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PRELIMINARY RESULTS OF ION AND ELECTRON COMPONENT MEASUREMENTS OF LARGE SCALE PLASMA CHARACTERISTICS OBSERVED BY PROGNOZ-4 DURING THE MAGNETOSPHERIC DISTURBANCE OF DECEMBER 26, 1975

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PRELIMINARY RESULTS OF ION AND ELECTRON COMPONENT MEASUREMENTS OF LARGE SCALE PLASMA CHARACTERISTICS OBSERVED BY PROGNOZ-4 DURING THE MAGNETOSPHERIC DISTURBANCE OF DECEMBER 26, 1975

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ABSTRACT

Preliminary results on plasma measurements of the Prognoz-4 satellite a few days before the beginning of the IMS period are presented. Electron as well as ion measurements were conducted in various plasma regions of the magnetosphere. In the 0-300 eV energy interval, the first electron spectra from the plasma mantle are given.

АННОТАЦИЯ

Приведены предварительные результаты плазменных измерений со спутника Прогноз-4, зарегистрированных за несколько дней до начала международных исследований магнитосферы. Были измерены спектры электронов и ионов в разных плазменных образованиях. Впервые опубликованы измеренные спектры электронов в энергетическом интервале 0-300 эВ.

KIVONAT

A Prognoz-4 mesterséges hold plazmaméréseinek előzetes eredményeit közöljük, melyeket néhány nappal a Nemzetközi Magnetoszféra Kutatás /IMS/ időszaka előtt regisztráltunk. Elektron és ion spektrumokat mértünk a magnetoszférikus plazma különböző tartományaiban. Elsőnek közöltünk a 0-300 eV energiatartományban mért elektronspektrumokat.

1. INTRODUCTION

The scientific apparatus of the Prognoz-4 satellite /launched on December 22, 1975 into an orbit with the following initial parameters: apogee ≈200000 km, perigee ≈600 km, inclination 65°/ contained two wide angle detectors for the investigation of low energy plasmas. The detector system was practically identical with those onboard the Venera-9 and Venera-10 space probes /Gringauz et al. 1976a/ and only slightly differed from the wide angle detectors of Mars-2, Mars-3 and Mars-5 space vehicles /Gringauz 1976b/ which were described in details by Gringauz et al. /1974/. For the investigation of the plasmasphere there were ion detectors similar to those described in connection with the Prognoz satellite /Bezrukikh et al. 1974/.

Plasma measurements conducted by identical instruments near Mars, Venus and Earth may be very useful for the understanding the various similar and different phenomena near these planets and for investigating the observed differences.

2. EXPERIMENT

On the Prognoz-4 as well as on the space probes of Mars and Venera series, the Faraday cup ion detector was continuously directed toward the Sun while the sensor of the electron retarding potential analyser pointed in the antisolar direction. Differential ion and integral electron spectra were registered in the energy range 0-4.4 keV for ions and 0-300 eV for electrons. A spectrum /16 energy intervals/ was measured in 160 seconds for each type of particles, and the analysis was carried out continuously.

In Table 1., the energy intervals for ions and the electron retarding potentials are presented.

N^o	ions		electrons
	E_{lower} /eV/	E_{upper} eV	E_{ret}/eV/
1	0	40	300
2	40	100	150
3	100	200	80
4	200	350	40
5	350	440	34
6	440	550	28
7	550	690	24
8	690	860	20
9	860	1070	18
10	1070	1330	16
11	1330	1670	14
12	1670	2080	12
13	2080	2600	10
14	2600	3200	8
15	3200	3800	4
16	3800	4400	0

Table 1.

3. DISCUSSION

In this paper the first, preliminary results measured on December 26, 1975 during the rising part of satellite's orbit /from $3R_e$ to $25R_e$ geocentric distances/ are discussed. As one can see from the data shown below, on this day a fast solar wind /bulk velocity 650 km/sec/ effected to the magnetosphere and caused a magnetic storm /K_p=4÷5/ /Solar Goephys. Data/.

In Fig. 1 it is shown that part of the Prognoz-4 trajectory, in solar-ecliptic system of coordinates /X_{SE}, $\sqrt{Y_{SE}^2 + Z_{SE}^2}$/, where the analyzed measurements took place. The large-scale plasma regions are marked along the trajectory as the satellite intersected them. In Fig. 2, ion and electron spectra typical for the various magnetospheric and solar wind plasmas are presented. On the top of the ion spectra the numbers of the energy intervals are marked.

