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RADIAL DIFFUSION OF ELECTRONS WITH ENERGY GREATER THAN 100 KEV IN THE OUTER RADIATION BELT

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SUMMARY

The study carried out in 1964 on time variations of electrons with energies $E_e > 100$ kev in the outer radiation zone shows that variations in electron intensity on the drift shells close to the Earth are systematically lagging relative to variations in electrons on shells with high values of L. This retardation is due to the diffusion of electrons with $E_e > 100$ kev across the drift shells. The "retardation" time Δt between the variations in electron intensity on various L-shells was determined by the statistical method and for L = 50 and L = 40 was $\sim 5 \pm 1$ days. Under specific assumptions this results in a drift velocity $\overline{V} \sim 0.2$ Earth's radii per day for $L \sim 4.4$. In the $40 < L < 0.5$ range, the time and the drift velocity of electrons measured by means of direct observation of the systematic displacement of the leading "wave" front of electrons with $E_e > 100$ kev and > 400 kev coincide within error limits with the results obtained by the correlation method. The diffusion velocity of electrons does not depend on the geomagnetic latitude.

* * *

Time variations in energetic electron intensity in the outer belt were observed both during magnetic disturbances and in magnetoquiet periods ($\Sigma K_p \leqslant 15$). Certain trends in the behavior of electron groups with different energies are revealed in [1-7]. However, no unambiguous connection between the variations in the belt and in the Earth's magnetic field has been ascertained as yet. On the basis of measurements carried out on satellites "EXPLORER-15" and "EXPLORER-26", McIlwain [8] assumed that the intensity variations of electrons with $E_e \geqslant 500$ kev in the outer belt are determined by at least five processes. One of these processes, namely the reversible adiabatic betatron acceleration or deceleration of particles during D_{st}-variations in the geomagnetic field, is investigated in detail in [8]. The other four processes are nonadiabatic and are easily discernable on the basis of characteristic times of action on electrons of the outer belt. Rapid nondiabatic increases and decreases of particle intensity occur during a time of the order of several hours. The exponential drop in electron intensity in the outer belt has a time constant of 16 ± 2 days on L = 3.6-3.8. For the fifth process, namely the radial electron diffusion, the dependence of drift time on parameter L is characteristic.

A theoretical investigation of particle transport across magnetic shells is made in [9-11] under the assumption that the two first adiabatic invariants are preserved. The cause of the transport is the drift of particles in nonstationary electric fields generated during assymetrical geomagnetic disturbances relative to longitude. The type of geomagnetic disturbance inducing particle transport has not been established with precision. Thus, Parker [9] shows that SC-type-magnetic storm disturbances could be the cause of the drift. B.A. Tverskoy [10] considers that proton and electron transfer is most effective under the action of sudden geomagnetic field impulses. In all these works solar wind is assumed to be the source of the particles. The distribution of protons in the magnetosphere is well explained by the diffusion theory. However, a description of the outer electron belt requires some additional conditions both with respect to the electron source at the magnetosphere boundary and for explaining the slot between the outer and the inner belt. From theory [10] it follows that the dependence of particle drift velocity on L is $v \sim L^9$. This agrees with the experiment but the experimentally determined velocity is several times higher. Experimental data on high-energy electron diffusion in the $3.4 < L < 5.0$ range were obtained for the first time in 1962-1963 on "EXPLORER-14" [2,3]. Similar results can be obtained for electrons with $E_e > 5$ Mev [8]. In these cases observations of a shift of the leading wave front were found to be possible, as during the passage of the leading wave front, the intensity electrons on a fixed L-shell is 50-100 times higher than in the wave's absence.

