"Physics of Auroral Phenomena", Proc. XXIV Annual Seminar, Apatity, pp.66-69, 2001

Polar Geophysical Institute

THE LONG-PERIOD DP-1 AND DP-2 VARIATION EFFECTS IN RADIATION BELTS

L.V.Tverskaya (*Skobeltsyn Institute of Nuclear Physics; Moscow State University; Moscow 119899, Russia, e-mail: tverskaya@taspd.sinp.msu.ru*)

Abstract. The long (~2-3 hours)-period stormtime self-excited DP-1 variations during a persistent southward Bz, which were first examined earlier, are discussed. The energetic electron increases in the inner belt due to the resonant acceleration resultant from those variations are analyzed. The quasi-periodic (a few hours) variations of the relativistic electron intensity in a geosynchronous orbit are analyzed on the basis of the GOES-8,10 measurements and ACE interplanetary data. The Molniya-1 data are used to demonstrate the DP-2 variation effects on low-energy radiation belt electrons and protons in the distant magnetosphere.

Introduction

Imhof et al. (1966) were the first to find the transient selective peaks in the differential spectra of relativistic electrons at the inner edge (L~1.15) of the inner radiation belt. The calculations (Cladis, 1966) have shown that the peaks are accompanied by resonant acceleration of particles by the electric fields induced under quasi-periodic variations of equatorial electrojet. The Molniya-1 measurements were used in (Vernov et al., 1972) to study the resonant acceleration of protons with energies of a few hundreds of keV. The peaks in the proton spectra on L~2.5 occur due to the giant (up to 1000 nT in a sunlit polar cap) quasi-periodic DP-2 variations, whose period is associated with the proton drift period at the respective L-shells. A Dst variation main phase 'step' is formed as this type of the DP-2 variations are developing, while the bay (DP-1 variation) amplitude becomes comparable to, or smaller than, the disturbance amplitude in the polar cap (Tverskaya and Khorosheva, 1974).

The DP-2 variations are known to be in a good correlation with the IMF Bz fluctuations (Nishida, 1968). Even in a relatively quiet environment there are Bz fluctuations in a geosynchronous orbit accompanied by correlated fluctuations of 50-150 keV trapped electron fluxes (Parks and Pellat, 1972).

A 2-3-hour period self-excitation mode can develop in substorms under a persistent southward orientation of the IMF (Tverskaya and Khorosheva, 1975). The present work examines the effect of long-period geomagnetic variations on the inner and outer radiation belt particles.

Results

The >0.28 MeV inner belt electron variations inferred from the data of low polar-orbiting satellites can be accounted for by t he 2-3-hour quasi-periodic global geomagnetic variations. That type of events is recorded during strong magnetic storms (Bostrom et al., 1968). Fig. 1a shows the >0.28 MeV electron event in the inner belt during the strong magnetic storm of 25 May 1967 (Bostrom et al., 1968). It is seen that the electron increase is most pronounced and shows the highest intensity within a narrow L-shell range (L~1.3-1.4). The measurements were of integral character, so the drift period of the measured electrons cannot be estimated in any way accurately. A rough estimate gives T~2.5 hours. Fig. 1b presents some of the magnetic data for that storm and Fig. 1c shows the Fourier spectrum of the AL-indices between 1900 UT on 25 May and 1500 UT on 26 May 1967, when the giant (~3000 nT) quasi-periodic DP-1 variations were observed (Tverskaya and Khorosheva, 1975). Within 0000-1400 UT on 26 May 1967, the IMF Bz was negative (the earlier hours have not been supported by any measurement data). The AL-index variation spectrum (as well as the spectra obtained at separate magnetic observatories (Tverskaya and Khorosheva, 1975) shows the expressed 2.6 and 3.2-hour peaks. Most probably, the above-mentioned quasi-periodic variations resulted in the resonant acceleration of electrons in the inner belt. It should be noted that the described above interval of quasi-periodic substorms was preceded for a few hours by the giant DP-2 variations of a ~2-hour period (Tverskaya and Khorosheva, 1974).

