The numerical simulation of the high speed plasma jets merging under the injection in the ionosphere [[1]](#footnote-1)\*)

DOI: 10.34854/ICPAF.2023.50.2023.1.1.151

1,2Losseva T.V., 1,2Urvachev E.M., 1Zetzer J.I., 1,2Lyakhov A.N.,  1Kosarev I.B., 1Poklad Yu.V.

1Sadovsky Institute of Geosphere Dynamics RAS, Moscow, Russia, [losseva@idg.chph.ras.ru](mailto:losseva@idg.chph.ras.ru)  
2Dukhov Automatics Research Institute, Moscow, Russia

The physics of the merging process of magnetized plasma jets as well as the dynamics of their magnetization is one of the frontiers in astrophysics [1], high energy physics and magnetized fusion [2]. The elaborated technique of plasma jet creation by the Explosive Type Generator (ETG) allows creating high speed plasma jets in the ionosphere using wide set of working materials (from Al to Pb). Such set up of an experiment allows maximal relevance to the astrophysical environment. Moreover, it excludes any impact of the chamber, namely the radiation reflection from the walls and premature closure of the electrical currents on the equipment.

Up to date we successfully evaluated single jet experiments "FLUXUS" (at 140 km altitude) and "North Star" (at 270 and 350 km altitudes). Aluminum plasma jet has 3 to 6 MJ energy with initial speed about 40 km/sec. The usage of multiple injection allows increasing of plasma energy transformation to the optical radiation with varying spectral properties controlled by the working material.

At the initial stage of the merging process the radiation from a certain jet modifies the ionization of the medium on the propagation path of other jets. Thus, the following subtasks are to be answered in the numerical experiment: the impact of injection geometry and the impact of the working material. Three scenarios are considered: counter injection, catch-up injection and convergent injection with various angle between two jets.

In the simulation we use the temporal scenario of the gas-dynamics parameters for metal plasma at the nozzle exit from [3]. The last has shown very good agreement with all available laboratory and ionosphere data. The merging dynamics of ETG-created metal plasma jets was studied by means of 3D numerical simulation. The radiation gas-dynamics explicit Godunov-type code FRONT is used in all studies. The Cartesian eulerian grid is used.

We show that the merging of plasma jets sufficiently increases the temperature in the interaction zone. The spectrum of plasma radiation shifts to extreme UV band.

References

1. Underwood, T.C., Loebner, K.T.K., Miller, V.A. et al. Dynamic formation of stable current-driven plasma jets. Sci Rep 9, 2588 (2019). https://doi.org/10.1038/s41598-019-39827-6
2. Wen H., Ren C., Hansen E. C., Michta D., Zhang Y., Langendorf S., and Tzeferacos P. Particle-in-cell modeling of plasma jet merging in the large-Hall-parameter regime. Physics of Plasmas 29, 062706 (2022) <https://doi.org/10.1063/5.0087035>
3. Losseva T. V., Kosarev I. B., Poklad Yu. V. , Lyakhov, Zetser Yu. I., and Urvachev E. M. Numerical Simulations of the First Stage of Dynamics of a High-Speed Plasma Jet in Fluxus and North Star Active Geophysical Rocket Experiments // Plasma Physics Reports, 2022, Vol. 48, No. 10, pp. 1106–1110. DOI: 10.1134/S1063780X2260058X

1. \*) [abstracts of this report in Russian](http://www.fpl.gpi.ru/Zvenigorod/L/Lt/ru/FH-Loseva.docx) [↑](#footnote-ref-1)