OPTICAL AND GAS-DYNAMIC PROPERTIES OF HIGH SPEED PLASMA JET IN "FLUXUS"AND "NORTH STAR"EXPERIMENTS

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Active geophysical rocket experiments "Fluxus"and "North Star "with injection of high-speed aluminum plasma jets into the Earth's ionosphere had been evaluated at altitudes of 140 km ("Fluxus") and above 270 km ("North Star"). The interaction of plasma jet with the surrounding magnetized ionospheric plasma was stated as the primary goal of experiments. The plasma jet was created by the cumulative explosive type plasma generators VGPS-300 ("Flaxus") and VGPS-400 ("North Star") developed at IDG RAS.

The scientific analysis of the evidence requires the determination of prompt plasma parameters under injection itself. To solve the aforementioned problem we must consider the radiation-gas dynamic set of equations (RGD), since emitted thermal radiation significantly impacts the dynamics of the plasma and propagates to the far zone. Then, it causes ionization, excitation and intense air glow as well.

A fairly simple physical and mathematical RGD model was elaborated using evidence from laboratory experiments. In these experiments an aluminum jet was injected into rarefied air of various densities in a special explosive vacuum chamber. This model is used for the successful solution of an ill-posed inverse problem of jet injection scenario determination. The model includes a set of RGD equations in lagrangian coordinates in spherically symmetric geometry. It describes the dynamics of a cone-shaped jet during and after injection from the generator nozzle. Also a diffusion approximation for multigroup radiation transfer equations is used, including losses due to radiation from the lateral surface of the cone. The model takes into account the RGD processes in the jet and in the air and the propagation of thermal radiation emitted by high-temperature plasma over long distance. The excitation of the ionosphere under the action of this radiation was estimated in the framework of a plasma chemical model. Numerical simulations were carried out using tables of thermodynamic and optical properties of aluminum plasma and air. The good agreement with experiment is observed for the radiation flux density in the visible and near infrared ranges.

The derived plasma injection scenarios were used in two-dimensional simulation of the initial stage of jet evolution. The last was evaluated by means of two different approaches to solving the problem. Two-dimensional simulation shows that the jet retains a cone-shaped shape for the entire simulation time. It proves the correctness of one-dimensional spherically symmetric gas dynamics equations to describe the initial stage of the plasma jet dynamic.

Our model makes it possible to correctly describe the initial gas-dynamic stage of the high-speed plasma jet dynamic which forms the further interaction of the jet with the ionosphere and the geomagnetic field. Due to the short time the sensors used in the experiment did not resolve this stage. Thus the numerical simulation is the only available instrument for the study of this stage.