The part of the trajectory analyzed begins inside the plasmasphere. In Fig. 2a one can see typical plasmaspheric ion and electron spectra. The maximal ion current in the 0-40 eV energy interval was detected; the integral electron spectrum shows an anomalous character /the I_e current shows an in-

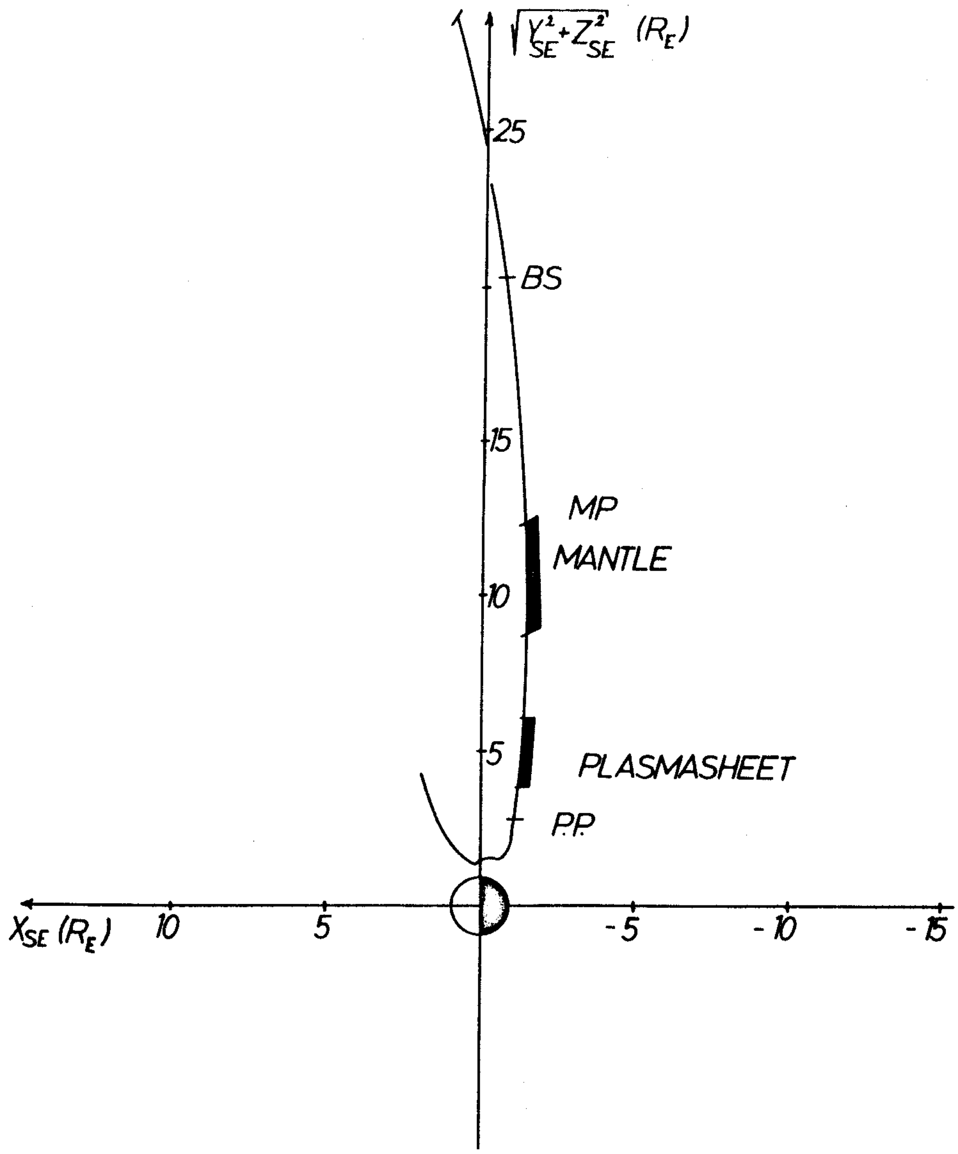

Fig. 1

creasing tendency as the retarding potential grows/. This anomalous phenomenon can be understood as the secondary electron emission from the electrodes and body of the electron sensor caused by plasmaspheric cold ions accelerated by the negative retarding potential of the wide angle electron analyser. The effect /the anomalous electron spectra/ does not occur after the satellite intersects the plasmapause - the electron currents show a decreasing character with growing retarding potential. The sharp increase of electron currents with energy near a few eV is connected with the registration of photoelectrons /Gringauz e al. 1974/.

