fluctuations. Resulting distribution functions of plasma components accurately represent the state observed in experiment. Researches submitted in this paper were conducted using the 2D3V FullPIC model of an ion thruster discharge chamber described in [1].

The analysis of simulation results revealed that electrons in discharge chamber of an ion thruster have non-Maxwellian distribution. Obtained energy distribution was approximated by gamma-function:

$$f(\varepsilon) = \varepsilon^{k-1} \frac{\exp\left(-\frac{\varepsilon}{\theta}\right)}{\Gamma(k)\theta^k}.$$

Here k characterizes shape of the distribution function and is defined as the ratio of square of function's expected value to its dispersion. For Maxwellian distribution, this shape parameter takes the value of 1.5. However, in the system under study this value varies from ~1.8 on the chamber axis to ~1.0 near the anode surface. The research revealed that there are two prime mechanisms responsible for deformation of the electron distribution function. The first one is determined by a monoenergetic stream of primary electrons in the axial region of a discharge chamber. This stream increases density of the distribution function in the middle energy range and decreases its dispersion. The second mechanism is a peculiarity of electron motion in the near-anode region. Only particles with near-zero component of velocity along magnetic field lines may exist there long enough. In the limit such anisotropy leads to two-dimensional electron distribution with $k = 1$. Obtained results should be taken into consideration while developing hydrodynamic or hybrid models of plasma in discharge chamber of an ion thruster or similar plasma systems.

[1] D.A. Kravchenko, Model of plasma in discharge chamber of ion thruster, Prikladnaja fizika [Applied physics], ISSN 1996-0948, 2015, №5, pp. 26-32 (in Russian)