Numerical investigation of stability of glow corona discharges and corona-to-streamer transition

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Stability of glow corona discharges against finite perturbations is studied in atmospheric pressure air in a point-to-plane electrode configuration with 1 cm gap. The corona is stable against finite perturbations for applied voltages smaller than 18 kV and unstable for voltages higher than 18 kV. Streamers appear when voltage is higher than 13 kV; sparks may form above 18 kV.

1. Introduction

Positive corona-to-streamer transition is an important research subject; e.g., [1]. A related topic is the stability of positive glow coronas against finite perturbations. Both topics are studied in this work.

2. The model

Species included in the modelling are positive and negative ions and the electrons. The kinetic scheme includes ionization, two and three-body dissociative attachment, electron-ion and ion-ion recombination, as well as photoionization. The equations solved are conservation equations for the charged particles and the Poisson equation. The rate of photoionization was evaluated by means of three-exponential Helmholtz model [2]. Standard boundary conditions have been used.

3. Results and discussion

Stable glow corona discharge was computed by means of a stationary solver for the point-to-plane discharge configuration with 1 cm gap in atmospheric-pressure air [3]. The computed current-voltage characteristic (CVC) is shown in figure 1. Using always the state with current 10^{-7} A and voltage of 12.8 kV as initial condition, the stability of glow corona was studied by increasing the applied voltage and following the evolution of the discharge over time with a time-dependent solver. If the applied voltage is in the range 12.8 up to 13 kV, the discharge evolves into a stable glow corona with no streamer formation. This threshold is marked in figure 1 by line 1. If the applied voltage exceeds 13 kV but is below 18 kV, partial streamers appear, then dissipate and the glow corona reappears. Examples of voltage steps used are: for 13 kV the length of streamer propagation is 2.9 mm; for 14 kV, 4.6 mm; for 15 kV, 6.1 mm; for 16 kV, 8.1 mm. The corona is stable against finite perturbations for applied voltages smaller than 18 kV and unstable for voltages higher than 18 kV; line 2 in figure 1.

If the ballast resistance is low and the applied voltage is maintained equal or higher than 18 kV, then discharge current will increase indefinitely and a spark will be formed. If the ballast resistance is appreciable, the increase in current after gap bridging will provoke a fall in the applied voltage. It may happen that the reduced voltage is insufficient to keep the streamer alive, so the streamer will dissipate rather than become a spark.

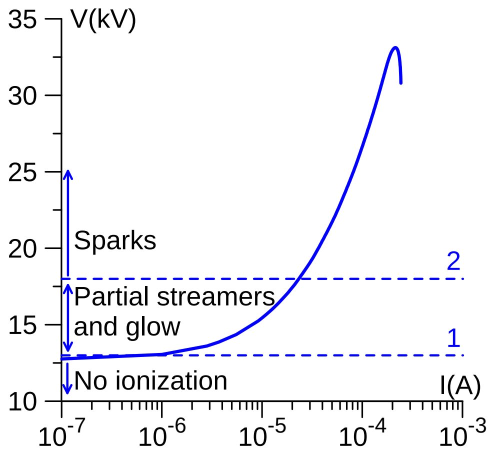

Figure 1: CVC of stable glow corona discharge.

4. Acknowledgements

The work at Universidade da Madeira was supported in part by FCT of Portugal through the project Pest-OE/UID/FIS/50010/2013.

5. References

[1] L. Liu and M. Becerra, *J. Phys. D: Appl. Phys.* **49** (2016) 225202.

[2] A. Bourdon et. al., *Plasma Sources Sci. Technol.* **16** (2007) 656.

[3] A. A. Kulikovsky, Phys. Rev. E **57** (1998) 7066.