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ANALYSIS OF CURRENT WAVEFORMS IN THE PULSED-TOWNSEND EXPERIMENT

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Abstract. The pulsed-Townsend (PT) experiment is the quintessential swarm experiment, wherein the spatiotemporal evolution of an electron swarm, as measured by an external circuit, allows the simultaneous determination of ionization, drift and diffusion properties (see e.g. [van Rijn *et al.* 2024]). The swarm transport properties can be used directly in the fluid modeling of plasmas [Petrović *et al.* 2009], or for the determination of the underlying scattering cross-sections [Muccignat *et al.* 2024]. Despite their importance, the interpretation of the transport properties measured in swarm experiments, including the PT, has been the subject of much historical debate and misunderstanding [Crompton 1967]. In 2021, it was shown that standard Brambring equation interpretation of the PT experiment current waveform is flawed when non-conservative processes are operative [Casey *et al.* 2021]. Specifically, the form of the continuity equation is not derivable from Boltzmann's equation, and the Townsend ionization coefficient is not consistent with either of the standard macroscopic or microscopic definitions. Casey and coworkers presented a consistent interpretation of the PT experiment and detailed how to relate the properties extracted via each description. In this work, we investigate the applicability of the analytic current waveform in extracting electron ionization, drift and diffusion properties from a simulated PT experiment. A Monte Carlo simulation was developed using simple model electron scattering cross-sections chosen to easily control the steady-state swarm properties. The accuracy of transport properties extracted from the simulated current waveform using the Casey equation form were investigated for a range of relative ionization, drift and diffusion strengths. Additionally, the effect of the electron source distribution, the relaxation to the steady-state, and Cathode re-absorption on the extracted properties are explored, and the implications to modern PT experiments is discussed.

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