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Method for the numerical calculation of the mechanism of the origin the NBE (CID) due to the volume phase wave of synchronous ignition of streamer flashes by EAS-RREA

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In an article by Kostinskiy et al. (2019) proposed the mechanism of the origin and development of lightning from initiating event to initial breakdown pulses (termed the Mechanism). The Mechanism assumes initiation occurs in a region of a thundercloud of 1 km^3 with electric field E > 0.3-0.4 MV/(m□atm), which contains, because of turbulence, numerous small "E_{th}-volumes" of 0.001 m^3 with E ≥ 3 MV/(m□atm). The Mechanism allows for lightning initiation by two observed types of initiating events: a high power VHF event called an NBE (narrow bipolar event or CID), or a weak VHF event. According to the Mechanism, both types of initiating events are caused by a group of relativistic runaway electron avalanche particles passing through many of the E_{th}-volumes, thereby causing the nearly simultaneous launching of many positive streamer flashes.

This report describes the method for the numerical calculation of the volume phase wave of ignition of streamer flashes in the turbulent region of a thundercloud, which is initiated by secondary particles of a extensive air shower (EAS). The lateral distribution of energetic electrons and positrons, which are created by cosmic particles with an energy ε> 10^{15} eV, is described by the equation Nishimura-Kamata-Greizen (Kamata & Nishimura, 1958). When an EAS enters an electric field with an intensity of E> 400 kV /(m□atm), which supports the movement of streamers, the electron runaway mechanism is sure to start working (runaway threshold E> 280 kV/ (m□atm), Dwyer, 2010). Each secondary electron and positron EAS initiates an avalanche of runaway electrons. The radial distribution of each avalanche was calculated in the diffusion approximation using the Dwyer-Babich approximation formulas (Dwyer, 2010; Babich & Bochkov, 2011). The model considered the effect of electrons of each such avalanche on the entire volume of a strong electric field.

The calculation showed that the EAS-RREA mechanism of almost simultaneous volumetric initiation of multiple streamer flashes can provide such NBE (CID) parameters as current and charge transfer at observation heights of 5–20 km above sea level.

References

Babich, L.P., Bochkov, E.I. (2011). Deterministic methods for numerical simulation of high-energy runaway electron avalanches. Journal of Experimental and Theoretical Physics, 112(3), 494–503, doi: 10.1134/S1063776111020014.

Dwyer, J. R. (2010), Diffusion of relativistic runaway electrons and implications for lightning initiation, J. Geophys. Res., 115, A00E14, doi:10.1029/2009JA014504.

Kamata, K., & Nishimura, J. (1958). The lateral and the angular structure functions of electron showers. Progress of Theoretical Physics Supplement, 6, 93. https://doi.org/10.1143/PTPS.6.93

Kostinskiy, A. Yu., Marshall, T.C., Stolzenburg, M. (2019), The Mechanism of the Origin and Development of Lightning from Initiating Event to Initial Breakdown Pulses, arXiv:1906.01033

Raizer Yu. (1991), Gas Discharge Physics, Springer-Verlag, 449 p.