Notre Dame Science
Department of Physics

On the origin of the huge natural electron accelerators operated in the thunderclouds

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Strong electrical fields inside thunderclouds give rise to fluxes of high energy electrons and, consequently, gamma rays and neutrons. Gamma rays and electrons are currently detected by the facilities of low orbiting satellites and by networks of surface particle detectors. During intensive particle fluxes, coinciding with thunderstorms, series of particle bursts were detected by the particle detectors of Aragats Space Environmental Center (ASEC) on altitude of 3200 m. We classify the thunderstorm ground enhancements (TGEs) in 2 categories, one lasting microseconds, the other lasting up to tens of minutes. Both types of events can occur at the same time, coinciding with large negative electric field between cloud and ground and negative intracloud lightning occurrence. Statistical analysis of the short TGE bursts sample suggests the duration is less than 50 μs and spatial extension is larger than 1000 m^2. Huge enhancements of the particle fluxes (up to 600%) and short extended burst of particle showers point on relativistic runaway electron avalanches (RREA) process in the thunderclouds. The smaller peaks in the secondary cosmic ray fluxes (1–20% enhancements) can be explained without evoking particle multiplication in the avalanche process. We discuss the origin of TGEs and its connection to the terrestrial gamma flashes (TGF), detected by orbiting gamma-ray observatories. Simultaneously detected energy spectra of electrons and gamma rays recovered from largest TGE events detected at Aragats are based on large statistics and are prolonged up to 100 MeV, which pose serious challenge to existing models of particle generation in the thunderclouds. Detection of neutrons during TGE events also will be presented and discussed.

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Special joint Astrophysics–High Energy Physics–Nuclear Physics seminar