

A criterion for infinite positron feedback in the dynamics of runaway electron avalanches

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Terrestrial Gamma-ray Flashes (TGF) - short ($\sim 100 \mu\text{s}$) and intense flashes of terrestrial gamma radiation, the source of which is thunderstorms. This remarkable natural phenomenon has been observed for over 20 years by satellites (for example, Fermi), as well as by ground-based observatories (for example, the Array telescope). It is believed that the source of gamma radiation is avalanches of runaway electrons accelerated by thunderstorm electric fields.

Joseph Dwyer proposed a model of runaway avalanches - the Relativistic Feedback Discharge Model (RFDM). According to this model, there is a feedback mechanism in the dynamics of avalanches that leads to the reproduction of avalanches and, therefore, their endless existence within strong atmospheric electric fields. Such an amazing process is caused by the creation of positrons by the bremsstrahlung of electron avalanches.

In this work, an analytical study of RFDM is carried out. The spatial distributions of particles are obtained for all generations of self-replicating avalanches. A criterion for the existence of infinite positron feedback in thunderclouds is also derived. Simulations on Geant4 support the result.

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