Let us note that an undistorted propagation pattern of electrons' diffusion wave was observed in [3] only in cases when a quiet period of 2-3 weeks duration followed a strong magnetic disturbance in the Earth's magnetic field ($\Sigma K_p \lessdot 15$). As numerous experiments have shown, the intensity of electrons with $E_e > 100$ kev does not correlate with the K_p-index and varies by no more than one order. Such intensity variations are comparable to variations due to the exponential decay and adiabatic acceleration or deceleration of electrons which hinders a direct observation of the diffusion "waves". However, it is possible to obtain data on particle diffusion by making use of the correlation method. At the same time electron intensity $N_k(t)$ measured on a k-th L-shell at the moment of time t is comparable to the intensity $N_i(t + \Delta t)$ obtained on the i-th L-shell $(k > i)$ at the moment of time $t + \Delta t$. Then the correlation coefficient r_{ik} between N_k and N_i is calculated for various time shifts Δt relative to t. This method was applied in processing the results of measurement by the "ELEKTRON" satellites.

EXPERIMENTAL PROCEDURE. Instrumentation. This article presents the results obtained on "ELEKTRON" satellites in 1964:

"ELEKTRON-2" from 31 Jan. to 1 May,
"ELEKTRON-3" from 1 July to 17 September
"ELEKTRON-4" from 11 July to 11 October

Satellite orbit parameters, methods of obtaining information and the characteristics of radiation detectors are described in [4,12]. The readings mainly utilized were those of detectors VF-1 ("ELEKTRON=3") and VS-1 ("ELEKTRON-2", "ELEKTRON-3", "ELEKTRON-4"). The VF-1 device is constituted of a NaI(Tl) crystal of 4.7 cm^2 area shielded by 1 g/cm^2 Al. The energy liberation events registered in the crystal were > 300 kev. The VS-1 device is an STS-5 gas-discharge counter shielded by 2.3g/cm^2 Al. Analysis of the experimental data shows that in the region of the outer radiation belt both detectors register only electron bremsstrahlung. Electrons with $E_e \sim$ 100-250 kev are the main contributors to the VS-1 count and electrons with $E_e \sim$ 400-800 kev to the VF-1 count. Reading variations of VS-1 and VF-1 counters in the same regions of the L-space are variations in the intensity of electrons with energies of 100-250 kev and above 400 kev. Using the ratio N(VF-1)/N(VC-1), counting rates of these devices on "ELEKTRON-3" make it possible to obtain data on the spectrum of electrons with E_e > 100 kev.

Data Normalization. All the data were plotted in L-, V-coordinates. When analyzing the data of satellite "ELEKTRON-3", we utilized the results obtained by it in identical flights through the outer belt. Then, the variations in detector counting rate on fixed L-shells were investigated. To eliminate variations due to the spatial electron distribution, all detector readings were reduced to the minimum latitude Φ_{min} at which the satellite crossed the assigned drift shell according to the relation:

$$N(\Phi_{min}) / N(\Phi) = [B(\Phi) / B(\Phi_{min})]^x, \quad (1)$$

where x is the altitude effect as a function of L. According to the data of numerous experiments, including those carried out on the "ELEKTRON" satellites [4], relation (1) is applicable in

