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Estimation of Physical Properties of Streamers in Transient Luminous Events from Non-Steady State Optical Emissions

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Optical emissions from sprite streamers are used to estimate peak electric fields and electron energies [e.g., Kuo et al., GRL, 32, L19103, 2005; Adachi et al., GRL, 33, L17803, 2006]. It has been shown that significant correction factors need to be used to account for the spatial shift between distributions of optical emissions in streamers and peak electric fields in their heads [Celestin and Pasko, GRL, 37, L07804, 2010]. The latter study involved the excited species $\mathrm{N_2(C_3\Pi_u)}$ and $\mathrm{N_2^+(B_2\Sigma_u^+)}$, whose populations are considered to be in steady state. The species $\mathrm{N_2(C_3\Pi_u)}$ and $\mathrm{N_2^+(B_2\Sigma_u^+)}$ are responsible for the second positive $(\mathrm{2PN_2})$ and first negative $(\mathrm{1NN_2^+})$ band systems of $\mathrm{N_2}$ and $\mathrm{N_2^+}$, respectively.

In this work, we show how this technique can be extended to non-steady state optical emissions, such as those produced by $\mathrm{N_2(a^1\Pi_g)}$ and $\mathrm{N_2(B^3\Pi_g)}$ in the form of Lyman-Birge-Hopfield (LBH) and first positive $(\mathrm{1PN_2})$ band systems, respectively. Additionally, we simulate numerically downward propagating sprite streamers and their optical emissions for the following band systems: $\mathrm{1PN_2}$, $\mathrm{2PN_2}$, LBH, and $\mathrm{1NN_2^+}$, and show how they relate to specific physical properties. This study particularly focuses on improving analysis of observational results from the future missions ASIM (ESA) and TARANIS (CNES) that will detect various optical emissions produced by transient luminous events in the nadir.