K. I. Gringauz, Sh. Sh. Dolginov, V. V. Bezrukikh, E. G. Eroshenko,

L. N. Zhuzgov, L. S. Musatov, E. K. Solomatina, U. V. Fastovskii

1964

SovietRxiv

Fig. 1

Figure 1: Fig. 1

Abstract

Full Text

Geophysics

K. I. Gringauz, Sh. Sh. Dolginov, V. V. Bezrukikh, E. G. Eroshenko, L. N. Zhuzgov, L. S. Musatov, E. K. Solomatina, U. V. Fastovskii

Observations by Means of the Elektron-2 Satellite of the Relationship Between Changes in the Magnetic Field and Fluxes of Positive Ions Inside the Earth' s Magnetosphere

(Presented by Academician A. L. Mints, 25 IX 1964)

The Elektron-2 satellite was placed on 30 I 1964 into an orbit with an apogee of $\sim 11.6R_{\mathrm{E}}$ (from the center of the Earth) at an angle of 61° to the equatorial plane. In the initial period of the satellite' s existence, the line connecting the apogee and perigee of its orbit made an angle of $\sim 80^{\circ}$ with the Earth–Sun direction, while the angle between the Earth–Sun direction and the plane of the satellite orbit was $\sim 20^{\circ}$ (Fig. 1).

The scientific apparatus installed on the Elektron-2 satellite included, along with other instruments, a charged-particle trap and magnetometers. The three-electrode trap was similar to the charged-particle traps installed since 1959 on Soviet space rockets ([1]); the potential of its outer grid was equal to the potential of the satellite body. In this connection the trap could register positive ions of all energies exceeding the potential of the satellite relative to the surrounding medium, which produced a positive current in the collector circuit of the trap, and fluxes of electrons with energies above 100 eV (above the potential of the inner grid), which produced negative currents in the same circuit. In addition, the trap registered photoelectrons from the inner grid, also in the form of negative currents in the collector circuit. Thus, if the total current in the collector circuit was positive, this unambiguously corresponded to the registration of fluxes of positive ions.

Fig. 1

The magnetometer whose readings are used in the present publication was a three-component instrument with orthogonal ferrozond sensors, with a measurement range of $\pm 120\gamma$ ($1\gamma = 10^{-5}$ oersted) for each component. The sensitivity

Fig. 2

Figure 2: Fig. 2

Fig. 3

Figure 3: Fig. 3

threshold of the magnetometer for each component was 2γ. Owing to the rotation of the container, it was possible ([2]) to determine and control the correction to the absolute zero of the field with an accuracy of up to 3γ. The constancy of the sensitivity of the apparatus was checked by monthly calibration of the magnetometer channels in flight.

In the present communication, some preliminary results are given from a comparison of data from a number of measurements made by means of the charged-particle trap and the magnetometer on Elektron-2, corresponding to the initial period of the satellite flight, as well as K_p-indices characterizing the disturbance of the geomagnetic field according to data from simultaneous measurements at ground magnetic observatories. This comparison indicates–

indicates the existence of a correlation between changes in magnetic activity at the Earth' s surface and changes in the intensity of the geomagnetic field and of positive-ion fluxes at large distances from the Earth inside its magnetosphere.

Fig. 2

Fig. 3

This conclusion is illustrated by data obtained on magnetically quiet days (30-31 I; Fig. 2), on magnetically disturbed days (31 I–1 II; Fig. 3), and during the period when a transition occurred from a magnetically quiet state to a magnetically disturbed state (11–12 II; Fig. 4), at distances

6-11.6 R_{E} during recession from and approach to the Earth. The geographic latitudes corresponding to the projections onto the Earth of these sections of the orbit lie within the range from 24° S to 60° S. The range of longitude variations on the orbit sections under consideration is $\sim 160°$.

Fig. 4

Consideration of the results presented in Figs. 2-4 (the time everywhere is Greenwich Mean Time, GMT) shows the following.

On the magnetically quiet days 30-31 January (K_p did not exceed 3), predominantly negative currents were recorded (with a very small number of positive values), corresponding to small values of the fluxes of positive ions. At the same time, the magnetometer recorded a field sufficiently regular in magnitude, exceeding the theoretical value by an amount $\Delta T \sim 20\gamma$, varying little over the entire section of the orbit considered. In the apogee region ΔT is about

40% of the calculated field, determined as the field of an eccentric dipole. We note that the magnetograms presented indicate that the orbit of Elektron-2 is located entirely inside the magnetosphere.

On a magnetically disturbed day (K_p from 3 to 5), only positive currents in the collector circuit of the trap were recorded on the section of the orbit considered, reaching values of $4 \cdot 10^{-10}$ A. Such currents may be caused by ion fluxes exceeding $2 \cdot 10^8$ cm^{-2}s^{-1} (which, in order of magnitude, corresponds to fluxes of solar plasma outside the magnetosphere [3-6]).