Under a persistent southward IMF orientation, the ~2-4-hour quasi- periodic intensity variations of relativistic electrons are observed at geosynchronous orbits. Fig. 2 exemplifies the variations. The IMF Bz component was negative for ~24 hours. The solar wind velocity varied little around 450 km/s. The solar wind density and the intensity of the interplanetary protons with energies of a few hundreds of keV were somewhat variable, but without any expressed periodicity and modulation depth that were found in the relativistic electron fluxes at the GOES-8 and 10 geosynchronous satellites. The intensity of tens keV interplanetary electrons was practically constant to ~ 10 UT of August 11, 2000. The tentative AL-index data are indicative of a good correspondence between the variations in the AL-index and in the electron intensity.

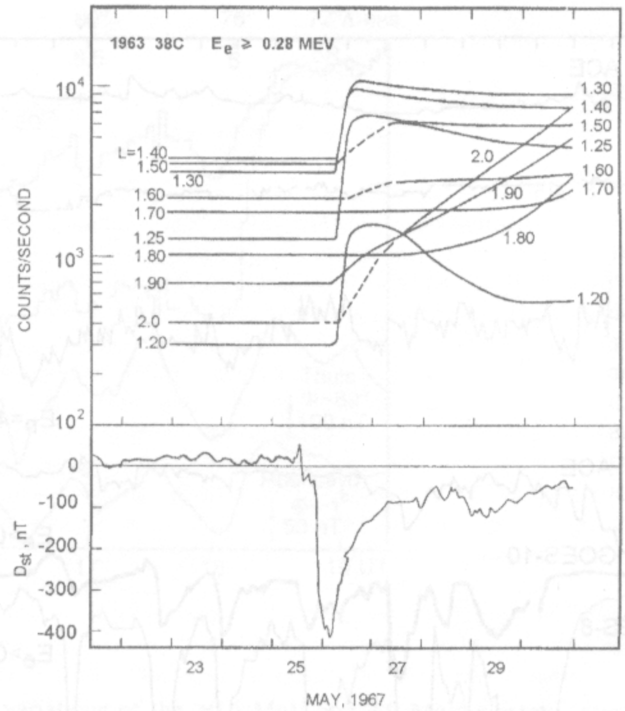

Fig. 1a. The >0.28 MeV inner belt electron increase during the 25 May 1967 storm observed on the 1963 38C satellite.

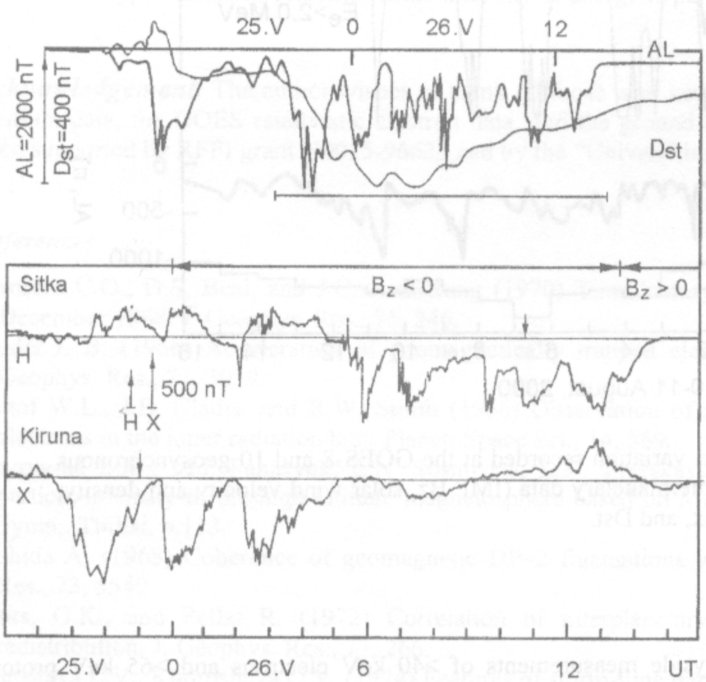

Fig. 1b. The 25 May 1967 storm geomagnetic data: the Dst-variation, the AL-index, the H- and X-components of the Sitka and Kiruna magnetic observatories.

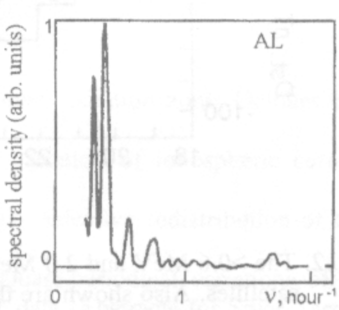

Fig. 1c. The Fourier spectrum of AL-index during the interval from 1900 UT on 25 May to 1500 UT on 26 May 1967.

