High order fluid model for simulations of streamers and sprites

A. Markosyan[1(*)], S. Dujko[1,2], U. Ebert[1,3]

[1] *Centrum Wiskunde & Informatica (CWI), P.O. Box 94079, NL-1090 GB Amsterdam, The Netherlands*
[2] *Institute of Physics, University of Belgrade, P.O.Box 68, 11080 Zemun Belgrade, Serbia*
[3] *Eindhoven University of Technology, Department of Applied Physics, P.O. Box 513, 5600 MB Eindhoven, The Netherlands*
[(*)] aram.markosyan@cwi.nl

Streamers occur in sprites and in the streamer corona of lightning leaders as well as in many industrial applications such as the treatment of exhaust gasses, polluted water or biogas. Almost all authors (and certainly all in geophysics) model streamers in fluid approximation with a reaction-drift diffusion model in local field approximation, which is equivalent to a closure after the first moment of the Boltzmann equation. Here a fourth order hydrodynamic model is developed for the streamer dynamics by closing the system after the third moment of the Boltzmann equation. The transport and reaction coefficients for the model were obtained by solving a multi-term Boltzmann equation [1]. The high order pressure tensor appearing in the heat flux equation is specified in terms of previous moments.
We simulate planar ionization fronts for negative streamers in nitrogen with both fluid models and compare them with the results of a full stochastic particle model of PIC-MCC [2] type. The high order model approximates the PIC-MCC model much better than classical one. The ionization level, and in particular, the average electron energies in the streamer channel are now correct. This is important especially for proper treatment of the excited species in the channel for plasma-chemical applications.

References

[1] S. Dujko et al, *Phys. Rev. E* 81 (2010) 046403.
[2] C. Li *et al.,* J. Comput. Phys. 229 (2010) 200; J. Phys. D: Appl. Phys. 42 (2009) 202003; J. Comput. Phys. 231 (2012) 1020.