Influence of Primary and Secondary Electron Ionization within Townsend Discharges. J. Nelson[1] and J. A. Riousset[1], [1]Emrby Riddle Aeronautical University, 1 Aerospace Blvd , Daytona Beach FL, 32114.

The basis of our understanding of dielectric breakdown, i.e., gas discharges, is Townsend's theory. Its formulation, as Paschen's law, describes non-thermal, self-sustained discharges occurring in high voltage, low current, and low-pressure conditions between two parallel plate electrodes [1]. Paschen's law has been developed for various gas mixtures with experimentally determined coefficients (A, B) and the poorly understood secondary electron emission (γ). The commonly used values of (A, B, γ) do not traditionally consider electrodes' geometry and material.

Riousset et al. (2022, JGR-Atm., under review) proposed a new formalism suitable for non-planar geometries. The new equations make use of the classic approximation of Townsend's reduced effective ionization coefficient: α_{eff}/N =A\exp(-BN/E) where (A, B) are constants and (E/N) is the reduced applied electric field (Td). Riousset et al. further demonstrate the role of mobility (μ) in non-uniform gaps and proposed a power law: μ =C(E/N)^D, where (C, D) are also coefficients. Combining those approximations, the authors numerically solve the updated conditions for initiating self-sustained discharges. Here we propose to use this new formalism and explicitly characterize the coefficients to the reduced Townsend effective ionization (α_{eff}) and mobility(μ) of (A, B, D), ascertain precise coefficients of (γ), and develop an experimental setup for their validation. The discharges are produced in Embry-Riddle Aeronautical University's Lightning Plasma Chamber (LPC), where the critical (initiation) voltage V_{cr} is measured at specific pressures (p) and distances (d) in air and CO_2 mixtures comparable to Earth and Mars atmospheres.

We further show that the Engel-Steenbeck equation [2] V_{cr} = B(pd)/(C + \ln(pd)) where C = ln[A/(ln(1+1/γ))], and the assumed value of (γ) do not adequately characterize the critical voltage under non-planar geometries. We propose to study the dependence of (A, B, D) on the gas mixture. Interestingly, the secondary ionization coefficient (γ) has been attributed to ``emission caused IN the gas'' [1] and ``electron generation ON the cathode'' [2]. Thus, we propose a (χ^2) analysis to assess the dependencies of (γ) on the environmental parameters. Ultimately, this work will support improving safety systems subject to low-current discharges.

References:

[1] Raizer, Y. P., et al. (1991) Gas Discharge Physics *Springer-Verlag.* [2] Fridman, A., Kennedy, L.A., (2011) Plasma Physics and Engineering (2nd ed.). *CRC Press.*