THE BIDIRECTIONAL OPPOSITE STREAMINGS OF PROTONS $E_p \geq 12$ keV IN THE NOON LOW LATITUDE MAGNETOSHEAT[1])

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The picture of electron and proton fluxes with $E \geq 12$ keV in the low latitude part of the passage of Prognoz-8 through the magnetosheat in the evening and noon sector (flank and front regions) is analysed. Strong variability at both the average level as well as its modulation during the rotation of the detector axis in the $(yz)_{GSE}$ plane is registered. In one front passage the registration of two opposite directed proton fluxes collimated at narrow angles parallel and antiparallel to $\boldsymbol{B}$ when the interplanetary field had $B_z < 0$ permits for a long time, practically through the whole magnetosheath. The pitch angle distribution changes its character in passing through the magnetopause to a typical quasitrapped distribution.

ДВУНАПРАВЛЕННЫЕ ПРОТИВОПОЛОЖНЫЕ ПОТОКИ ПРОТОНОВ С ЭНЕРГИЕЙ $E_p \geq 12$ кэВ В НИЗКОШИРОТНОЙ ПЕРЕХОДНОЙ ОБЛАСТИ

В работе проводится анализ потоков электронов и протонов с энергией $E \geq$ 12 кэВ в низкочастотной части прохождения спутника «Прогноз-8» через переходную область в вечернем и полуденном секторах (боковая и передняя области). Зарегистрирована сильная переменность среднего уровня и его модуляции при вращении детектора вокруг оси в плоскости $(yz)_{GSE}$. Регистрация двух противоположно направленных потоков протонов, коллимированных под углами, которые почти параллельны полю $\boldsymbol{B}$ в случае, когда межпланетное поле $B_z < 0$ сохраняется в течение длительного времени, практически на протяжении всей переходной области. Питч-угловое распределение меняется при прохождении через магнитопаузу в типичное распределение квазизахвата.

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

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I. INTRODUCTION

The energetic particles investigation near the magnetopause and in the mag-
netosheath have important physical consequences for the topology of the magnetic field and the reconnection of the geomagnetic and the interplanetary field, for the acceleration processes, and the whole complex of physical phenomena connected with the interaction of the solar wind with the magnetosphere.

In the past few years, especially the measurements on ISEE 1 and 2 brought new information about these processes. Plasma and magnetic field measurements have lead to the first evidence of plasma acceleration, typical for the reconnection processes [1]. Particle measurements have proved these results [2, 3].

The important question of the origin of energetic particles detected in the magnetosheath is in the centre of interest of investigators in the given field. In some papers the existence of a layer just outside the magnetopause [4, 5] consisting of ions [4, 5] or electrons [6, 7] is reported. The question of what portion of magnetospheric particles leaking along the reconnected field line from the mag-
netopause [8] contributes to the whole magnetosheath particles has not been solved definitely. In several works, for instance [9], the source of energetic particles in the magnetosheath is suggested to come from the particles, accelerated in the bow shock region which may under special conditions contribute to the magnetosheath particle population. This agrees with the results of [10] where the close correlation of the energetic ions in the magnetosheath with the direction of the interplanetary magnetic field has been proved. From this point of view measurements of particles together with the magnetic field and plasma are interesting.

II. EXPERIMENT

The apparatus DOK-T placed on the high altitude satellite Prognoz-8 flown into orbit in December 1980 was used in the experiment. The possibility to use the passively cooled silicon detectors for lowering the noise level of the system detector plus preamplifier was investigated. The purpose of the cooling was to make a lower threshold for the registration of the charged particles. In the experiment mentioned the cooling of the detector was to $-70\,°C$. The apparatus included the system of automatic control of the discrimination threshold of the noise level. The discrimi-
nation threshold was set to be equal to 3 FWHM of the generator peak, that was at a room temperature equal to 16 keV (for the electrons the calibrations were made with ^{109}Cd) and during the experiment in space it was lowered to 9 keV.

This detector registered the electrons above 9 keV and protons with $E \geqslant 12$ keV. The geometrical factor of the detector was much higher than that for the channel analysers, which are often used in the energy region mentioned. This enables to register also low energy electron and proton fluxes. The apparatus measured

reliably during the whole active work of Prognoz-8 and available data cover approximately 9 month. A detailed description is presented in [16].

The axis of the detector was oriented perpendicularly to the axis of the satellite rotation, direction towards the Sun. This enabled to measure the angular distribu-
tion of the particles in the plane $(yz)_{GSE}$.

III. OBSERVATIONS

Measurements by the DOK-T apparatus on board Prognoz-8 analysed further the cover on the projection xy in the GSE system the sector of local times from 17 to 11 LT, which enables to follow the particle fluxes in the longitude region of the "foreshock". Fig. 1 gives the projection of several orbits to the xy plane which were observed in the provisional analysis of the fluxes of electrons and protons in the magnetosheath region. Passages were used of the satellite from interplanetary space into the magnetosphere at relatively low latitudes of 22—30°.

