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Revisiting the positive DC corona discharge theory: beyond Peek's and Townsend's law NICOLAS MONROLIN, OLIVIER PRAUD, FRANCK PLOURABOUE, IMFT UMR 5502 CNRS-INPT-UPS — The classical positive Corona Discharge (CD) theory in cylindrical axisymmetric configuration is revisited in order to find analytically the influence of gas properties and thermodynamic conditions on the corona current. The matched asymptotic expansion of Durbin & Turyn of a simplified but self-consistent problem is performed and explicit analytical solutions are derived. The mathematical derivation permits to express a new positive DC corona current-voltage characteristic, either choosing dimensionless or dimensional formulation. In dimensional variables, the current-voltage law and the corona inception voltage explicitly depends on electrodes size and on physical gas properties such as ionization and photoionization parameters. The analytical predictions are successfully confronted with experiments and with Peek's and Townsend's laws. An analytical expression of the corona inception voltage φ_{on} is proposed, which depends on known values of the physical parameters without adjustable parameters. As a proof of consistency, the classical Townsend current-voltage law $I = C\varphi(\varphi - \varphi_{on})$ is retrieved by linearizing the non-dimensional analytical solution. A brief parametric study showcases the interest of this analytical current model especially for exploring small corona wires or considering various thermodynamic conditions.

Franck Plouraboue
CNRS/INSA

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