Numerical simulation of the early plasma spread stage in the large-scale plasma ionospheric experiments

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Large-scale plasma ejection experiments in the earth ionosphere and magnetosphere are the effective tool for geophysical researches of the near-earth space environment (NESE). The scientific and applied meaning of the such experiment results are determined by the physical and numerical models developed on theirs basis which can be used for prediction of the plasma perturbations behavior in the NESE.

In the paper the mathematical tool for computation of the initial stage plasma dynamics parameters shaped by strong explosion is proposed. The explosion initial energy is $4\times10^{12}-4\times10^{15}$ [J] and the plasma mass is $M\approx300-1000$ [kg]. The unified algorithm allowing to compute three initial stages of the explosion: the earliest radiative gas-dynamic stage of the spread, the accelerative stage of the spread and the initial stage of the plasma deceleration due to geomagnetic field interaction is created. The first stage defines the energy which remains in the plasma after the radiation outlet. During the second the plasma charge structure is shaping as a result of the ionization and temperature nonequilibriums and the electron temperature becomes different form the ion temperature.

It was shown that after the kinetic processes tempering the plasma ionization level is mainly defined by the initial energy density. For ratio $e/M\approx4\times10^{9}$ [J/kg] the ionization level is $a_{\infty}=n_e/n\approx4\times10^{-4}$ and plasma mainly consists of the neutral particles. With ratio e/M grows the ionization level a_{∞} also grows and at $e/M\geq2\times10^{12}$ [J/kg] becomes bigger then one. The plasma ionization level a_{∞} is the main parameter which defines the plasma-field interaction and the final distribution of the neutral and ionized components in the environment.

The results show that at mean value $e/M\approx10^{12}$ [J/kg] the ionization level $a_{\infty}\approx0.5$ and after the plasma spreads out up to the radius $R\approx10$ [km] the split of the ionized and neutral components becomes possible and we have to use multispeed approach in our model.