Mathematical model of Hypersonic Plasma Flows Expanding in Vacuum.

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General and particular solutions, describing evolution of plasma plumes exhausted by electric propulsion are submitted in the paper. A brief description of algorithms developed for computation of spatial plasma properties distributions of plumes in space are also presented.

In the paper, the dynamics problem describing evolution of fully ionised stationary hypersonic plasma jet is formulated and solved in a self-similar form. It is shown that plasma expansion into space is determined not only by collision processes and initial conditions but also by internal self-consistent electric fields. These fields appear due to high electron mobility and are proportional to the local density and temperature gradients. In rarefied plasmas, distribution of the inner fields is strongly effected by the thermal conductivity of electrons that provides effective transfer of energy to the periphery of plasma jet, particularly from the points of local energy extraction and out of plasma generator. Ions are accelerated by those plasma fields predominantly in the directions of maximum gradient. In the result, density of substance in the peripheral zones of jets is sufficiently greater than one in perfect gases.

The combined equations for two-component fully ionised plasma are used to describe steady state plasma plume evolution. The energy and motion equations describe interaction between ions and electrons due to collisions and self-consistent electric field that tends to keep electrons in vicinity of the flow core and, in contrary, accelerates ions along the potential gradient. The continuity equation and motion equation for electrons were used to evaluate: the components of electric current, relative motion of electrons and ions, Joule's heating, electron thermal conductivity, viscous force in an ion flow and corresponding heat release.

In the paper the simulation of influence of external magnetic field on plasma flow is presented.
For a case, when the neutral background exists into plasma plume volume , two mathematical algorithms , i.e. free-molecular and continual flow, have been developed to calculate the characteristics of secondary plasma arising in a EP' plume. First of them can be used for case, when secondary plasma does not distort the distribution of parameters of primary beam. Algorithm includes the calculation of birth rate of secondary ions within primary beam and their further expansion under influence of electrostatic field without collisions. Second algorithm means for the case, when the density of secondary plasma is comparable with a density of primary beam. In this case the secondary plasma distorts a potential distribution in primary beam. For this case the software CFSP has been developed. The algorithm of this program is based on solution of a set of continual equations describing the secondary plasma parameters. The algorithm offers a relatively simple way to take into account how the newly born secondary ions modify an electric potential distribution in the primary beam.
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