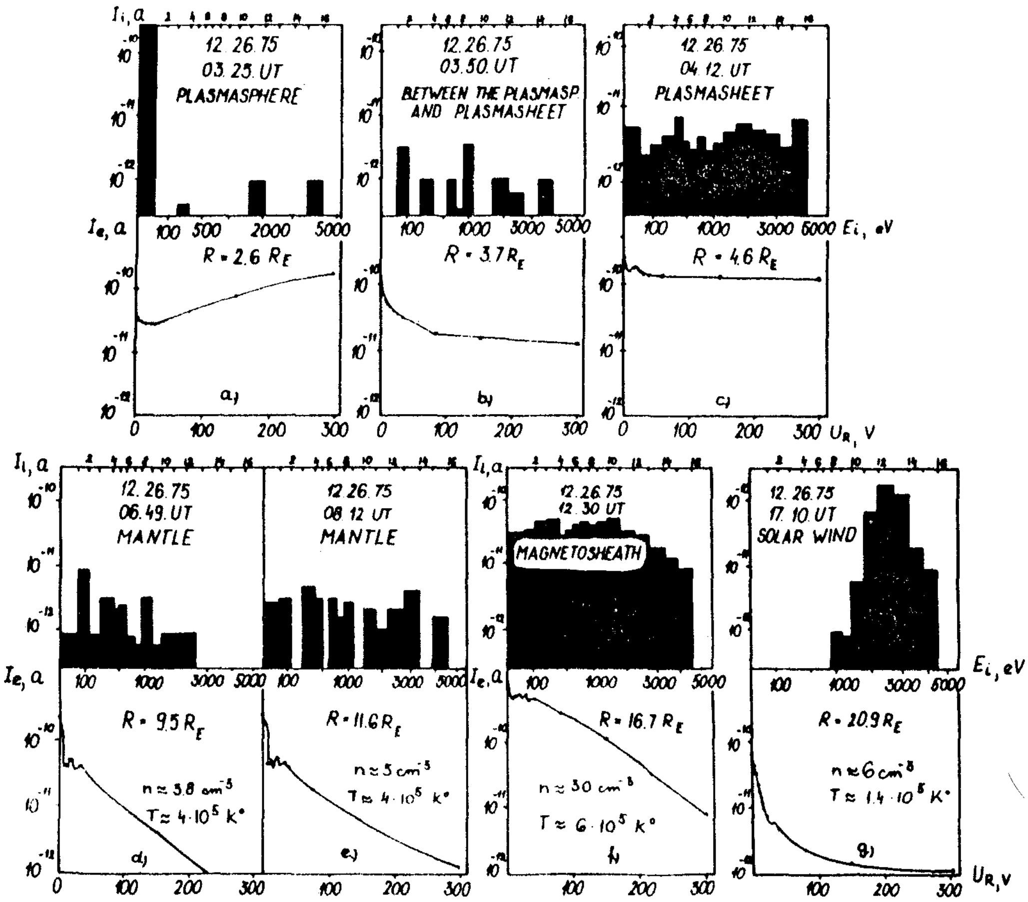

Fig. 2

In Fig. 2b. the ion and electron spectra obtained between the plasmasphere and the plasmasheet are shown. The behaviour of the electron curves shows that there is a finite current of relatively energetic electrons />300 eV/ in this region; the charged particle density derived from ion spectra is 2.5 cm^{-3}. It is worth mentioning that in the cases when the distribution is far from the Maxwellian one /as for instance in Fig. 2b/ the density can be roughly derived from the ion spectra as the sum of densities in all the 16 energy intervals:

$$n \approx \sum_{i=1}^{16} \frac{N_i}{V_i}$$

where N_i /$cm^{-2}sec^{-1}$/ is the current and V_i is the mean velocity of ions in the i-th energy interval. /N_i can be evaluated from the current registered by the detector and the physical parameters of the sensor./ We can calculate the approximate bulk velocity using a method similar to Bezrukikh et al. /1975/:

$$\bar{V} \approx \frac{\sum_{i=1}^{16} N_i}{\sum_{i=1}^{16} \frac{N_i}{V_i}}$$

In Fig. 2c spectra obtained inside the plasmasheet are presented. In all 16 intervals, ion currents with comparatively small fluctuations and large electron currents /even with energy >300 eV/ were observed. In connection with the plasmasheet region marked in Fig. 1., it should be kept in mind that the plasmasheet does not have a cylindrically-symmetric configuration, so our representation is oversimplificated.

