acta phys. slov. 34 (1984), No. 2—3

# STRUCTURE OF SOLAR COSMIC RAY FLUXES IN THE POLAR CAPS[1])

## СТРУКТУРА ПОТОКОВ СОЛНЕЧНЫХ КОСМИЧЕСКИХ ЛУЧЕЙ В ПОЛЯРНЫХ ШАПКАХ

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The investigation of SCR fluxes in the magnetosphere [1—3] has shown that fluxes are often non-uniform. These inhomogeneities are connected with the high latitude magnetosphere and with conditions of the interplanetary space [4, 5].

Mechanisms are studied of the penetration of energetic particle into the closed magnetosphere (the field lines of one polar cap are connected with the field lines of another polar cap), originating during intervals when the interplanetary field has the $B_z > 0$ component, and into the open magnetosphere (the field lines of polar caps are interconnected with the field lines of IMF), originating when $B_z < 0$.

The major part of the data on the structure of the proton fluxes in the polar cap was analysed in terms of an open magnetosphere model [1, 3, 5].

As it was shown in [3], it is possible to distinguish the quasitrapping region (low latitude polar region [6]) and the polar cap (high latitude polar region). This image corresponds to $B_z < 0$.

In the case of $B_z > 0$, the structure of fluxes in the polar cap is more complex [7, 8] and several regions with their own peculiarities in the sense of particle penetration there exist.

We have analysed data on proton fluxes $E_p > 1$ MeV obtained on November 22—25, 1977 on board of "Intercosmos-17" and "Cosmos-900". Particle data on one pass of Intercosmos-17 satellite in the polar region are given in Fig. 1. The IMF had the components $B_x > 0$, $B_y < 0$, $B_z \geq 0$ [9]. It means that our data were obtained under the conditions corresponding to those of a closed magnetospheric model. We have also used the data of "Prognoz-6" on solar cosmic rays with $E_p \geq 1$ MeV in interplanetary space. The axis of the satellite was directed towards the Sun and the detector was set at an angle of 45° to this direction. This enabled to measure the anisotropy flux of particles moving away from the Sun.

The different regions of solar proton intensities at high latitudes are shown in Fig. 2. The regions marked by vertical lines correspond to the recording of depressed intensity of SCR for more than 50 % passages through the given region according to both satellite data. Horizontal lines mark the regions where more frequently a high intensity of SCR occurs. Comparison of these regions with the boundary of electron ($E_e > 30$ keV) penetration according to data [10] shows that a higher intensity of protons is found in the closed field line region. In that region the enhanced intensity was found only in 80 % of

[1]) Contribution presented at the International Symposium on Acceleration and Propagation of Energetic Particles in the Heliosphere in Smolenice, September 27 — October 1, 1982.

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Intercosmos-17 passages. According to the data of Cosmos-900 it was difficult to distinguish this region because the data were recorded by an intensimeter where variations of ~30 % were difficult to determine.

From the evening side at $\Lambda > 80°$ in the southern and northern hemisphere in 50 % of passages the intensity was registered to be 30—40 % lower in comparison with other polar cap regions. The region of depressed intensity was found also in the morning sector at $\Lambda \sim 80—88°$ and it was seen more clearly. In the northern hemisphere only 1 of 14 passages did not manifest this region. In the southern hemisphere there were only 4 passages through this region and during one of them the lower intensity was not registered. In the midnight sector of the northern region the depressed intensity at $\Lambda \sim 70—75°$ was found in 50 % of the events.

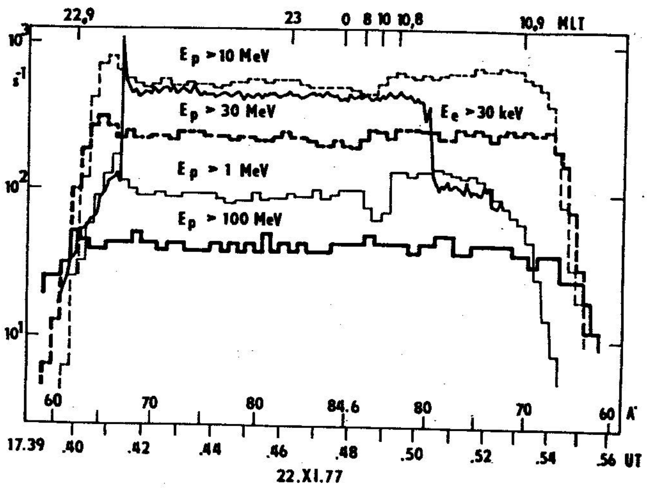


Fig. 1. Data obtained during one pass of Intercosmos-17 satellite through the south polar region. At the top of the figure the local magnetic time is shown. Four proton channels and one electron channel are drawn. $\Lambda$ denotes the invariant latitude.

Comparison of electron and proton fluxes in the polar caps shows that electron fluxes are practically uniform in the whole region where they are penetrating. The gyroradius of an electron is much less than the width of the magnetopause or the neutral sheet in the geomagnetic tail, and because of that the penetration of electrons from the interplanetary space into the magnetosphere has an adiabatical character. From this it is possible to conclude, in agreement with [4, 5] and in disagreement with the theoretical conclusion in [7], that the penetration of protons in different regions of magnetopause has a different character, which may be adiabatical, or non-adiabatical.

