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COMPUTATIONAL STUDY OF ExB DISCHARGE USING A TWO-DIMENSIONAL AXIAL-AZIMUTHAL MODEL *)

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The problem of describing the behavior of an electric discharge in the presence of electric and magnetic fields arises in many areas of modern science, including the numerical modeling of plasma in the discharge channel of Hall thrusters. One of the key challenges in such modeling is the description of turbulent (anomalous) electron conductivity of plasma across the magnetic field. The mechanism responsible for this type of conductivity is known to be the propagation of waves in the azimuthal direction (along the direction of electron drift) [1]. Thus, to calculate the anomalous conductivity in a numerical model, it is necessary to take into account azimuthal instabilities, but, at the same time, it is necessary to include in calculation radial and axial directions to account for the interaction of plasma with the walls of the discharge channel.

Currently the creation of a three-dimensional plasma model is not possible due to the high computational complexity. Therefore, radial-axial models are used in thruster modeling, using various empirical laws to account for turbulent conductivity [2], and axial-azimuthal models are used to study turbulent conductivity and azimuthal instabilities.

In this study, a numerical analysis of the ExB discharge was performed using a two-dimensional axial-azimuthal model (2D2V PIC) optimized for high-performance numerical calculations (multi-threaded computations and SIMD). The dynamics of the ion and electron components of the plasma in a self-consistent electric and external magnetic field were calculated using the particle-in-cell method, while collisions between particles, which are the source of classical conductivity, were not taken into account in the calculation. Particular attention was paid to the behavior of the azimuthal waves and turbulent conductivity, focusing on the correlation between the electron concentration and the azimuthal electric field.

References

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