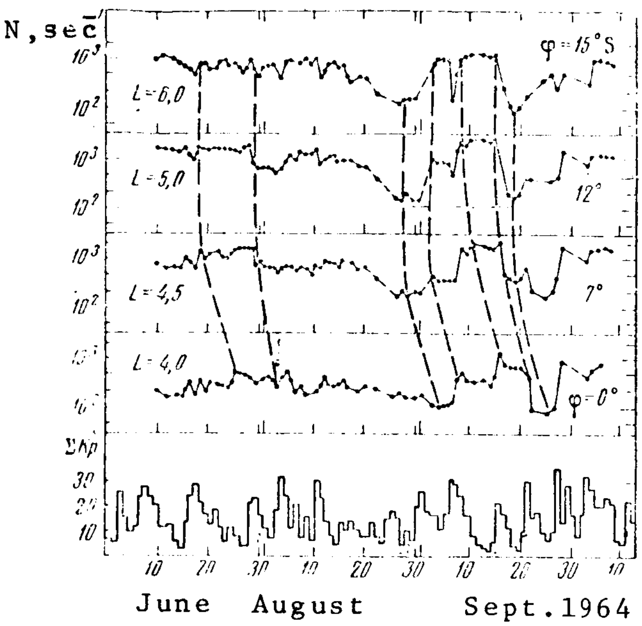

Fig.I

the 0° < Φ < 50° latitude range with the exception of short time intervals following the nonadiabatic disturbances in the belt. The quantities x used in scaling the intensities represent the mean values of the index of the instanteneous altitude effect of electrons with E_e > 100 kev. The instantenous altitude effect was obtained in more than 30 cases on the basis of simultaneous measurements of the counting rates of VS-1 devices on "ELEKTRON-3" and "ELEKTRON-4" satellites which intersected the same L-shell at substantially different latitudes ($\Delta\Phi \sim 30$-$40°$). The quantities x on the investigated L-shells, as well as the latitude ranges in which use was made of satellites "ELEKTRON-2" and "ELEKTRON-4" data for studying electron variations, are shown in Table I. It follows from the latter that the maximum correction value does not exceed 70%, owing to which the reduction of the data to Φ_{min} does not essentially distort the nature of temporal intensity dependence.

Precision of Measurements. Under the conditions of the experiment, satellites "ELEKTRON-2" and "ELEKTRON-3" covered $\Delta L \sim 0.1$ in a two-minute averaging cycle and $\Delta L \sim 0.4$ in an 8 minute one. During the averaging cycle time "ELEKTRON-3" covered $\Delta L \sim 0.2$. With a two-minute averaging on "ELEKTRON-2" and "ELEKTRON-4", the intensity on the adjacent cycles differred by 10% and with an eight-minute averaging by 40%. On "ELEKTRON-3" the intensity on the adjacent cycles differred by 20%.

TABLE I.

L	Φ°_{min}	$B_{min}\cdot 10^{-3}$	Φ°_{max}	$B_{max}\cdot 10^{-3}$	B_{max}/B_{min}	x	$(B_{max}/B_{min})^x$
4,0	0	5,0	20	9,5	1,9	0,3	1,25
4,5	7	3,8	25	8,0	2,1	0,4	1,30
5,0	12	3,0	28	6,5	2,2	0,4	1,37
6,0	15	2,0	30	5,0	2,5	0,6	1,7

OBSERVATION OF TEMPORAL INTENSITY VARIATIONS OF ENERGETIC ELECTRONS IN THE OUTER BELT. Fig. I shows the temporal intensity variations of electrons registered by the VS-1 on L = 4.0; 4.5; 5.0;

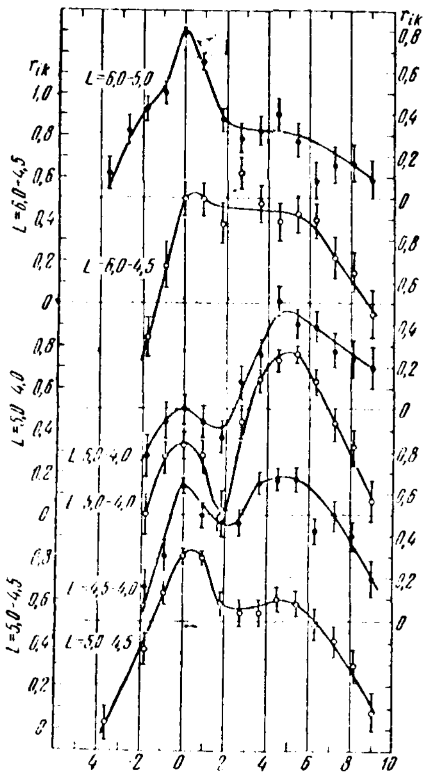

Fig. 2

6.0 according to data of "ELEKTRON-4". It follows from Fig.1, that the relationship between the intensity of electrons with $E_e > 100$ kev and the K_p-index is not evident. The temporal intensity dependences differ by their nature on each L. It may be seen that in the majority of cases measurements of the intensity of electrons with $E_e > 100$ kev on the investigated L-shells do not take place simultaneously whereupon the variations on L = 4.0 lag relative to the variations on L = 6.0 - 5.0.

