Foundations and Interpretations of the Pulsed-Townsend Swarm Experiment and the use of Machine Learning for Self-Consistent Cross-Section Sets

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The pulsed-Townsend (PT) experiment is a common swarm technique which is routinely used to (i) provide transport coefficients for plasma discharge modelling, and (ii) assess the accuracy and self-consistency of cross-section sets of electron/ion interactions with gaseous systems. The Townsend coefficient, drift velocity and diffusion coefficient for electrons and ions drifting and diffusing in background gases. In this work, the governing equation used to analyse the PT experiment is analysed when non-conservative processes are operative. It highlights, the transport properties derived from PT experiments are not directly comparable to the standard transport coefficients. We highlight, however, how the reaction rate and bulk drift velocity can be better approximated from these PT transport properties, although proper comparison with the bulk transport coefficients requires a slight reanalysis of the PT experiment current transients. Estimates of the errors originating from the incorrect governing equation and subsequent analysis are presented for various atomic and molecular gases as a guide for uncertainties in the previous data. Further, in this presentation we will highlight the use of machine learning techniques to develop self-consistent cross-section sets for electron-neutral interactions in both gaseous and liquid systems.