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[Invited Lecture]

Impact of Solar Activity on the Evolution of Positive and Negative Streamers in Sprite Phenomena

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Abstract: Sprites are large-scale transient luminous events occurring high above thunderstorm clouds, typically in the mesosphere at altitudes between 50 and 90 km. They are initiated by intense electric fields following lightning discharges and are characterized by rapidly propagating streamers. Streamers are thin filaments of weakly-ionised nonstationary plasma produced by an ionisation front that moves through non-ionised matter. Understanding the dynamics of sprite streamers is essential for modelling upper atmospheric electrical phenomena and their coupling to space weather. In this study, we present a classical fluid model for streamer inception and propagation, implemented using the AMReX software framework for adaptive mesh refinement and parallel computing (Simonović et al. 2024). We specifically investigated the influence of background ionisation on the evolution of positive and negative streamers. Background ionisation in the upper atmosphere is strongly dependent on galactic cosmic ray (GCR) flux, which is modulated by solar activity through the heliospheric magnetic field. Periods of low solar activity correspond to increased GCR penetration and higher ionisation levels, potentially

altering streamer morphology, velocity, and branching behavior. Our simulations reveal distinct differences in streamer dynamics under varying ionisation conditions, highlighting the sensitivity of sprite formation to space weather parameters. These findings contribute to a deeper understanding of the electrodynamic coupling between the troposphere and ionosphere and underscore the importance of solar-terrestrial interactions in shaping transient luminous events.

Keywords: sprites, streamers, fluid model, ionisation, solar activity

References

Simonović, I, Bošnjaković, D, Teunissen, J & Dujko, S 2024, Plasma Sources Sci. Technol. **33** 085012