The most typical intensity variations in electrons with $E_e > 100$ kev, shifted in time on various L-shells, are marked in Fig. 1 with dashed lines. The correlation method was applied in order to make more precise the temporal relationship between the variations in electrons with $E_e > 100$ kev in the various regions of the outer belt. Correlation coefficients r_{ik} between the counting rates of the VS-1 device, were computed for each $L_i = i$ and $L_k = k$ pair of L-shells for various time shifts Δt. The dependence of r_{ik} on Δt is shown in Fig.2. It can be seen that the r_{ik} value maximum is reached on the majority of curves for a specific value of Δt dependent on L_i and L_k (Table 2).

To verify whether or not the peaks on the curve of r_{ik} dependence Δt are a consequence of periodicity of electron variation in the outer belt, we have investigated the dependence of the autocorrelation coefficient r_{ii} on Δt.. The data of the analysis for L = 4,5,6 are plotted in Fig. 3. It may be seen that the variations of electron on L-shells have no definite period.

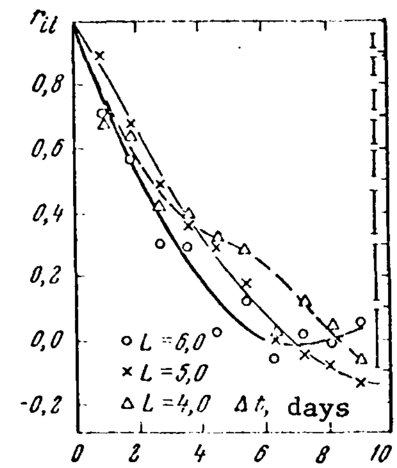

Fig. 3

Therefore, conclusion can be derived from Fig. 2 and Table 2 that the intensity variations of electrons with $E_e > 100$ kev on L = 4.0 lag by ∿ 5 days relative to variations in electron intensity on the outer L-shells. This systematic lag can be explained by the drift of electrons across the L-shells. According to Frank [3] the dependence of drift velocity of electrons with $E_e > 1.6$ Mev on parameter L can be represented as:

$$v = aL^9. \quad (2)$$

TABLE 2

$L_k - L_i$	6,0 – 5,0	6,0 – 4,5	6,0 – 4,5	5,0 – 4,5	5,0 – 4,5	5,0 – 4,0	5,0 – 4,0	4,5 – 4,0	4,5 – 4,0	6,0 – 4,0
r_{ik}	0,80	0,50	0,50	0,80	0,80	0,31	0,77	0,63	0,67	0,50
Δt, Days	0	0	1	0	1	0	5	0	4	5
a, R_3/days			$7{,}1 \cdot 10^{-7}$		$4{,}7 \cdot 10^{-7}$		$3{,}3 \cdot 10^{-7}$		$3{,}3 \cdot 10^{-7}$	$1{,}0 \cdot 10^{-7}$

It is shown in [10] that for $E_e > 100$ kev the drift velocity of electrons does not depend on energy. Consequently, expression (2) can be applied also to electrons registered in the outer belt by the VS-1 detector. The coefficient a can be calculated on the basis of the data in Fig.2 by means of formula (2). The values of this coefficient are compiled in Table 2, from which it results that the values of a obtained from the comparison of electron intensity variations on L = 6.0-4.0, 5.0-4.0, 4.5-4.0, are equal within the error limits. This confirms the assumption that the lag of variations on L = 4.0 is due to electron diffusion in this region of the outer belt. The maxima of correlation coefficient r_{ik} at $\Delta t = 0$ in the $4.5 < L < 6.0$ range show that the simultaneous variations are the most essential for this region of the outer belt.

A sharp increase of electron drift velocity in the $4.5 < L < 6.0$ range can be understood if one considers that a simultaneous electron acceleration up to energies of the order of several hundred kev takes place in this region of the outer belt. On the basis of the data of Fig.2 it may be assumed that instantaneous acceleration can act up to a certain drift shell comprised in the $4.5 < L < 5.0$ range. A diffusion wave, whose velocity is determined by expression (2), propagates from this L-shell toward the Earth. This instanteneous acceleration mechanism is not yet clarified. It should be noted that the decrease in the drift velocity of electrons with $E_e < 100$ kev results in some peculiarities in the nature of the correlation curves shown in Fig.2. Thus, electrons with $E_e < 100$ kev ($E_e \sim 30$-50 kev) are registered on L = 6.0 with low effectiveness and their drift time up to L = 4 is considerably longer than 5 days. On L = 4.0 the energy of these electrons will exceed 100 kev and the effectiveness of their registration will sharply increase with the resulting spreading of the r_{ik} maximum toward the side of high Δt.