The magnetometer recorded a field with $\Delta T \sim 40\gamma$, which in the apogee region amounts to 100% of the calculated field. The significant field fluctuations observed in this case correlate with the observed variations of the geomagnetic field on the Earth.

The beginning of the day 12 February was characterized by low magnetic activity (K_p = 1-2). At 6^h05^m all ground observatories noted a disturbance with a sudden onset. The magnetic-activity index increased to 3 and reached 4 by 9^h. At 6^h the satellite reached apogee. The magnetometer, which at the beginning of the day recorded a value of ΔT characteristic of quiet days, recorded, around 6^h, a fairly rapid increase of the field; subsequently the value of ΔT reached the value characteristic of a disturbed period.

The collector currents of the traps up to $t = 03^h$ were predominantly negative, which is characteristic of a magnetically quiet period. Beginning approximately from

at 03h the number of recorded positive current values began to increase, which indicates an increase in the fluxes of positive ions. During the period $t = 9^h \div 11^h$, when $K_p = 4$, mainly positive currents were recorded, corresponding to ion fluxes of the order of 10^8 cm^{-2}s^{-1}, which is characteristic of a magnetically disturbed period.

It should be noted that on 12 II the increase in the fluxes of positive ions preceded the increase in the magnetic field by approximately 3 hours, whereas the increase in the magnetic field near the satellite and on Earth began, to a first approximation, simultaneously—at any rate with very small intervals—and occurred at a significantly higher rate than the transition of the trap from a state with negative collector currents to a state with positive collector currents. At the same time it must be noted that on some days no correlation was observed between the fluxes of positive ions, on the one hand, and the quantities ΔT and K_p, discussed above, on the other. Thus, from the data obtained on 19 II and 1 III, it is seen that enhanced fluxes of positive ions occurred at low values of ΔT and K_p. However, each of these cases was preceded by a day with elevated ΔT and K_p.

In a number of observations previously carried out with magnetometers on space rockets and satellites ([7–8] and others), a correlation was established between the variability of the magnetic field in space and indices of magnetic activity at the

Earth' s surface. In experiments involving direct measurements of solar-plasma fluxes outside the geomagnetic field, a correlation was noted between the intensity and velocity of the particles in these fluxes and geomagnetic disturbances on Earth ([3,4,6]). Fluxes of positive ions were observed in the outer radiation belt ([9,10]) and beyond the boundary of the magnetosphere ([11]) on the American satellite Explorer 12, launched in August 1961 into an orbit inclined to the equator at an angle of 330°, with apogee $\sim 13R_E$ in the direction of the Sun.

Unlike the observations on Explorer 12 mentioned above, the observations of positive-ion fluxes described in the present communication pertain to a region lying beyond the outer radiation belt but within the magnetosphere, although the satellite' s distances from the Earth in both cases are approximately the same. (This is associated with the different inclinations to the equator of the orbits of the two satellites.) As far as we know, similar measurements in the indicated region were first made on Electron-2.

It remains unclear whether the fluxes observed by means of the charged-particle trap on Electron-2 are produced by the solar wind penetrating deep into the magnetosphere, or whether they are formed from particles of near-Earth plasma accelerated by some as yet unstudied mechanism. It may be expected that new information contributing to the clarification of these phenomena will be obtained after final processing of the measurement results from other instruments installed on the Electron-2 and Electron-4 satellites.

The phenomena described in the present communication apparently pertain to essential details of the mechanism by which geomagnetic disturbances arise.

Received
15 IX 1964

CITED LITERATURE

[1] K. I. Gringauz, V. V. Bezrukikh et al., DAN, 131, 1301 (1960). [2] Sh. Sh. Dolginov, E. G. Eroshenko, L. N. Zhuzgov, N. V. Pushkov, *Artificial Earth Satellites*, vol. 5, Publishing House of the USSR Academy of Sciences, 1960. [3] K. I. Gringauz, *Space Research*, II, 539, Amsterdam, 1961. [4] K. I. Gringauz, V. V. Bezrukikh et al., *Space Research*, III, Amsterdam, 1962. [5] A. Bonetti, H. S. Bridge et al., *Space Research*, III, Amsterdam, 1962. [6] M. Neigebauer, C. W. Snyder, *Space Research*, IV, Amsterdam, 1963. [7] M. G. Mikhailovich, A. D. Shevnin, DAN, 135, 298 (1960). [8] C. W. Greenstadt, *Nature*, 191, 329 (1961). [9] L. R. Davis, J. M. Williamson, *Space Res.*, III, 1963. [10] M. Bader, *J. Geophys. Res.*, 67, 13, 5007 (1962). [11] A. Hoffman, L. R. Davis, J. W. Williamson, *J. Geophys. Res.*, 67, 13, 5001 (1962).

Note: Figure translations are in progress. See original paper for figures.