
Self-consistent modeling of Relativistic Runaway Electron Avalanches using a relativistic electromagnetic Particle-in-Cell method

Pierre Gourbin^{*1} and Sebastien Celestin²

¹Laboratoire de Physique et de Chimie de l'Environnement et de l'Espace – LPC2E, CNRS Orleans, Université d'Orléans – France

²Laboratoire de Physique et de Chimie de l'Environnement et de l'Espace – LPC2E, CNRS Orleans, Université d'Orléans – France

Résumé

Terrestrial gamma ray flashes (TGFs), which occur during thunderstorms, are very short bursts of gamma rays produced by bremsstrahlung emission from energetic electrons created in Relativistic Runaway Electron Avalanches (RREAs). This phenomenon can only occur under a relatively high electric field, which allows the electrons to accelerate continuously and produce even more secondary high-energy runaway electrons while partially ionizing the air.

How such phenomenon establishes itself within the environment of thunderclouds remains up for debate. In recent years, radio emissions over a wide range of frequencies have been observed in association with TGFs. For example, Energetic In-cloud Pulses (EIPs) [e.g., Cummer et al, GRL, 48, e2021GL093627, 2021], slow LF pulses [e.g., Wada et al., GRL, 49, e2021GL097348, 2022], and VHF emissions [e.g., Lyu et al, GRL, 45, 2097-2105, 2018].

In this work, we developed a collisional Monte Carlo code coupled with an electromagnetic Particle-In-Cell (PIC) model to simulate relativistic runaway electron avalanches and the associated electromagnetic field produced by high- and low-energy particles. In so doing, we obtain self-consistent simulations of RREAs, hence constraining deeper the production context of TGFs. A better understanding of corresponding radio emissions can provide critical information about the mechanisms underlying TGFs.

^{*}Intervenant