6th Asia-Pacific Conference on Plasma Physics, 9-14 Oct, 2022, Remote e-conference

Analysis of Fermi acceleration of electrons from electric fields during dipolarization

Kaiti Wang[1], Tohru Hada[2]

[1] Department of Aerospace Engineering, Tamkang University, [2] International Research Center for Space and Planetary Environmental Sciences, Kyushu University

e-mail (speaker): ktwang@mail.tku.edu.tw

Low energy electrons exhibit various types of pitch-angle anisotropies in the near-earth region of the magnetotail [1]. In particular, the so-called cigar-type anisotropies ($T_{\parallel} > T_{\perp}$) are often found in association with dipolarization events, implying a presence of preferential parallel heating processes during the dipolarization. One candidate of such a process may be the Fermi mechanism, in which the enhanced dawn-to-dusk electric field adiabatically accelerates the electrons as it couples to the curvature drift [2].

In this study, we examine the electron acceleration from this mechanism by deriving the curvature drift velocities using observed electric fields and magnetic fields from THEMIS mission during dipolarization [3]. The dipolarization means that the ambient magnetic field configuration changes from stretched fields to dipolarized fields, so the dipolarization angle, the angle between the local magnetic field vector and the equatorial plane, increases accordingly. The pitch angle distributions of electrons had been found to vary when dipolarization occurred [1]. The associated changes of energies and pitch angles of electrons are then calculated via the Fermi acceleration mechanism, and the deduced field-aligned anisotropies as well as differential energy fluxes are compared with the observations. Two representative events at 10 Earth radii are adopted for the calculations. One event showed an increase in differential energy fluxes above ~ 2keV when the dipolarization angle reaches the peak (Top panel of Figure 1). On the other hand, the other event showed a decrease in these fluxes above a similar energy level during dipolarization (Bottom panel of Figure 1). Although the Fermi process should accelerate the electrons in parallel directions due to the shrinkage of the magnetic field, deceleration was found to occur through inputting these real observed values of the electric/magnetic fields.

This acceleration is found to produce an increase in differential energy flux above ~ 2keV, consistent with the observed feature shown in the top panel of Figure 1. The deceleration is found to be able to result in a decrease in differential energy flux above ~ 2keV, consistent with the observed feature of the other representative event as shown in the bottom panel of Figure 1. Hence, this can be considered as the scientific benefit from observations besides theoretical work. Finally, the perpendicular acceleration from electric fields coupled to gradient drifts are also taken into account to evaluate their effects.

References

[1] K. Wang et al, J. Geophys. Res. 119, 9747-9760 (2014)

[2] T. Hada et al, J. Geophys. Res. 86, 11,211-11,224 (1981)

[3] V. Angelopoulos, Space Sci. Rev. 141, 5-34 (2008)

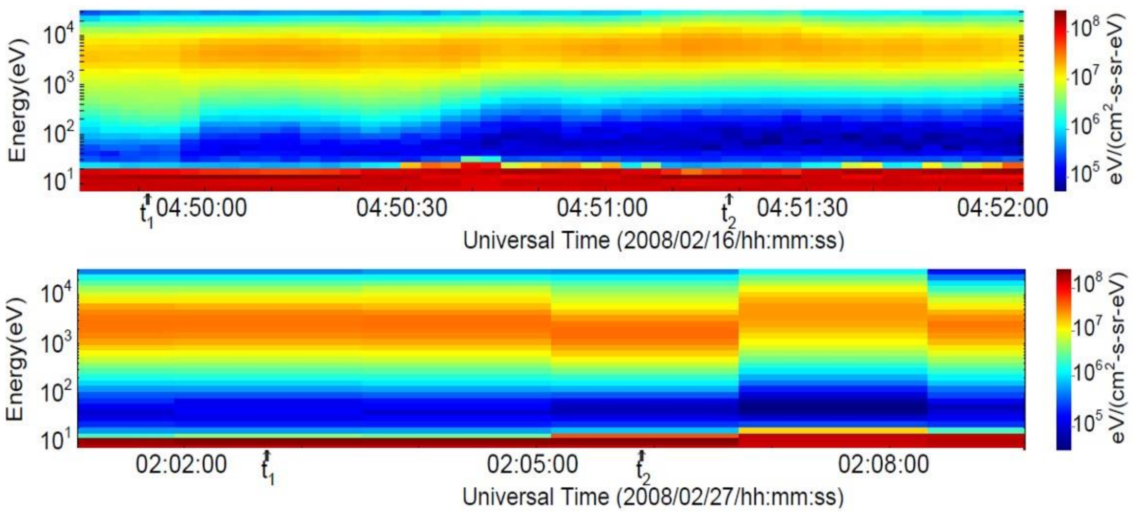

Figure 1 Temporal variations of differential energy flux (eV/(cm^2 s sr eV)) observed by ESA (ElectroStatic Analyzer) from 7eV to 30keV by THEMIS mission at two dipolarization sites. The notation t_1 denotes the data time right before the dipolarization, and the notation t_2 denotes when the dipolarization angle reached the peak. (Top) Observations on February 16 of 2008 by the Probe D. The differential energy flux increased from t_1 to t_2 at above ~ 2 keV. (Bottom) Observations on February 27 of 2008 by the Probe E. The differential energy flux decreased from t_1 to t_2 at above ~ 2 keV.