Therefore, it becomes possible to explain the disruption in the monotony of the drop after the maximum has been reached and the presence of "protrusions" on the curves for the correlation coefficient r_{ik} by comparing the intensities of electrons on drift shells with L = 6.0-5.0, 6.0-4.5, 6.0-4.0, 5.0-4.5 etc.

<u>VARIATIONS OF ELECTRONS WITH $E_e > 100$ KEV AT HIGH GEOMAGNETIC LATITUDES.</u> Intensity variations of electrons with $E_e > 100$ kev

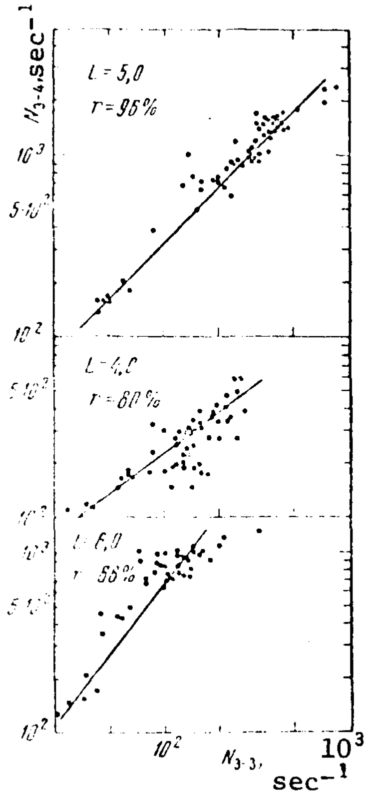

Fig.4

and > 400 kev were investigated in the 45 - 55° geomagnetic latitude region with the aid of satellite "ELEKTRON-3". Analysis of VS-1 data shows that at latitudes 45 - 55° and in the vicinity of the equator the nature of intensity variation of electrons with E_e > 100 kev is essentially the same.. Fig.4 shows the connection between the counting rates of detector VS-1 on satellites "ELEKTRON-3" a d "ELEKTRON-4" with an accuracy of up to 3 hrs for the same instant of time. Electron intensity variations on L = 6.0; 5.0 and 4.0 were investigated and the correlation coefficient was calculated between the counting rates of the device on the upper and the lower satellite. Calculations show that the correlation coefficient is 0.88 on L = 6.0, 0.96 on L = 5.0, and 0.88 on L =4.0 The high values of the coefficient r and the obliquity of the regression line, which is close to 45°, make it possible to consider that in the region of high geomagnetic latitudes intensity variations in electrons with E_e > 100 kev are due to electron diffusion across magnetic shells and to instantaneous acceleration. Apparently, some degree of decrease in r on L = 6.0 and 4.0 is connected with the variation in particle angular distribution with latitude during various geomagnetic disturbances.

DIRECT OBSERVATION OF DIFFUSION WAVES. During measurements on satellite "ELEKTRON-3" several cases of formation and propagation of a diffusion wave of electrons with E_e > 100 kev were detected. Two such cases are shown in Fig.5 and 6. Fig.5 a and b show the successive intensity profiles of electrons with E_e > 100 kev (VS-1 device) and > 400 kev (VF-1-device) in the outer belt from August 4-11, 1964. For August 4 the electron intensity profiles correspond to unperturbed state of the belt. A magnetic storm with sudden commencement was registered from August 4 to 6. During the magnetic storm a substantial decrease in electron intensity occurred in the belt as may be seen by the curves of Fig.4 for August 5-6. Fig.4 shows that the strongest variations took place for electrons with E_e > 400 kev. Thus, intensity decrease in electrons with E_e > 400 kev was detected up to L $\sim$ 3.3, and for electrons with E_e > 100 kev to L $\sim$ 4.5, whereupon, on August 5 electrons with E_e > 400 kev were generally absent on L $\sim$ 5.0. On August 6, they appeared in the L $\sim$ 4.8 region and by August 7 a second intensity maximum of electrons with E_e > 400 kev was formed in the vicinity of L $\sim$ 5.0. For electrons with E_e > 400 kev the double-humped belt

