Simulation of Low Temperature, Weakly Ionized Plasmas with applications to electric power industry

A. Villa[1], B. Crippa[2], A. Scotti[2], G. Buccella[1], and D. Fasani[1]

[1]RSE - Ricerca sul Sistema Energetico, Milano, Italy
[2]Politecnico di Milano, Milano, Italy

November 13, 2025

Partial discharges (PDs) are among the main degenerative phenomena affecting electrical components in power networks. Several configurations can lead to PDs (Corona, Dielectric Barrier Discharges, Surface Discharges, etc); however, their key ingredients typically include the formation of a low-temperature, weakly ionized plasma, caused by a strong electric field, that interacts with a dielectric material. The interaction between the plasma and the primary insulating material (usually a polymer) causes ageing and depolymerization of the material. When PDs occur within an insulating material, they can promote the propagation of internal defects through a phenomenon known as electrical treeing, which may eventually result in the failure of the electrical component.
Simulation plays a major role in this field. In this work, we highlight some features of the most commonly used hydrodynamic models that make them challenging to solve from a numerical standpoint. We also discuss a few strategies that can be employed to reduce the computational burden. Other key aspects include the multi-scale and multi-physics nature of plasma–polymer interactions, for which we briefly present possible modelling approaches.
Finally, we provide an outlook on future work that may ultimately enable the simulation of electrical treeing and PD phenomena within this framework.