Electron Acceleration Induced by Cosmic Rays in Terrestrial Thunderstorms

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Intense non-thermal x rays and gamma rays have been observed from terrestrial thunderstorm activities by satellites including BATSE [1] and RHESSI [2], and ground-based detectors [3,4,5,6]. These non-thermal photons are thought to originate from bremsstrahlung of relativistic electrons accelerated by strong electric fields in thunderclouds and lightning, strongly suggesting that electrons are accelerated to relativistic energies in terrestrial thunderstorms. Thus, measurements of such photons can provide valuable information on electric-field acceleration in terrestrial environment, and also planetary one. As one viable mechanism to produce those relativistic electrons, the relativistic runaway electron avalanche model, involving acceleration and multiplications of electrons caused by cosmic rays [7], has been proposed. However, from an observational viewpoint, it is still unclear whether or not cosmic rays really trigger the electron acceleration. Aiming at elucidating electron acceleration in terrestrial atmosphere via gamma-ray observations, we have conducted experiments at the coastal area of Japan Sea and high mountains. Actually, 8 gamma-ray bursts, extending to 10 MeV or higher, have been detected since 2006. In this presentation, several characteristic measurements done in 2006 - 2010 will be presented. Then, we discuss the mechanism of electron acceleration associated with thunderstorm activity. Especially, we focus on the cosmic-ray trigger problem and acceleration limit of electric-field acceleration in terrestrial atmosphere, electric-field acceleration; gamma rays; thunderclouds; lightning; collisional plasma

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