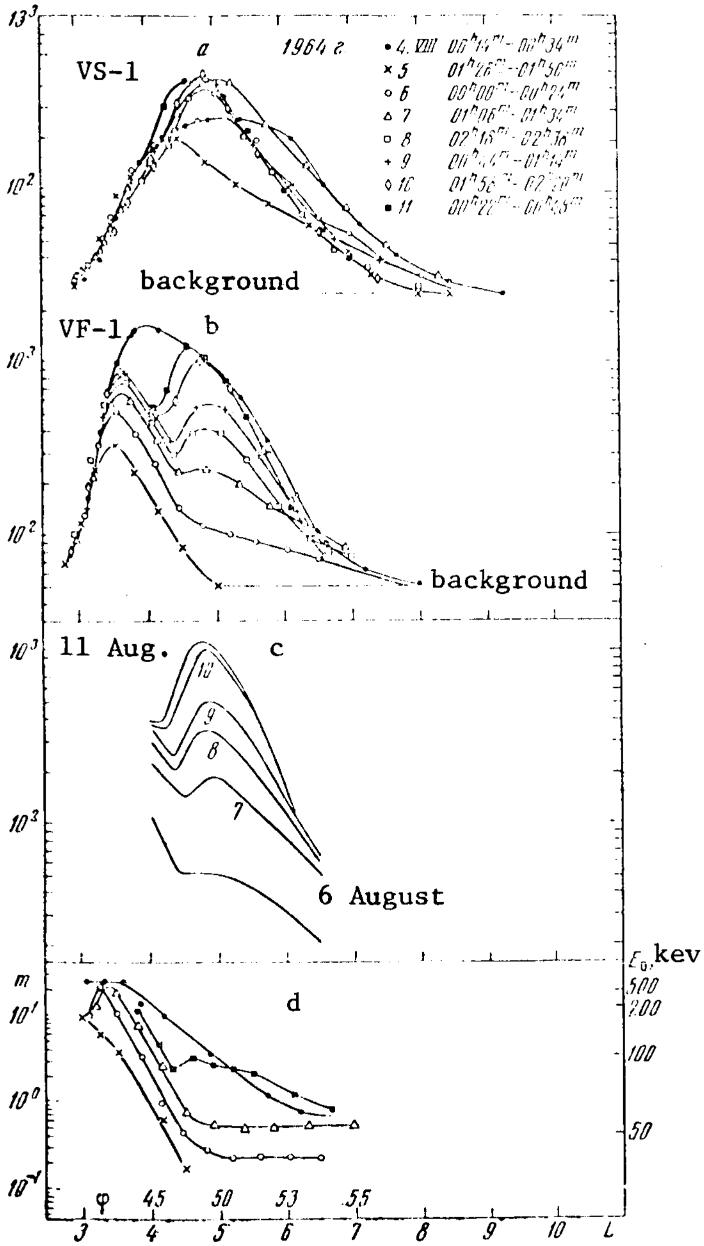

Fig.5

shape was observed up to August 11 when a recurrent disturbance took place in the geomagnetic field.

Let us note that from August 6 to 11 the intensity maximum of electrons with E_e > 100 kev was also located on L ∿ 5.0 and that the intensity of these electrons on L ∿ 5.0 was constant with the exception of August 6-7. The intensity of electrons with E_e > 400 kev in the region of the second maximum increased from August 6 to 11. The ratio of counting rates of VF-1 and VS-1 devices is

$$m = \frac{N(VF-1) - 50}{N(VS-1) - 25}$$

where 50 sec^{-1} and 25 sec^{-1} are the background counting rates respectively for VF-1 and VS-1; it allows a rough estimate of the spectrum of electrons with E_e > 100 kev in the outer belt. The value of m for the investigated period is shown in Fig.5. It can be seen that on August 5 the electron spectrum was softer than prior to the magnetic storm; it became harder with time, approaching the electron spectrum of the undisturbed belt. On August 6 the electron spectrum was identical in the L ⩾ 4.8 region, which corresponds to the simultaneous appearance of electrons with E_e > 400 kev in all this region.

