X-and γ- emissions from runaway electrons associated with thunderstorms

D. Cinar[1], O. Chanrion[1], T. Neubert[1].

[1] *National Space Institute, Technical University of Denmark, 2800 Lyngby, Denmark*

The aim of this paper is the study of the production of X- and gamma- emissions in the atmosphere in association with thunderstorms. These emissions have been observed by space campaigns [1]. They had been first associated with high energy electrons initiated by cosmic rays and accelerated further by the thundercloud electric field [2]. It has also been suggested that runaway electrons from streamer tips of lightning leaders could play a role. The X- and gamma- emissions come from the Bremsstrahlung mechanism. The study make use of a Monte Carlo model that can reproduce the acceleration of electron in thunderstorm field, interactions with air molecules and the generation of hard radiations. The paper reports preliminary results.

1. Introduction

In this paper we present preliminary results of the Monte Carlo model that is used to study acceleration of electrons in a background electric field originating from thunderstorms to energy necessary to produce hard emissions. The study is motivated by the discovery of Terrestrial Gamma Ray Flashes (TGFs) observations from satellites [1, 3] and is related to the space missions ASIM and TARANIS.
It is understood that the radiation comes from bremsstrahlung from high energy electrons accelerated in the electric field of discharges associated with the thunderstorm [1, 4]. Two mechanisms are suggested for the source of these energetic electrons: relativistic electrons are initiated by cosmic rays [5], and cold electrons are accelerated near the enhanced field regions of leader tips of a lightning [6].

2. Modelling

The Monte Carlo study has started with standard simulation of electron drifting in an electric field and colliding with the neutrals via elastic, in-elastic, and ionization processes. Simulations have shown the possibility for streamers to generate runaway electrons from cold electrons [6]. The code has been extended to include the bremsstrahlung, by using data from [7].

3. Preliminary results.

The preliminary results discuss the impact of the external conditions on the energy distribution on the photon emission spectrum.

4. References

[1] G. J. Fishman, P. N. Bhat, R. Mallozzi, J. M. Horack, T. Koshut, C. Kouveliotou, G. N. Pendleton, C. A. Meegan, R. B. Wilson, W. S. Paciesas, S. J. Goodman, H. J. Christian, Discovery of Intense Gamma-Ray Flashes of Atmospheric Origin, Science, New Series 264 (1994) 5163.

[2] O. Chanrion, T. Neubert, A PIC-MCC code for simulation of streamer propagation in air, Journal of Computational Physics 227 (2008).

[3] M. S. Briggs, V. Connaughton, C. Wilson-Hodge, R. D. Preece, G. J. Fishman, R. M. Kippen, P. N. Bhat, W. S. Paciesas, V. L. Chaplin, C. A. Meegan, A. von Kienlin, J. Greiner, J. R. Dwyer, D. M. Smith, Electron-positron beams from terrestrial lightning observed with Fermi GBM, Geophysical research letters (2011) 38.

[4] T. Neubert, On Sprites and Their Exotic Kin, Atmospheric science 300, 747 (2003).

[5] A.V. Gurevich, G.M. Milikh, R. Roussel-Dupre, Runaway electron mechanism of air breakdown and preconditioning during a thunderstorm, Physics Letters A 165 (1992).

[6] O. Chanrion, T. Neubert, Production of runaway electrons by negative streamer discharges, Journal of geophysical research (2010) 115.

[7] S. M. Seltzer, M. J. Berger, Bremsstrahlung energy spectra from electrons with kinetic energy 1 keV -10 GeV incident on screened nuclei and orbital electrons of neutral atoms with Z = l - 100, Atomic data and nuclear data tables (1986) 35.