Towards efficient data-driven numerical models for streamer discharges

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Streamer discharges are multiscale and strongly non-linear phenomena. While a typical streamer in air at atmospheric pressure spans several centimeters in length, the strong electric field driving its propagation is due to a steep density gradient in thin layers of a few micrometers. On the other hand, the non-linearity comes from the coupling between the electric field, transport terms, and source terms. Hence, the challenges for computer streamer simulations reside in the need of very high-resolution space meshes and small time steps to properly account for the various space and time scales. For that reason, most of the simulations are performed in 2D cylindrically symmetric domains as 3D simulations turn out to be extremely computationally demanding and out of reach for many research groups.

The recent advances in the field of machine learning are propelling its use in a wide range of applications. Some of this advances leverage the power of neural networks able to learn from data without explicit mathematical models when data is abundant. Nevertheless, Physics can be embedded in data-driven models through various techniques such as minimization of physics-informed cost functions, easing the lack of data due to costly numerical simulations.

In this work we report on our efforts to develop and incorporate machine learning methods that improve the efficiency of numerical simulations of streamer discharges.