Modeling of expansion of aluminum plasma jet with ionization kinetics

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One of the possible methods for studying physical processes in the ionosphere and magnetosphere are active geophysical rocket experiments (AGRE), during which an influence of some calibrated source of disturbance is performed on the medium. To interpret the recorded phenomena, it is necessary to properly determine the parameters of the source used, its evolution and interaction with the background environment.

In the experiments, an aluminum plasma jet with an initial size of several centimeters and an average speed of 30-40 km / s spreads over several kilometers. Traditional plasma state models — local thermodynamic equilibrium (LTE) approximation, coronal equilibrium (CE) describing a stationary plasma, are unsuitable for modeling a plasma with rapidly changing parameters. In this case, when considering the gas-dynamic motion, it is necessary to take into account the deviation of ion concentrations in both ground and excited states from stationary values.

The simulation of the plasma jet expansion was carried out by solving of a system of one-dimensional gas-dynamic equations written in Lagrangian coordinates for the case of spherical symmetry. Comparison of the results of two-dimensional calculations and one-dimensional showed that for the axial part of the jet in a one-dimensional calculation, the values of gas-dynamic parameters are close to those obtained in two-dimensional calculations. Simultaneously with the gas-dynamic equations, a system of ordinary differential equations for the relative populations of the ground states of the ions was calculated.

The results of modeling of non-equilibrium ionization in an aluminum plasma of a jet of an explosive generator, injected into the ionosphere during active geophysical experiments, were presented. The achievement of the “hardening” state of the degree of ionization was shown. The results of non-equilibrium modeling and estimates based on them were used to investigate other stages of expansion and other injection scenarios to determine the ionization state of the plasma and the electron concentration in it.