SH 6.I-I6

DYNAMICS OF THE PENETRATION BOUNDARIES OF SOLAR PROTONS DURING A STRONG MAGNETIC STORM

G.A. Glukhov, Yu.P. Kratenko
The Tashkent State University, 700095, Tashkent, USSR

Yu.V. Mineev
Institute of Nuclear Physics, Moscow State University,
Moscow II9899, USSR

Abstract. On the basis of the Intercosmos-I9 data, the variations in the equatorial penetration boundary of solar protons with E_p = 0.9-8.0 MeV during a strong magnetic storm of April 3-5, I979 are studied. The dynamics of this boundary is compared with the dynamics of the outer trapping boundary of electrons with E_e = 0.3-0.6 MeV. Alongside with the solar-proton penetration we study the structure of the real magnetic field. The uniqe data on the thin structure of development of a magnetospheric substorm have been obtained for the first time.

In our previous paper /I/ we have analyzed the features of the latitudinal profiles of the SCR protons with E_p = = 0.9-8.0 MeV in the polar regions during a strong magnetic storm of April 3-5, I979 on the basis of the Intercosmos-I9 data (a perigee of ~ 500 km, an apogee of ~ I000 km, a period of ~ I00 min, an inclination of ~ 74°). The present paper is a study of the dynamics of the equatorial penetration boundary (Λ_{peq}) of the SCR protons for this magnetic storm (D_{st}-variation and the AE-index are presented in the lower part of fig.I). The variations in Λ_{peq} are studied alongside with the dynamics of the outer trapping boundaries of electrons with E_e = 0.3-0.6 MeV and E_e = 0.9-I.2 MeV which enables us to investigate the thin structure of development of magnetospheric substorms. Observations of electrons and protons were made by a semiconductor telescope aboard Intercosmos-I9 (IC-I9)/2/.

The outer trapping boundary of electrons was ment to be the threshold sensitivity of the instrument to the particles with a given energy. This definition of the boundary is justified because near the trapping boundary there was a rapid decrease in the particle intensity. Λ_{peq} was determined from the onset of a rapid decrease in intensity.

The dynamics of Λ_{peq} during the event in question is shown in the upper half of fig.I. Data I refer to the day (open circles) and morning (solid circles) sectors MLT and data II, to the evening (open circles) and night (solid circles) sectors. Here is also given the averaged location of Λ_{peq} for protons with $E_p \geqslant$ I MeV in the day (broken lines I), morning (solid lines I), evening (broken lines II) and night (solid lines II) sectors MLT according to the Cosmos-900 (C-900) and Cosmos-I067) data.

The comparison between the results of observations made on various satellites shows that at the day and night hours MLT the C-900 and C-I067 data, is available, are in good agreement with the IC-I9 data. At the morning hours MLT on the main phase of the April, 3 magnetic storm at 20-23 UT the IC-I9 data are I-2° higher than the C-900 and C-I067 data, at the maximum D_{st} the IC-I9 data coincide with the C-900 and C-I067 data and at the end of the recovery phase the IC-I9 data coincide or are I° lower than the C-900 and C-I067 data at the pre-noon hours (9.5-II.5) MLT. A strong shift of the evening boundary to lower latitudes down to 55° was observed nearly an hour earlier on the IC-I9 as compared with C-900 and C-I067. According to the IC-I9 data, the evening boundary there shifted to larger latitudes, in conformity with the D_{st}-variation, and again to lower latitudes and the second minimum in the position of this boundary was observed at the maximum of the main phase of the storm. The complex analysis of the main parameters of the magnetosphere disturbance (D_{st}, AE) and the parameters of the interplanetary space (the magnitude and direction of the IMF, the solar wind velocity and density) shown that the strong shift of the evening boundary to lower latitudes is caused by the development of the magnetospheric substorm.

