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Original article

Nightside Electron Injections during the 25th June 2005 magnetic Substorm

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A R T I C L E I N F O

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Abstract

This paper presents the observations from three geosynchronous satellite stations during a substorm on June 25, 2005. The event was seen at three satellites. These satellites are LANL − 97A, LANL − 02A, and LANL − 01A). The injection was observed to be dispersed at the three locations of the geosynchronous satellites. It found that energetic electrons progress faster. The increase began instantly after substorm onset.

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Introduction

Since 1989 Los Almos National Laboratory (LANL) satellites have launched a new generation of energetic particle detectors called Synchronous Orbit Particle Analyzers (SOPA) instruments (Belian *et al*. 1992) The basic scientific use of the Geosynchronous Earth Orbit (GEO) energetic particle database mainly concerned with research of substorms. Energetic particle injection at geosynchronous orbit is one of the most common and reliable indicators of substorm onset signatures and occurs on average every 2.5 hours. Energetic electron enhancement events in the magnetosphere are usually related to disturbed events such as substorms. It is well known that energetic particles appear in geosynchronous orbit, 6.6 RE subsequent to a substorm expansion phase, in a narrow band at near local midnight (Belian *et al*. 1992). During the substorm expansion phase an injections of the fresh plasma into the inner magnetosphere, can appear dispersive meaning that the flux enhancement for different energies occurs at different time, thus the system shows the dispersion (as more energetic particles arrive faster); (Collier and Hughes 2004a, Collier and Hughes 2004b, Collier 2004 and Liu *et al* 2004). The injection region typically extends over a few hours of local time (Reeves et al 1992). Energetic electron injection into the inner magnetosphere is a truly process of magnetospheric substorm (Mcllwian, 1974, Baker *et al*, 1998, Liu 2003, Reeves etal 1990, Birn, *et al.* 1998, Sarris and Li, 2005, Birn *et al,* 1997, Lubehich *et al.* 2006 and Sams *et al*. 2003). During a substorm expansion phase, the plasma particles are accelerated and injected into the midnight sector of the Earth's inner magnetosphere, into the region of a dipolar magnetic field (Lubehich, *et al.* 2006). The region within approximately 6.6 RE, contains electrons injected in the night-side Earth's inner magnetosphere with energies from hundreds of keV to tens of MeV, during the onset of the substorm expansion phase. The population of electrons in the Nightside Earth's inner magnetosphere increases over a large range of energies.

Observations and Discussions

The figures in this part, comes from the data that obtained from the Synchronous Orbit Particle Analyzer (SOPA) instruments in the Los Almos National Laboratory (LANL) satellites in Geosynchronous Earth Orbit (GEO), meaning that they hover continuously over one position on the surface above the Earth. GEO is an orbit with the Earth with an orbital period of one sidereal day (approximately 23 hours 56 minutes and 4 seconds), in the plane of the Earth's equator approximately at an altitude of 6.6 RE. The interest in the GEO data in the context of this work lies in the location of the satellites, in the Earth's inner magnetosphere. This region is within approximately 6.6 RE, which is the part of the magnetosphere where the Earth's magnetic field lines are not significantly distorted by the solar wind and where the field is approximated by a centered dipole. As indicated in Figure 1, the locations of the spacecraft with the international designators LANL-01A (at longitude 8 deg), LANL-02A (at longitude 69 deg), and LANL-97A (at longitude 144 deg). Each satellite is labelled by longitude φ. The LANL − 01A and LANL-02A satellites were situated near local midnight while the LANL-97A spacecraft was situated in the predawn to dawn sector.

Los Alamos National Laboratory (LANL) SOPA energetic electron averaged differential flux measurements from three different satellites are presented in Figure 2 shows the energetic electron fluxes from the SOPA instrument on board LANL − 97A, LANL − 02A, and LANL − 01A (top, middle, and bottom) respectively.

One can instantly see from Figure 2 that the electron flux increases dispersion in any of the Los Almos National Laboratory (LANL) satellites. Only three energy channels (75-105 keV, 105-150 keV, and 225-315 keV) are displayed in the Figure 2 because their fluxes peak at night side as a result of substorm injections. From Figure 2, we also note that the dispersion in the electron fluxes is least at LANL − 01A and increases at LANL − 02A, addition, the electron flux increases appear to show the reverse behavior, with the most dispersion seen at LANL − 97A which were farther to the East. This behavior is consistent with an injection of energetic electrons on the Nightside.

