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Current State of the Lightning-Leader-Based TGF Production Theory

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1. Extended Abstract

Terrestrial Gamma ray Flashes (TGFs) are brief (~100 μs) bursts of gamma rays produced in thunderstorms and usually detected from low Earth orbit [1]. TGFs are currently understood to be correlated with initial development stages of normal polarity intracloud lightning that transports negative charges upward (+IC) [e.g., 2]. The TGF source altitude determined from radio emissions typically ranges between 10 and 14 km [3]. It is in agreement with the expected spectrum of bremsstrahlung photons produced in this altitude range by relativistic runaway electron avalanches (RREAs) and transported through the atmosphere up to satellite altitude [4]. Two ensembles of mechanisms (named "theories" for simplicity in the following) are usually advanced in the literature to explain TGFs. One theory assumes the existence of ambient relatively strong large-scale electric fields in thunderstorms acting on secondary cosmic ray electrons and accompanied by relativistic feedback mechanisms [5]. The other is based on the existence of impulsive events named negative corona flashes in the propagation of a negative lightning stepping leader strongly increasing the electric field in the vicinity of the leader tip. Small-scale discharges named streamers can locally produce extreme electric fields in their heads and hence conduce to the production of thermal runaway electrons, which are capable of further acceleration in the electric field produced by the leader itself [6, 7]. Both theories are not mutually exclusive and both involve RREA-like mechanisms [e.g., 8]. However, they also lead to different measurable predictions, including variability in the gamma ray energy spectrum [8], the resulting optical emissions [e.g., 9], the resulting radio emissions [e.g., 10], the physical relation with the causative lightning discharge, and the geometry of source regions.

In this work, we will review the current state of the lightning-leader-based TGF theory in order to obtain a set of predicted observations that could potentially be used to refute one of the above-mentioned theories or both.

2. References

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