So, the IC-I9 data confirm the conclusion made in ref. /3/ about the prior and leading decrease in Λ_{peq} in the evening sector, that is connected with the asymmetric intrusion of particles of the storm ring current and the magnetic field decrease, yet, this effect is observed on the phase of development of an individual substorm and not of the storm as in ref./3/.

The evening boundary of penetration of solar protons coincides with the night boundary on the recovery phase of the storm.

The IC-data are obtained at later morning and later evening hours MLT which accounts for the differences in the location of the morning and evening boundaries determined from the IC-I9, C-900 and C-I067 data.

The dynamics of the outer trapping boundary of electrons is shown in the middle part of fig.I. A set of curves I is for electrons with E_e = 0.3-0.6 MeV and a set of curves II, for electrons with E_e = 0.9-I.2 MeV. The open circles correspond to the data obtained on the dayside and the solid circles, on the nightside. The position of the trapping boundaries of electrons is seen to be asymmetric in the midday-midnight plane and the asymmetry value depends on energy: the asymmetry decreases with increasing electron energy.

On the dayside the position of the trapping boundaries of electrons depends on rigidity. On the nightside this dependence is much weaker. As the magnetic field increases and decreases during the magnetic storms and substorms, the trapping boundaries shift to higher and lower in variant latitudes, respectively, in which case the trapping boundaries of electrons with different energies come close to each other as the magnetic field decreases and move away from each other as the field increases.

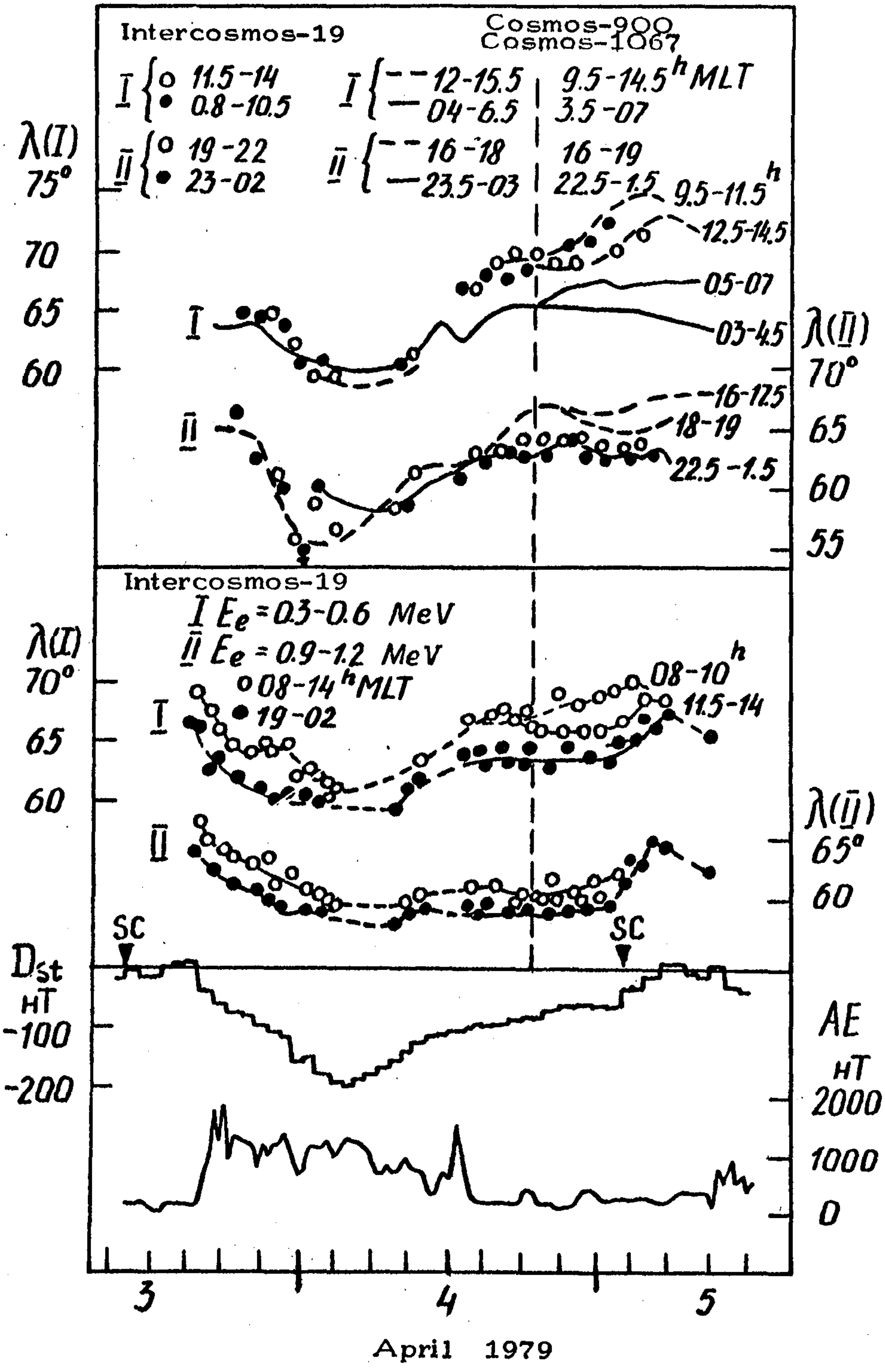
Intercosmos-19
Cosmos-900
Cosmos-1067
I { ○ 11.5-14, ● 0.8-10.5
I { - - 12-15.5 | 9.5-14.5^h MLT; — 04-6.5 | 3.5-07
II { ○ 19-22, ● 23-02
II { - - 16-18 | 16-19; — 23.5-03 | 22.5-1.5
λ(I) 75° 70 65 60
λ(II) 70° 65 60 55
9.5-11.5^h
12.5-14.5
05-07
03-4.5
16-17.5
18-19
22.5-1.5
Intercosmos-19
I Ee = 0.3-0.6 MeV
II Ee = 0.9-1.2 MeV
○ 08-14^h MLT
● 19-02
λ(I) 70° 65 60
λ(II) 65° 60
08-10^h
11.5-14
SC
SC
Dst нТ -100 -200
AE нТ 2000 1000 0
3
4
5
April 1979