From figure 2 top at LANL − 97A the electronic signatures for the approximately 02:60 UT event shows a dispersion increase at night side with progressively more dispersed signatures as you go east and this is consistent with a Nightside substorm. For example, the substorm onset occurred approximately at 02:60 UT (black vertical line). Between 03:00 and 04:30 UT, Strong injections electron fluxes were also observed. For lower energy electrons, 75-105 KeV, their fluxes peak at night side as a result of substorm injections. Here, Figure 2 at LANL − 97A shows lower energy electron peaking after high energetic electrons (high energetic electrons drift and arrived to the location faster), this means the highest energy electrons drift most rapidly and thus arrive first than lower energy around the Earth if injected at the same location. As evident from figure 2, middle at LANL − 02A the intense electron band extending from about 02:30 to 03:90 UT. Between 04:00 to 05:00 UT, weak injections in the inner magnetosphere energy electron fluxes were also observed. One can immediately see from Figure 2 LANL − 01A that the electron flux increases dispersion in any of the three energy channels (75-105 keV, 105-150 keV, and 225-315 keV). Between 03:10 to 05:00 UT, weak injections in the inner magnetosphere energy electron fluxes were also seen.

Figure 2 bottom at LANL − 01A shows electron fluxes increase during the period between 02:30 to 03:30 UT, followed decreases electron fluxes in 03:60. Weak injections in the inner magnetosphere energy electron fluxes were also seen between 03:70 and 05:00 UT.

Satellite observations have shown that fluxes of electrons in the Earth's magnetosphere vary during the onset of substorms. Energetic electrons are injected into the Earth's inner magnetosphere around midnight at the onset of the substorm expansion phase. Electrons proceed and drift eastward towards dawn. Electrons with different energies are dispersed because of their drift velocities. The geosynchronous region is selected as the main source of electrons.

The reasons at a geocentric distance of L = 6.6, the geomagnetic field in this region is highly dynamic, and a burst of energy, from tens of keV to tens of MeV, electrons are injected into the inner magnetosphere during the onset of a substorm.

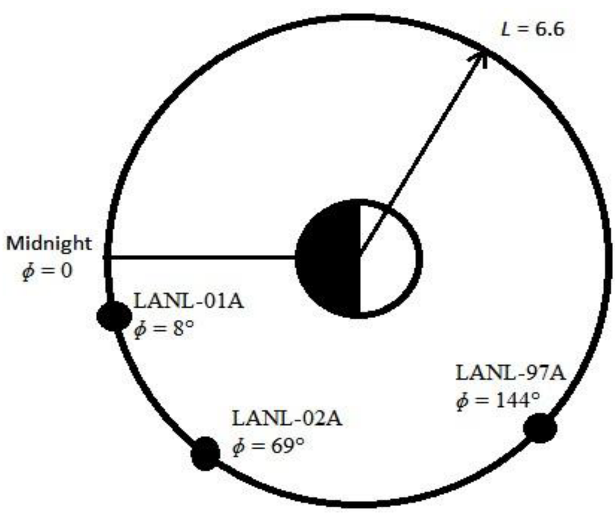
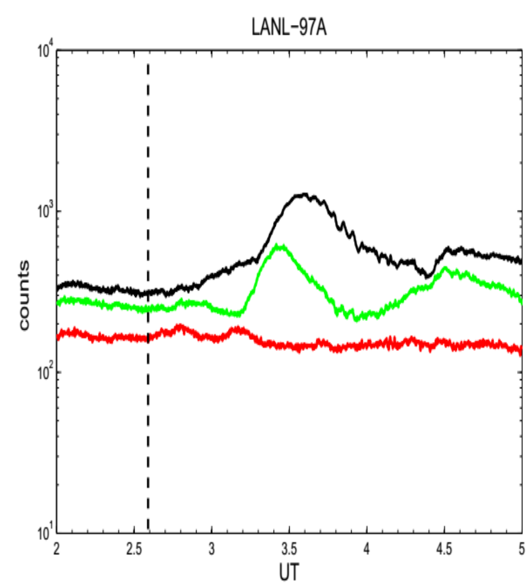


Figure (1). The configuration of the Los Alamos geosynchronous shows the spacecraft locations on June 25, 2005, corresponding to spacecraft LANL-01A, LANL-02A, and LANL-97A, respectively. Each satellite is labeled with longitude φ. Where φ = 0 is centered around midnight