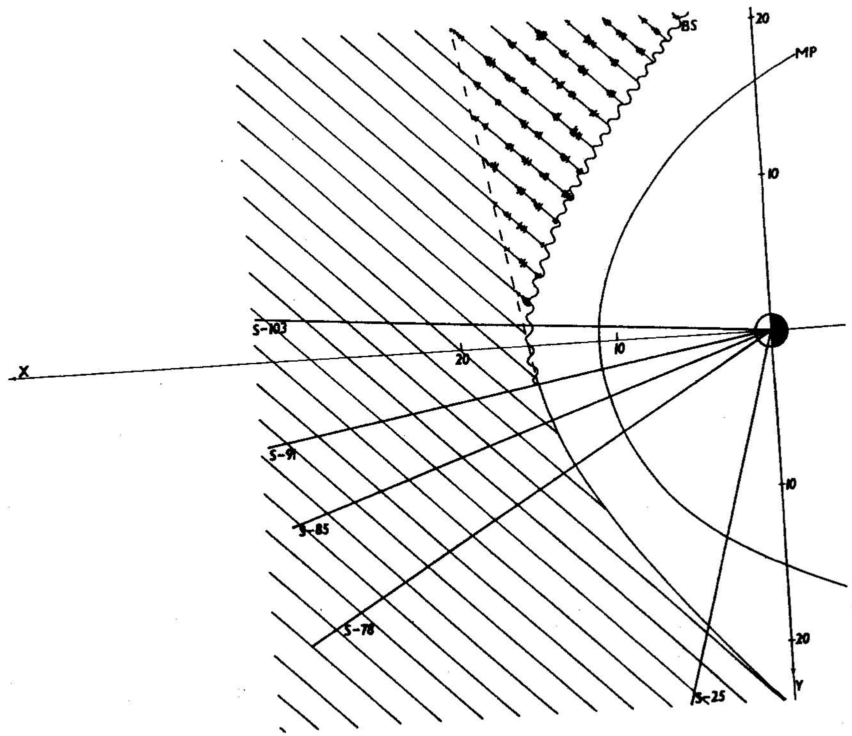

Fig. 1. Projection of the Prognoz-8 trajectory in the $(xy)_{GSE}$ plane for several orbits used in the analysis.

Although there was not made a detailed analysis of the magnetosheath fluxes, the general picture can be characterized by a strong variability not only at the general level (more than a factor of 10^3), but also in the modulations due to the rotation of the detector. The average level of the flux is affected by a contribution of particles from the solar flares and during the time intervals with high geomagnetic activity. These special features do not allow a correct statement of the dependence of the proton and electron fluxes on the longitude during "normal" or "quiet" conditions, but there is a tendency of increase of the average flux of particles from the flank to the front passages. A part of the profile of the counting rate of the detector of the flank orbit on January 13, 1981 is given in Fig. 2. The passage is characteristic with fluctuations of the flux reaching in some cases 10^2 imp/s and a manifestation of the magnetopause passage is evident on the counting rate. The outer part of the magnetosheath up to approximately 1300 MT is not filled with particles and there are only several low level fluctuations presented.

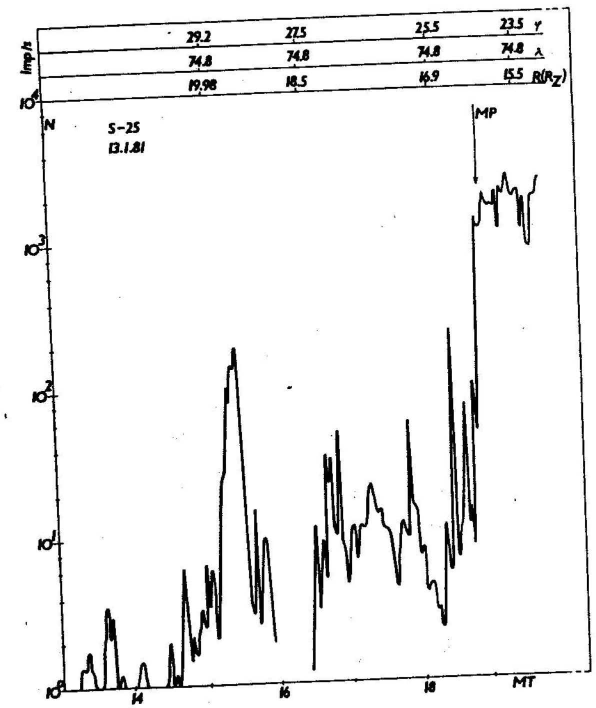

Fig. 2. The profile of the counting rate of the detector (described in the text) for the passage of the satellite through the part of magnetosheath on one of the flank orbits. Passage at the bow shock was at 6.20 MT. The position of the magnetopause is shown.

