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Feedback Matrix Approach for Relativistic Runaway Electron Avalanches Dynamics in Complex Electric Field Structures

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Abstract : Relativistic runaway electron avalanches (RREA) are a widely accepted source of thunderstorm gamma-radiation. In regions with huge electric field strength, RREA can multiply via relativistic feedback. The relativistic feedback is caused both by positron production and by runaway electron bremsstrahlung gamma-rays reversal. In complex multilayer thunderstorm electric field structures, an additional reactor feedback mechanism appears due to gamma-ray exchange between separate strong electric field regions with different electric field directions. The study of this reactor mechanism in conjunction with the relativistic feedback with Monte Carlo simulations or by direct solution of the kinetic Boltzmann equation requires a significant amount of computational time. In this work, a theoretical approach to study feedback mechanisms in RREA physics is developed. It is based on the matrix of feedback operators construction. With the feedback matrix, the problem of the dynamics of avalanches in complex electric structures is reduced to the problem of finding eigenvectors and eigenvalues. A method of matrix elements calculation is proposed. The proposed concept was used to study the dynamics of RREAs in multilayer thunderclouds.

Keywords : terrestrial Gamma-ray flashes, thunderstorm ground enhancement, relativistic runaway electron avalanches, gamma-rays, high-energy atmospheric physics, TGF, TGE, thunderstorm, relativistic feedback, reactor feedback, reactor model
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