Geophysical parameters in Figure 3 (first panel), Kp, (second panel) display Dst index, and the third panel is the north-south component of the magnetic field (GSM-Bz), the value of GSM-Bz between -10 nT and 10 nT. At midnight (GSM-Bz) shows a value increase during the period between 02:30 to 03:30 UT, followed by a negative excursion of Bz. The geomagnetic activity (storms, substorms, and aurora) of the magnetosphere is described by a variety of Geophysical parameters that are derived from ground-based magnetometer data to ensure continuous coverage. The Kp (Figure 3 (first panel)) is very sensitive to substorm event activity, making Kp one of the main Geophysical parameters used to describe substorms. Figure 3 illustrates the UT-variations of the Kp. The Dst is the magnetic index used in magnetosphereic physics, which is an average of the storm time horizontal magnetic field variation at different stations near the magnetic equator. The Dst index reached maximum negative values of approximately -29 nT making this significant geomagnetic event on 25 June 2005. Figure 3 plots Kp, Dst, and Bz variation during substorm event on June 25, 2005 and corresponding changes for Kp, Dst, and Bz variations. From the top is Kp index, Dst index, and Bz; the variation for the same time period t = (0-24) UT, (bottom) panel at t = (2-5) UT on June 25, 2005.



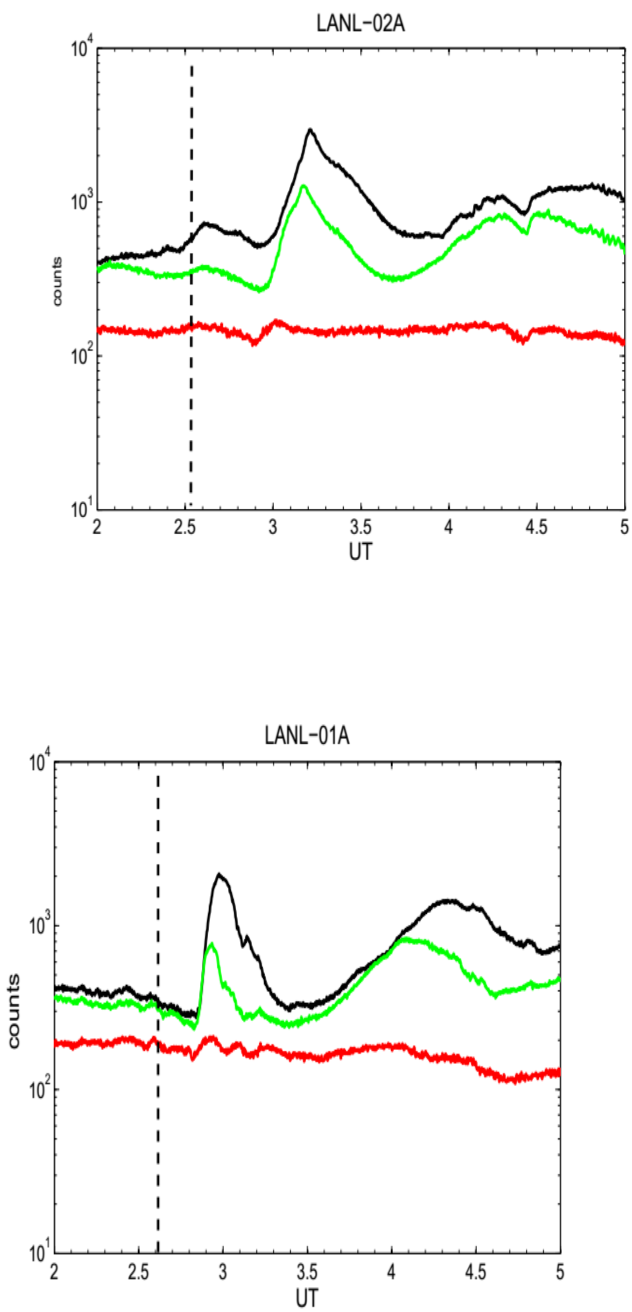


Figure 2. Electron injections as observed by SOPA instrument. (top, middle, and bottom) energetic electron fluxes (counts) from SOPA on board LANL-97A, LANL-02A, and LANL-01A. The three traces (black to red) represent the following energy channels ((75-105 keV, 105-150 keV, and 225-315 keV)). day of 25 June 2005