The region of a more difficult proton penetration into the magnetosphere was most clearly pronounced in the morning sector at high latitudes $\Lambda \gtrsim 82°$. In paper [11] on electrons in the near region the region of the closed field lines was separated, although in our case the non-uniform flux of electrons was not registered. The difference in the registration conditions should be mentioned: 22—25 Nov. 1977 it was $B_z \sim 0 \div 3$ nT, while on August 4, 1972 [11] $B_z \sim 9$ nT and this difference may play its role.

In [7] the following division of the polar cap region das performed: The zone of quasitrapping — the



region is marked in Fig. 2 by horizontal lines. It is filled by cosmic ray particles falling at the front side of the geomagnetic tail, possibly on the morning or the noon [12] part of the magnetosphere. Issuing from the night, morning and evening sides at $\Lambda \lesssim 80°$ with $B_z \sim 0$ or at $\Lambda \sim 85—88°$ with $B_z > 0$, there is a region of field lines intersecting the neutral sheet. Especially on these field lines there were found from time to time regions of a depressed intensity.

The morning region of depressed intensity is situated in agreement with [7] on field lines connected with the interplanetary field. If in this case a rotational discontinuity appears on the magnetopause, then the cosmic ray flux falling onto the magnetosphere, under certain conditions is reflected. This may cause the lowering of the intensity in the region discussed.

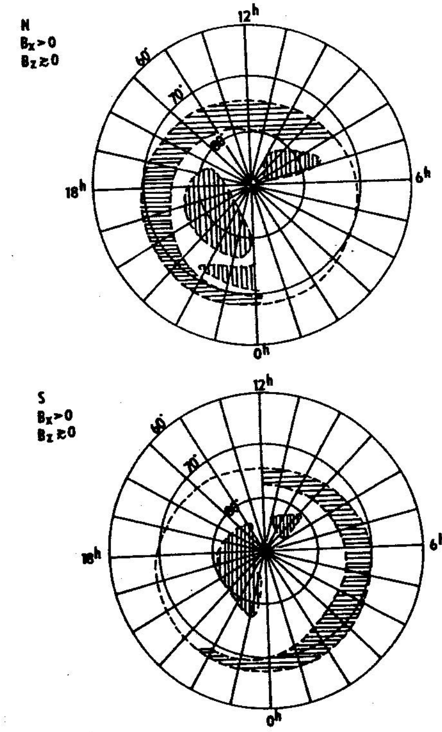


Fig. 2. The structure of proton fluxes $E_p > 1$ MeV in the polar caps. The horizontal dotting denotes the enhanced proton intensity. The vertical dotting denotes the depressed proton intensity.

It is interesting to note that the variations of proton fluxes in the polar cap were proportional to the variations of proton intensities in interplanetary space according to data of "Prognoz-6". Only in the case when "Prognoz-6" was inside the magnetosphere (November 23), the anisotropy of the proton flux was negligibly low, i.e. the flux was isotropic despite the existence of intensity variations in the whole polar cap.

In this way, the analysis of data from "Intercosmos-17" and "Cosmos-900" enabled to confirm the conclusion that the low latitude polar region (quasitrapping region) differs in its characteristics from the high latitude polar region.

In the high latitude region the region of difficult SCR penetration for $\Lambda \gtrsim 80°$ in the late morning hours can be distinguished reliably. Relatively frequently there occurs the decrease of the intensity in the evening and night sector at high latitudes. The amplitude of the proton intensity variations along the polar cap is proportional to the amplitude of that in the interplanetary medium because of the anisotropy of the flux in the interplanetary medium.

## REFERENCES


[1] Van Allen, J. A., Fennel, J. F., Ness, N. F.: J. Geophys. Res. *76* (1971), 4262.

[2] Hynds, R. J., Morfill, G., Rampling, R.: J. Geophys. Res. *79* (1974), 1332.

[3] Ivanova, T. A., Sosnovets, E. N., Tverskaya, L. V.: Geomagnetism i Aeronomia *16* (1976), 159.

[4] Palmer, A. D., Jackson, J. D., Hones, E. W. Jr.: J. Geophys. Res. *84* (1979), 109.

[5] Morfill, G., Scholer, M.: Space Sci, Reviews *15* (1973), 267.

[6] McDiarmid, I. B., Burrows, J. R.: J. Geophys. Res. *74* (1969), 6239.

[7] Alekseyev, I. I., Kropotkin, A. P., Shabansky, V. P.: Geomagnetism i Aeronomia *15* (1975), 13.

[8] Akasofu, S. I., Covey, D. N., Meng, C. I.: Planetary and Space Sci. *29* (1981), 803.

[9] King, J. H.: (1979) *Interplanetary Medium Data Book Supplements*, 1975—1978, NSSDC /WDC-A-RES 79-08.

[10] Biryukov, A. S., et al.: (*this issue*)

[11] McDiarmid, I. B., Burrows, J. R., Wilson, M. D.: J. Geophys. Res. *85* (1980), 1163.

[12] Ivanova, T. A., Kuznetsov, S. N., Sosnovets, E. N.: *17th ICRC*, Paris, France, July 13—25 1981, Conf. Papers SH1 session, Vol. 3, p. 496.


Received January 4th, 1983

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