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Simulating streamer discharges in full 3D

Ute Ebert (1), Jannis Teunissen (1,3), Casper Rutjes (1), and Behnaz Bagheri (1)
(1) CWI, MD, Amsterdam, Netherlands (ute.ebert@cwi.nl), (3) KU Leuven, Belgium

Ionization avalanches, space charge effects and consecutive streamer discharges determine the early stages of electric breakdown in air, during lightning inception or in narrow bipolar pulses, ahead of lightning leaders or directly as sprite discharges.

Streamer discharges can start from some hydrometeor and connect to other hydrometeors; streamers typically appear in large numbers, they can branch and interact with each other. To model any phenomena beyond cylindrically symmetric single streamers, fully three-dimensional simulations are required that appropriately resolve the space charge effects. For most phenomena a fluid model for the densities of charged particles is sufficient, but for realistic modeling of inception and branching, electrons have to be modeled as discrete particles with stochastic behavior. Particle modeling also allows to study electron run-away.

I will review recent progress in developing efficient open source numerical discharge models https://gitlab.com/MD-CWI-NL (started and supervised by Jannis Teunissen), and I will discuss new approaches and results by Casper Rutjes and Behnaz Bagheri that go beyond the publications [1,2].

[1] Simulating streamer discharges in 3D with the parallel adaptive Afivo framework,
J. Teunissen, U. Ebert, J. Phys. D: Appl. Phys. 50, 474001 [13 pages] (2017).

[2] 3D PIC-MCC simulations of discharge inception around a sharp anode in nitrogen/oxygen mixtures,
J. Teunissen, U. Ebert, Plasma Sources Sci. Technol. 25, 044005 [13 pages] (2016).