Because of the availability of only two of three components of B (B_y, B_z) convenient for analysis, there are presented front orbits, where we can suppose in agreement with [11] that B_x is negligibly less than the projection of B onto the yz plane. Fig. 3 shows the profile of the particle flux (2 min averages) (on March 18, 1981) when the satellite passed through the bow shock into the magnetosheath

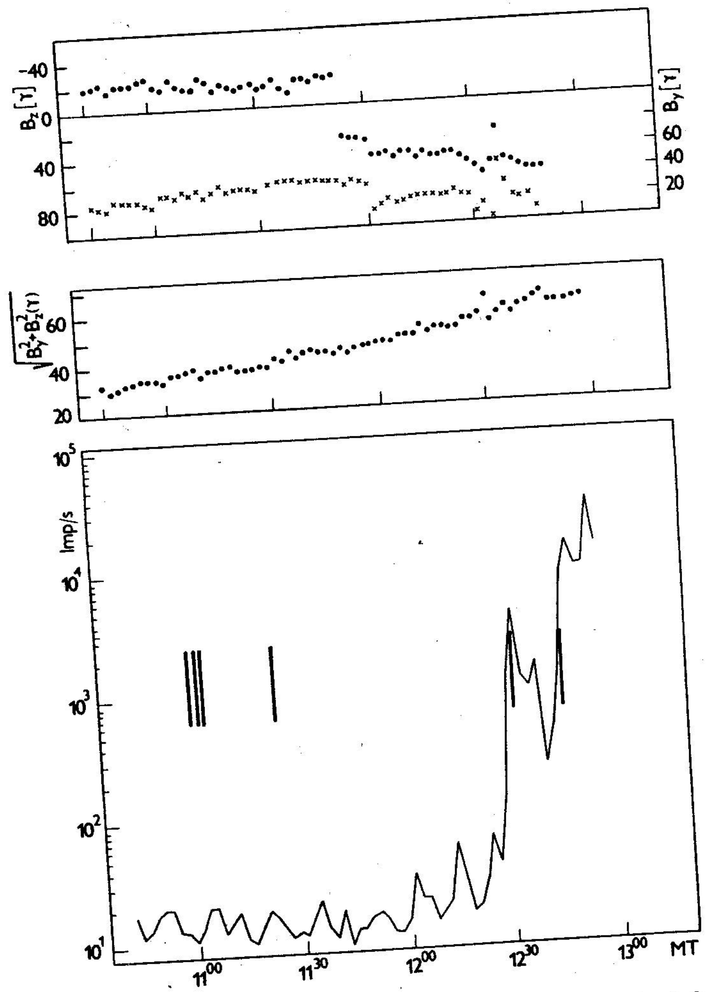

Fig. 3. The profile of the proton flux $E_p \geq 12$ keV in the part of the magnetosheath for seans 78 (see Fig. 1). The values of B_z, B_y and $\sqrt{B_z^2+B_y^2}$ are given also. The passage into the magnetosphere is manifested by the change of the sign of B_z.

near the subsolar point. There are given also the B_y, B_z components and $\sqrt{B_y^2+B_z^2}$. At the given period the interplanetary magnetic field had a negative component B_z. At several intervals of measurement another apparatus placed on board Prognoz-8 called Promics, used for plasma measurements, gave a 10—10^2 times higher flux of protons in comparison with electrons in the energy interval of 8—30 keV. For these clearly "proton" intervals there are shown pitch angle distributions of protons (their projection only on the *zy* plane) in Fig. 4, i.e. the dependences of the flux on the angle between the direction of the detector axis with the projection of **B** onto the *yz* plane.

