Japan Geoscience Union Meeting 2010
(May 23-28 2010 at Makuhari, Chiba, Japan)

PEM031-03 Room: Exibition hall 7 subroom 1 Time: May 24 09:26-09:39

Particle acceleration in terrestrial thunderstorm activity

Harufumi Tsuchiya[1*], Teruaki Enoto[2], Tatsuo Torii[3], Hiroshi Kato[1], Masaharu Okano[1], Kazuo Makishima[1]

[1]Cosmic Radiation Laboratory, RIKEN, [2]Dep. of Phys., Univ. of Tokyo, [3]Japan Atomic Energy Agency

Recent observations using satellites and ground-based detectors have measured non-thermal radiations, including x rays and gamma rays, associated with terrestrial thunderstorm activity. These non-thermal radiations suggest that terrestrial lightning discharges and thunderclouds are particle accelerators driven by their strong electric fields. However, the ability of lightning discharges and thunderclouds to accelerate electrons to high energies remain much less understood. For example, how electrons start to be accelerated in dense terrestrial atmosphere is unclear. In addition, a limit on an achievable energy of electrons is also unknown.

Up to date, it has been widely discussed that non-thermal radiations related to thunderstorm activity are attributable to relativistic runaway electrons. Fast seed electrons, generated by e.g. cosmic rays penetrating thunderclouds, acquire energies from ambient electric fields high enough to exceed their ionization loss. Then, they will be accelerated to relativistic energies. Those accelerated electrons would increase in their number, via multiple scatterings, in the electric field and in turn radiate gamma rays via bremsstrahlung. Accordingly, through observations of non-thermal photons emitted from thunderstorm activity, we will be able to understand how lightning discharges and thunderclouds accelerate electrons to relativistic energies. Also, those observations may give a hint to elucidate electric-field acceleration in astrophysical objects such as solar flares and pulsar magnetosphere. Furthermore, it has been interestingly thought that electrons multiplied may cause lightning discharges in planetary atmosphere as well as terrestrial one. Thus, those non-thermal photon observations would give a better understanding on how lightning discharges occurs in terrestrial and planetary atmosphere. Therefore, in order to understand how electrons are accelerated in terrestrial thunderstorm activity, we have operated gamma-ray observations at the coastal area of Japan sea and high mountains since 2006 December.

From 2006 to 2009, we have successfully observed 11 gamma-ray emissions including 5 short-duration bursts and 6 long-duration ones. Here, we call energetic radiations, which last for milli-second or less and are associated with lightning discharges, as short-duration ones. On the other hand, we define as long-duration bursts, count enhancements that last for few seconds to a few minutes and do not clearly associate with lightning discharges. Many of the two types of radiation bursts observed clearly extend to around 10 MeV, showing that electrons can be accelerated to at least 10 MeV in terrestrial thunderstorms. However, it is still unclear whether or not acceleration limits of the short-duration and long-duration bursts are the same, since they largely differ in time and spatial scale.

In this presentation, we would like to focus on observations of long-duration gamma-ray emissions originating from long-duration electron acceleration in thunderclouds. In particular, we will investigate an acceleration limit of electrons in thunderclouds, and compare it with that obtained from a satellite observation of short-duration gamma-ray radiations associated with lightning discharges. In addition, we will mention whether or not observed long-duration emissions are attributable to cosmic-ray electrons. Then, we will discuss differences and similarities between

short-duration acceleration related to lightning discharges and long-duration one occurring in thunderclouds.

Keywords: gamma rays, particle acceleration, thuderclouds, lightning discharges