Fig.1

The comparison between the dynamics of the equatorial region of penetration of the SCR protons and the outer trapping boundaries of electrons with E_e = 0.3-0.6 MeV and E_e = 0.9-I.2 MeV shown that on the dayside these boundaries behave in a similar manner. On the nighside Λ_{peq} coincides to within I^o with the trapping boundary of electrons with E_e = 0.3-0.6 MeV except for the time moments within several minutes before the onset of magnetospheric substorms when the SCR protons are injected into deep L-shells; in this case the proton intensity peaks near the injection boundary and then falls down abruptly towards low latitudes. The intensity maximum can, apparently, be explained by the proton acceleration under the action of the enhanced electric field. Following the injection the SCR protons with E_p = = 0.9-8.0 MeV penetrate deep into the trapping region of electrons with E_e = 0.3-0.6 MeV and during strong magnetospheric substorms, into the trapping region of protons with E_p = 0.9-8.0 MeV.

Because of the violation of the adiabatic conditions of motion, a rapid precipitation of the SCR protons takes place following the injection in the trapping region of electrons with E_e = 0.3-0.6 MeV and also in the quasitrapping region on the dayside. The strong precipitation can also result from the parasitic scattering of the SCR protons on the electromagnetic radiation of the ring current protons.

References

I. Yu.V.Mineev et al. Proc. I8-th Int.Cos.Ray Conf., Bangalore, India, I983, 3, 262-265.

2. Yu.V.Mineev and E.S.Spirkova. Sov.Journal "Vestnik MGU", series 3, I98I, 22, I, 9I-95.

3. L.A.Darchieva et al. Sov. Journal "Geomagnetizm and Aeronomy", I983, 23, 59-64.