RADIATION OF EXPANDING ALUMINUM PLASMA IN THE IONOSPHERE

Losseva T.V., Kosarev I.B., Zetzer J.I., Lyakhov A.N.

Institute of Geosphere Dynamics RAS, Moscow, Russia, losseva@idg.chph.ras.ru

At the end of the last century, a number of active geophysical rocket experiments (AGRE) were performed. Metallic (Al) plasma was ejected into the Earth’s ionosphere by explosive-type generator. The purpose of these experiments was to study the processes of plasma interaction with the geomagnetic field, the generation of ionospheric disturbances with different spatial scales, and the determination of the optical characteristics of the disturbed region. A number of studies were devoted to the numerical simulation of the aluminum jet and metal clouds dynamics. The main result was the qualitative and quantitative agreement with observational data on diamagnetic cavern formation in the geomagnetic field at the initial stage of plasma motion. Verification of the metallic plasma expansion models at late time is possible only on optical data, provided by ground-based, satellite and rocket measurements in the wavelength range from UV to far-IR with high temporal and spectral resolution. Solution of such a problem requires radiation transfer processes incorporation into a numerical model. At the early stage of metallic plasma expansion into rarefied air, the radiation-gas-dynamic (RGD) model is applicable.

Numerical simulation of the expansion dynamics for a dense aluminum plasma bunch in the F-layer of the ionosphere was evaluated by means of numerical solution of spherically symmetric RGD equations for various initial conditions [1]. It is assumed that aluminum vapors hold local thermodynamical equilibrium. The tables of the thermodynamic and optical properties of aluminum vapor were used [2]. An implicit absolutely stable completely conservative scheme was used to solve gas-dynamic equations describing the motion of aluminum vapor in Lagrangian frame. A diffusion approximation for self-consistent calculation of radiation transfer was used. The boundary conditions correspond to the ambient air pressure at the height under consideration. The radiative characteristics of the disturbed region were calculated by independently integrating the radiative transfer equations along a large set of rays passing through the region with the obtained gas-dynamic parameters to the observation point.

The temporal dynamics of the plasma parameters as well as the radiation from plasma cloud in a wide wavelength range (namely the density of radiation fluxes at various observation points and radiation patterns) are obtained. The extra ionization of the surrounding ionosphere under the impact of the emitted radiation was calculated. The elaborated model allows qualitatively to explain the optical observations of ring plasma formations in experiments of 1958 and 1962.

References

1. Losseva T.V., Golub' A.P., Kosarev I.B., Lyakhov A.N., Poklad Yu.V., Gavrilov B.G., Zetzer J.I., Chermenin A.V. Prompt stage of plasma jet in active geophysical space experiments // Dinamicheskie processih v geosferakh (Dynamic Processes in Geospheres), Moscow, GEOS, 2017. С. 102-110.
2. Kosarev I.B. Radiative properties of aluminum plasma // Dinamicheskie protsesih v geosferakh (Dynamic Processes in Geospheres), Moscow, GEOS, 2017. С. 110-116.