Fig.5b shows that during the investigated period the inner edge of the second maximum of electrons with E_e > 400 kev, as well as the dip between the first and the second maximum, shifted toward the side of the smaller L. This is more clearly noticeable in Fig.5c which shows the dynamics of the maximum of additional

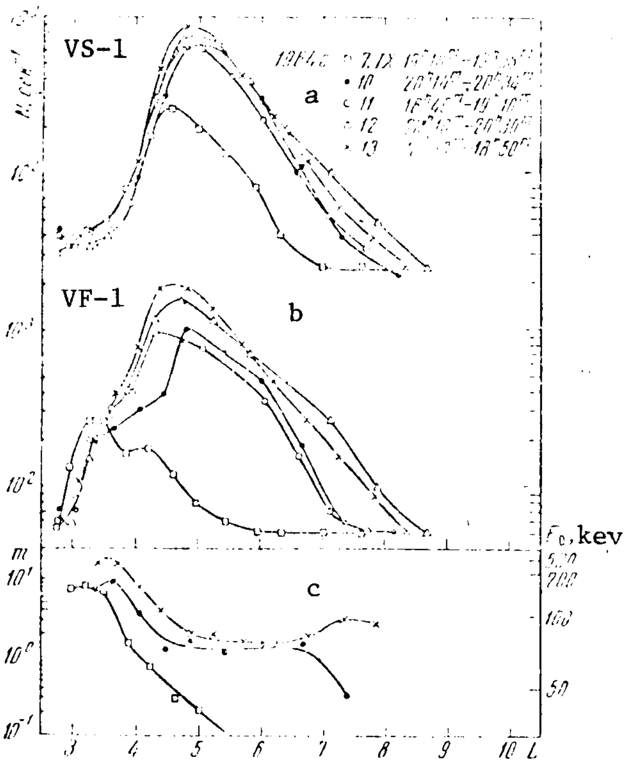

Fig. 6

electrons, having made their appearance on August 6. The curves of Fig.5c were obtained by subtracting the intensity of electrons with E_e > 400 kev registered on August 5 from the data of the following days. It can be seen that the position of the maximum of additional electrons varied by $\Delta L \sim 0.2$,, while the inner edge and the gap were displaced by $\Delta L \sim 0.4$. This inward motion can be connected with electron diffusion from L = 4.7-4.8 toward the Earth. As may be seen from Fig.5b,c, the twisting of the leading electron "wave" front confirms a decrease in particle diffusion velocity with decrease of L. Fig.5a shows that the inner edge of the profile of electrons with E_e > 100 kev was displaced from August 7 to 11 by $\Delta L \sim 0.35$. These data are not in contradiction with the results of the statistical analysis.

Another case of electron diffusion wave propagation was registered from August 7 to 13. Fig.6b,a shows the successive profiles of the counting rate of VF-1 and VS-1 devices for the investigated period. The measurements show that as a consequence of the magnetic storm of August 7, the intensity of electrons with E_e > 400 kev on L $\sim$ 3.5 was by two orders lower than before the storm. Decrease in intensity by a factor of 5-10 was also detected on L $\sim$ 4.5 with respect to electrons with E_e > 100 kev. As is shown in Fig.6c, on August 7 the electron spectrum was also considerably softer than on undisturbed days. Data for September 8 and 9 are absent and this is why, the electron behavior in the outer belt could not be traced. Intensity profiles of electrons with E_e > 100 kev and > 400 kev obtained on September 10 immediately after the storm are shown in Fig.6. The maximum of the belt occurs on 2 $\sim$ 5.0. As may be seen in Fig.6, the inner edge of electron intensity profile from September 10 to 13 is systematically displaced toward the side of smaller L and the belt gradually takes its usual shape. This inward motion is especially evident for electrons with E_e > 400 kev during the storm their intensity had greatly decreased and the belt was virtually formed anew by the propagating electron wave. In three days the inner edge of the intensity profile of electrons with E_e > 400 kev was displace $\Delta L \sim 0.5$, which corresponds to the propagation of electron diffusion at a velocity determined by formula (2) with $a = 3.3 \cdot 10^{-7}\ R_E \cdot day^{-1}$.

