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Terrestrial Gamma-ray Flashes

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Lightning and thunderstorm systems in general have been recently recognized as powerful particle accelerators, capable of producing electrons, positrons, gamma-rays and neutrons with energies as high as several tens of MeV. In fact, these natural systems turn out to be the highest energy and most efficient natural particle accelerators on Earth. Terrestrial Gamma-ray Flashes (TGFs) are few milliseconds long, very intense bursts of gamma-rays and are one of the most intriguing manifestation of these natural accelerators. Only three currently operative missions are capable of detecting TGFs from space: the RHESSI, Fermi and AGILE satellites. The basic physical mechanism responsible for TGF production is commonly believed to be the so called Relativistic Runaway Electron Avalanche (RREA) process, which allows a seed electron of sufficiently high energy in a thundercloud electric field to overcome the friction force and increase its energy up to relativistic values, and possibly produce secondary electrons that can drive an avalanche multiplication. Subsequent collision of relativistic electrons with air molecules lead to gamma-ray production by Bremsstrahlung, while further interaction of gamma-rays with matter can produce electron-positron pairs and neutrons. Although this model is widely accepted, there are several points still obscure, namely: the highest achievable energies, which translates into the maximum voltage drop that can be established within thunderclouds, the connection with lightning and cloud microphysics and the overall occurrence rate of TGFs. In this presentation I will review the characteristics of TGFs and the basic principles of the associated production models. Then I will focus on the recent AGILE discoveries concerning the high energy extension of the TGF spectrum, which is difficult to reconcile with current theoretical models.

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