

Particle and Fluid Models for Streamers and Sparks: Comparison and Spatial Coupling

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Streamers are used in industrial applications such as lighting, ozone generation and gas purification, and they occur in natural processes such as lightning and transient luminous events in the upper atmosphere. To understand the generic mechanism of ionization fronts and the growth of streamer channels, both fluid and particle models have been developed. While fluid models are computationally efficient in regions with large particle densities like the interior of a streamer finger, particle models represent the full microscopic scattering physics and are appropriate for regions with low densities and for particles with high energies like in the “pulled” ionization front ahead of the streamer finger. Electron energies in the leading edge of a particle front can actually become substantially higher than the current fluid approximation would suggest, leading eventually to X-rays and run-aways. Furthermore, the statistics of few single particles in the front can create fluctuations of velocity and ionization rate and might trigger inherent instabilities. If the field is high, these effects are particularly severe. The goal of the project is therefore to develop a computation scheme that is hybrid in space. We have compared negative planar ionization fronts in pure nitrogen in the fluid or the particle model. The ionization density behind the particle front is higher while front velocities are similar. We analyze and explain this discrepancy [1]. We also show how to couple a fluid and a particle model in different region of the ionization front [2] making efficient hybrid calculations possible.

[1] C. Li, W. J . M. Brok, U. Ebert, and J. J. A. M. van der Mullen, Deviations from the local field approximation in negative streamer heads, *J. Appl. Phys.* 101, 123305 (2007).

[2] C. Li, U. Ebert, W. J . M. Brok, W. Hundsdorfer, Spatial coupling of particle and fluid models for streamers: where nonlocality matters, *J. Phys. D: Appl. Phys.* 41 032005 (2008).