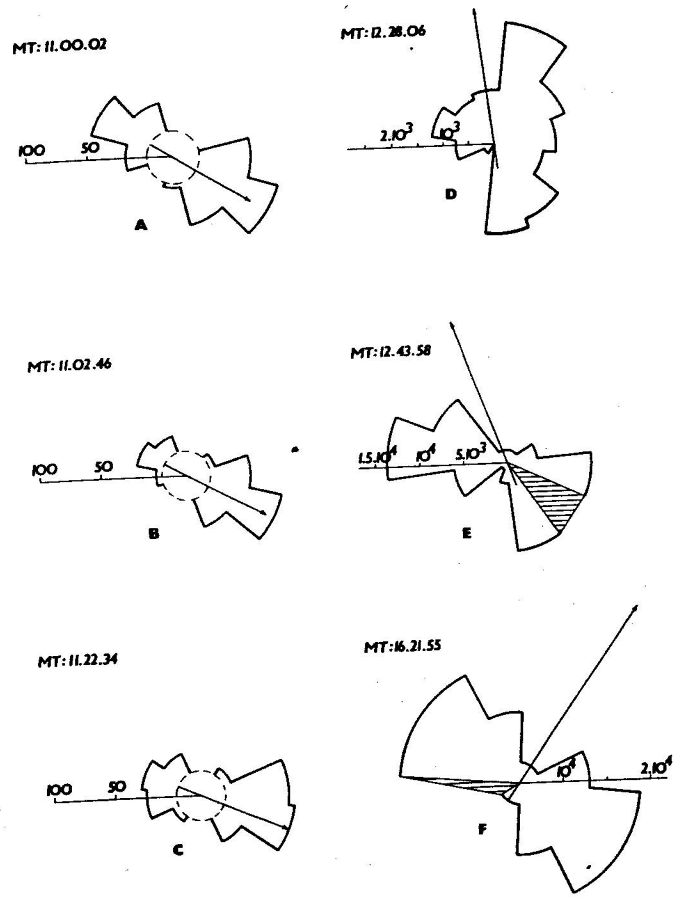

Fig. 4. The projection of the pitch-angle distributions of proton $E_p \geq 12$ keV into the *y*, *z* planes for the moments marked in Fig. 3 are given. The distributions in the left column are for the magnetosheath and the right-hand side gives the passage into the quasitrapping region in the magnetosphere.

In all cases a two-side oppositely streaming structure of the flux is seen predominantly at a narrow angle along **B** with the significant flux also in the opposite direction, while zero fluxes are typical for the angles of 315—45° and 135—225°, respectively with the **B** direction.

The analysis of the whole pitch angle distribution within the whole time interval when the satellite was in the magnetosheath region has proved that such a picture is permanent and characteristic for this near-subsolar point passage. The ratio $J_\downarrow/J_\uparrow$, where the arrow ↓ depicts the flux along **B**, changes from 7:1 to 2:1. Because of that our point of view is that DOK-T registered predominantly in this whole region protons with energies above 12 keV.

After passing the magnetopause (the change of the B_z sign), the particle fluxes increase and their distribution is continually changed into a distribution typical for quasitrapped particles (Fig. 4d, e, f).

IV. DISCUSSION AND CONCLUSION

The pitch angle distribution of protons with energies above 30 keV in the magnetosheath was investigated recently [8, 14]. In the first of the papers it is shown that when the satellite has left the magnetopause, the distribution changes from a quasitrapped to a collimated one along **B**, while in the opposite direction no particles have been registered. On the basis of this fact the authors conclude that magnetospheric particles leak along reconnected field lines into the magnetosheath. In our experiment the analysis is based on the pitch angle distribution in the plane $(yz)_{GSE}$.

Lowering the threshold of registration to 12 keV we can see in the $(yz)_{GSE}$ plane also a predominant direction of particles along **B**, out of the magnetopause to the magnetosheath. But in addition to this there exists also the proton flux antiparallel to **B** from the geomagnetic tail region toward the magnetopause. This contribution is in some cases comparable with the flux along **B**. It is possible to suggest that oppositely streaming proton fluxes can be of a different origin and their spectra are different. For verifying this it is necessary to measure energy spectra in various directions separately. It should be noted that the comparison of distributions of 30 keV and 60 keV protons in the magnetosheath in [8] qualitatively agrees with the situation here. Some particles of 30 keV are streaming towards the magnetopause and this may be connected with the pitch angle scattering within the magnetosheath which affects more efficiently particles of lower energies.

The two-component situation, when particles of higher energies are collimated along **B** in a direction opposite to that of the plasma stream is present in the geomagnetic tail, when acceleration processes in the plasma sheet take place [15].

The distribution of protons in FTE (Flux Transfer Events), characteristic by the change of polarity of $B_x>0$, $B_x<0$ and recovery to $B_x \simeq 0$ [11] have also the form of narrow collimated fluxes along $\boldsymbol{B}$, and at the beginning of particle registration there is a typical slight component of flux antiparallel to $\boldsymbol{B}$ [14]. But such fluxes of protons $E_p>30$ keV, as shown also in [17], are present in the magnetosheath only at separate events. At energies of $E \geqslant 12$ keV the directed fluxes along $\boldsymbol{B}$ and antiparallel ones are detected continuously during long time intervals and are a permanent phenomenon, not typical for only one "layer".

The registration of protons of low energies with the help of Si detectors (with a relatively high geometrical factor) enables to obtain new information on the origin of the charged particles in the magnetosheath, which has not been satisfactorily solved. For a further progress in understanding the measurement here presented it is necessary to obtain a more detailed picture of the 3-dimensional distribution function for electrons and ions with different energies beginning at ~ 10 keV. Such measurements are proposed for the projects Intershock and Interball.

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Received January 4th, 1983