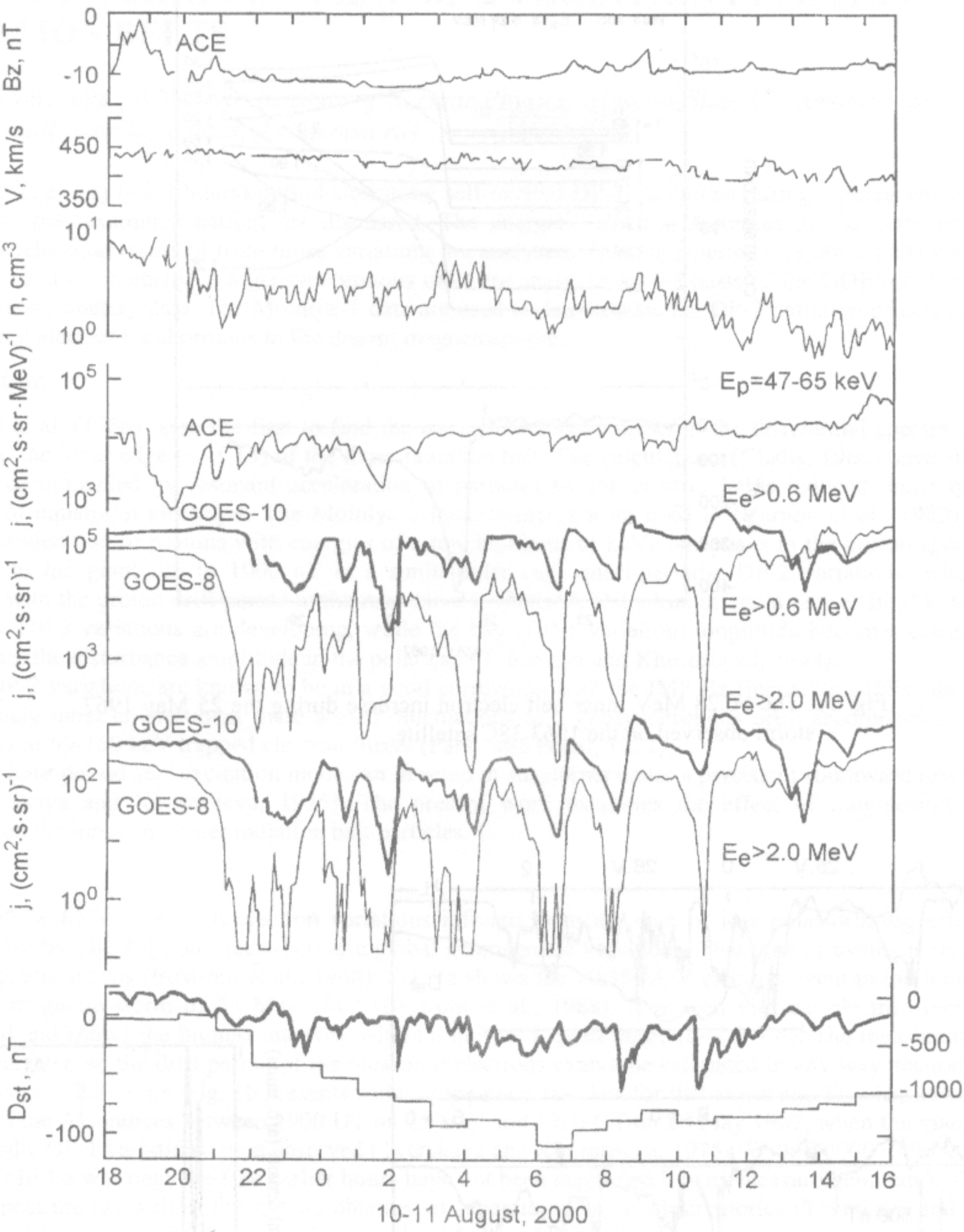

Fig. 2. The >0.6 MeV and 2.0 MeV electron variation recorded at the GOES-8 and 10 geosynchronous satellites. Also shown are the ACE interplanetary data (IMF Bz, solar wind velocity and density, 47-65 keV proton intensity), AL-index, and Dst.