Half-hourly samples /and in the regions of rapid variations ten-minute samples/ of the ion density n are shown in the top of Fig. 3, from 0600 to 1730 UT. In the middle of the figure one can see the ion bulk velocity $\bar{V}$, while the lower curve represents the magnetic field strength B.

It is possible to determine the moments of magnetopause and bow shock crossings from Fig. 3. Between 0830 and 0900 UT the density increased sharply but not monotonically, as did the bulk velocity. The maximal value of $\bar{V}$ and minimal value of n were simultaneously observed. During this period the magnetic field decreased by a factor of 2.5 /from $\approx$50 γ to $\approx$20 γ/. These facts suggest the conclusion that we observed the Prognoz-4 intersection of the magnetopause. Probably the fluctuations of plasma parameters during this time interval are connected with the disturbed magnetosphere.

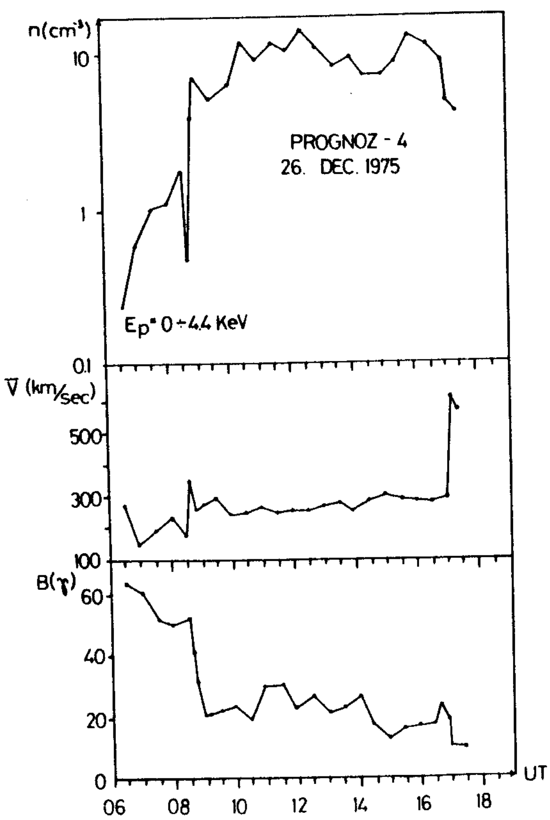

Fig. 3

At 1700 UT a sudden increase of $\bar{V}$ and decrease on n and B was simultaneously registered, due to the intersection of bow shock.

The electron and ion spectra in Fig. 2f correspond to the magnetosheath, in Fig. 2g to the solar wind.

The magnetospheric plasma region near magnetopause - characterized by a gradual decrease of the ion velocity and temperature from the magnetopause to the depth of the magnetosphere - is variously referred to as the "diffuse boundary of magnetosphere" /Intrilligator and Wolfe 1972, Bezrukikh et al. 1975, Akasofu et al. 1973/, or the "plasma mantle" /Scopke et al. 1974, Rosenbauer et al. 1975/. We prefer the expression "plasma mantle" as the most laconic and original one /in contrast to the names of other magnetospheric plasma regions/. In the papers mentioned above the physical properties of the plasma mantle were determined only from the ion and magnetic field characteristics. The data measured by Prognoz-4 give us the first possibility to study the electron component in the mantle. Fig. 2 and Fig. 3 show that the mantle's ion component registered on Prognoz-4 has a similar behaviour to that described in the above-mentioned papers: compared to the magnetosheath, there is a decrease of the ion currents and bulk velocities. To speak of the ion temperature in the mantle is meaningless as the ion's distribution function is far from the Maxwellian. From the electron spectra shown in Fig. 2d, 2e and 2f one can see that the density and temperature of electrons in the mantle are definitely lower than in the magnetosheath near the bow shock. On the other hand, as we go into the deep magnetosphere from the magnetopause, the current and density of electrons decrease as well as the number of energetic electrons />200 eV/.

4. CONCLUDING REMARKS

Samples of plasma measurements conducted onboard the Prognoz-4 setellite a few days before the beginning of the Interantional Magnetospheric Study are presented. On the basis of our preliminary results one can form an opinion of the usefulness of our data obtained during the IMS period. Our data set /including electron as well as ion measurements/ contains more measured components than previous experiments. It is thus possible to investigate the dynamics of all the fundamental plasma regions inside the magnetosphere /plasmasphere, plasmasheet, plasma mantle/ and of the magnetosheath and the solar wind.

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