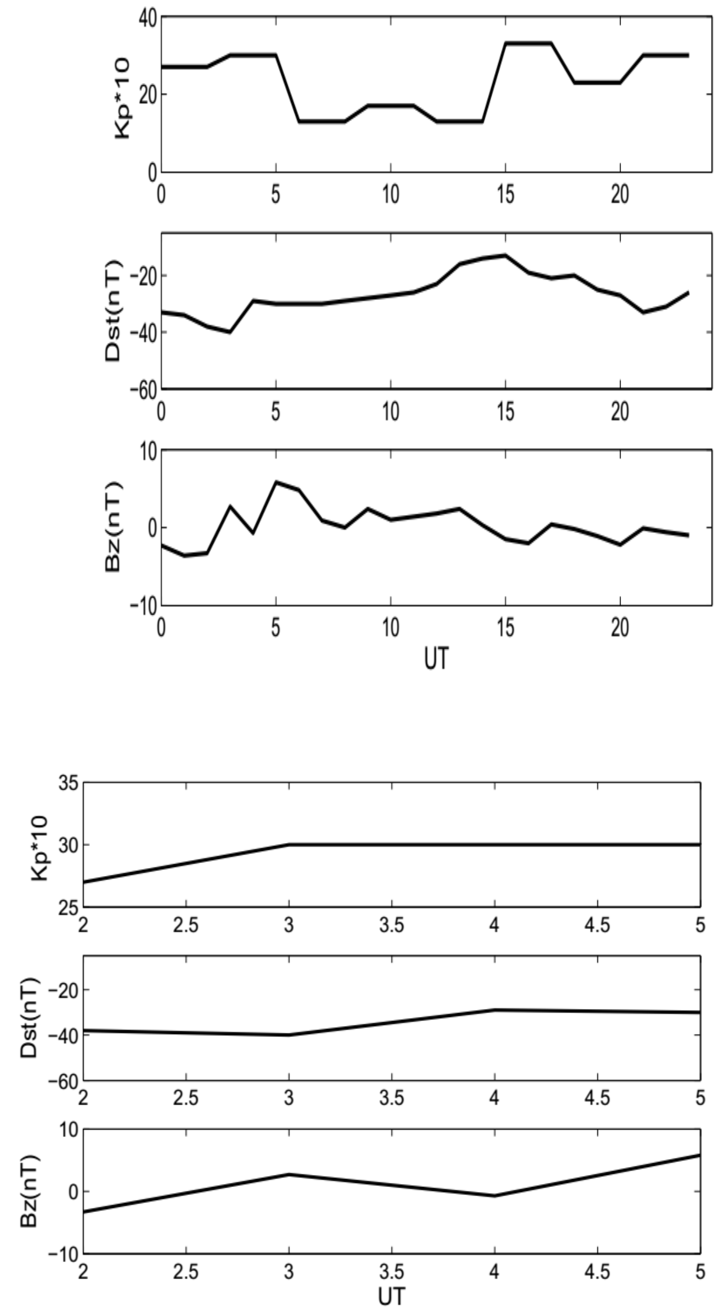


Figure 3. Geophysical parameters, from the top are Kp index, Dst index, and Bz. The variation of Dst index for the same time period t = (0-24) UT, (bottom) panal at t = (2-5) UT on June 25th 2005

Conclusions

In this paper, we examined the energetic electron fluxes enhancements associated with the June 25th 2005 substorm event in detail. It has shown rapid injections of energetic electron 75-315 keV into the inner magnetosphere at L = 6.6RE due to Geophysical parameters. We found that the dispersion in the electron fluxes is least at LANL−01A and increases at LANL−02A, addition, the electron flux increases appear to show the reverse behavior, with the most dispersion seen at LANL − 97A. This study, therefore, indicates that the behavior is consistent with an injection of energetic electrons on the Nightside. Energetic electron observed in the inner magnetosphere was correlated with changes in magnetic field (GSM-Bz).

Most notable it shows lower energy electron peaking after high energetic electrons (high energetic electrons drift and arrived to the location faster), this means that, the highest energy electrons drift most rapidly and thus arrive first before than lower energy around the Earth if injected at the same location. The progressive increase in the energetic electrons began immediately after substorm onset.

Our results suggested that the progressive and localized electron increases are the two main ingredients of the electron dynamics during the substorm onset.

Acknowledgements

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