Fig. 3 shows the results of Molniya-1 dayside measurements of >40 keV electrons and >65 keV protons (Kovrygina et al., 1986). The synchronous 1-hour electron and proton variations are quite evident. The ground-based observations show the DP-2 type global variations (see the Thule polar cap data and the Huancayo equatorial data), which modulate the trapped particle intensity in the distant magnetosphere. The variation behavior synchronism in the ground-based and satellite data indicate that the disturbances are global and temporal, rather than spatial. A similar effect for the 50-150 keV electrons was also observed in the synchronous orbit (Parks and Pellat, 1972)

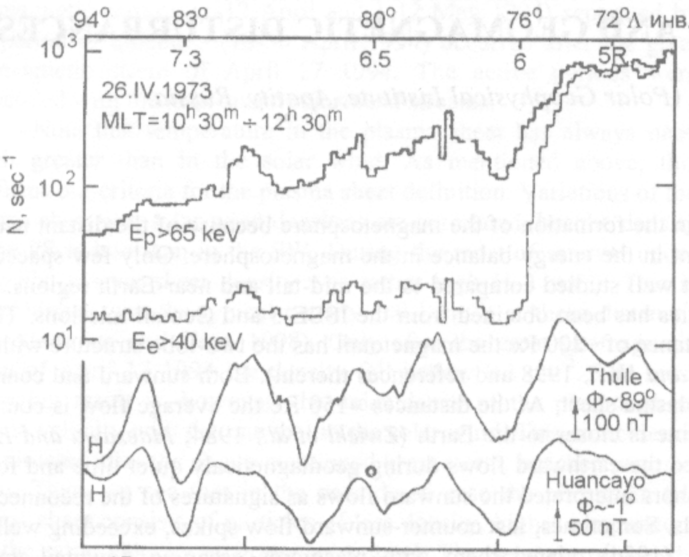

Fig. 3. The >40 keV electron and >65 keV proton flux variations inferred from the Molniya-1 measurement data. The upper scale shows the invariant latitude and the geocentric distance. Two lower curves are the H-components of the Thule and Huancayo magnetic observatories.

Conclusions

1. The long-period (2-4-hour) variations of the >0.6 MeV and 2.0 MeV electron intensity have been recorded at geosynchronous satellites under a persistent southward IMF orientation.
2. The events observed in the >0.28 MeV inner belt electron fluxes during strong magnetic storms are due to the resonant acceleration of particles when affected by the substorm-type quasi-periodic global geomagnetic disturbances.
3. The DP-2 type variations redistribute the intensity of energetic particles in the distant magnetosphere

Acknowledgement. The author wishes to thank all those who keep the Internet sites with the ACE interplanetary medium data, the GOES relativistic electron data, and the ground-based geomagnetic activity data. The work has been supported by RFFI grant N0015-96623 and by the "Universities of Russia" grant.

References

Bostrom C.O., D.S. Beal, and J.C. Armstrong (1970) Time history of the inner radiation zone, October 1963 to December 1968. J. Geophys. Res., 75, 246.

Cladis J. B. (1966) Acceleration of geomagnetically trapped electrons by variation of ionospheric currents. J. Geophys. Res., 71, 5019.

Imhof W.L., J.B. Cladis, and R.W. Smith (1966) Observation of an energy – selective redistribution of trapped electrons in the inner radiation belt. Planet. Space Sci., 14, 569.

Kovrygina L.M., M.I. Panasyuk, E.N. Sosnovets, L.V. Tverskaya (1976) Quasi-periodical variations of charge particle intensity in the high latitude magnetosphere based on Molniya – 1 data. Abstracts for Solar Terr. Phys. Symp., Tbilisi, p.113.

Nishida A. (1968) Coherence of geomagnetic DP–2 fluctuations with interplanetary magnetic field. J. Geophys. Res., 73, 5549.

Parks, G.K., and Pellat R. (1972) Correlation of interplanetary space Bz fluctuations and trapped particle redistribution. J. Geophys. Res., 77, 266.

Tverskaya L.V., Khorosheva O.V. (1974) Features of storm-time giant DP-2 variations. Geomagn. i Aeron., 14, 106.

Tverskaya L.V., Khorosheva O.V. (1975) Self-excited character of magnetospheric substorms. Geomagn. i Aeron., 15, 573.

Vernov S.N., Panasyuk M. I., Sosnovets E.N., Tverskaya L.V., Khorosheva O.V., (1972) Resonant acceleration of low energy protons in the Earth's radiation belts. Geomagn. i Aeron., 12, 785.