Comparison of the data of Figs.5 and 6 makes it possible to conclude that in both cases the displacement of the inner edge of the intensity profile of electrons with $E_e > 400$ kev occurs in the $4.2 < L < 4.8$ range at a diffusion wave velocity determined by relation (2). Moreover, during the diffusion wave formation there takes place a process of instantaneous acceleration of electrons with $E_e > 100$ kev up to energies of the order of several hundred kev, while in the $L > 4.5$ region the spectrum of electrons with $E_e > 100$ kev is identical. Some differences in the investigated examples can be explained by the varying degree of the effect of magnetic disturbances on the outer radiation belt on August 4-6 and September 6-10.

DISCUSSION OF THE RESULTS. Measurements carried out on "ELEKTRON" satellites make it possible to establish an interrelation between the intensity variations of electrons with $E_e > 100$ kev in different regions of the outer radiation belt. Electron intensity variations on the $L = 4.0$ lag systematically with respect to intensity variations in the $4.5 < L < 6.0$ range. As is made evident by statistical analysis, the lag time Δt between variations on $L = 5.0$ and on $L = 4.0$ is $\sim$ 5-6 days. In a number of cases, especially following magnetic disturbances, the inner edge of the intensity profile of electrons with $E_e > 100$ kev and > 400 kev was displaced from $L \sim 4.7$-4.8 to $L \sim 4.0$.

The time lag between intensity variations of electrons on $L = 4.0$ and $L = 4.5$-6.0, as well as the displacements of the inner edge of the electron intensity profile toward the side of smaller L, seem to be the manifestation of one and the same process, namely the radial diffusion of electrons with $E_e > 100$ kev in the $L < 5.0$ region. The obtained results allowed a rough estimate of electron drift velocity. Thus, for $L \approx 4.4$, $\bar{v} = 0.2\ R_E \cdot day^{-1}$. At the same time it was assumed that the particle drift velocity $v \sim L^9$ and for $E_e > 100$ kev it is independent of energy. However, the diffusion of electrons cannot explain the simultaneity of electron intensity variations in the $4.5 < L < 6.0$ range nor the identity of the spectrum of electrons with $E_e > 100$ kev in the $L > 4.5$ region following magnetic disturbances. This can be explained by the process tentatively called instantaneous acceleration or deceleration. Therefore, all electron variations resulting in the formation of the outer belt can be explained on the basis of three processes, namely radial diffusion, and instataneous acceleration and deceleration, whose spheres of actions can be separated.

Let us investigate the results of measurements on "ELEKTRON" satellites on the basis of the five processes proposed by McIllwain [8]. Fig.1 shows that in the investigated L range no exponential decrease of electrons with $E_e > 100$ kev is observed. This was to be expected, since on $L > 4$ the electron diffusion time is considerably shorter ($\sim$ 6 days) than the exponential decrease constant ($\sim$ 16 days). A detailed investigation of the data did not yield any satisfactory correlation between electron intensity and D_{st}-variations. Rapid nonadiabatic intensity increases and, especially, decreases in electrons with $E_e > 400$ kev in the outer belt were observed also in this experiment, but for electrons with $E_e > 100$ kev they were relatively slight. Possibly, the explanation lies in the fact that there were no strong magnetic storms during the operation of "ELEKTRON" satellites, while during measurements on satellites "EXPLORER-15" and "EXPLORER-26" storms with $K_p \sim 8$ were registered. It may be noted that in September 1964, when the magnetic disturbances in the magnetic field were stronger than in July/August, the amplitude of electron intensity variations had somewhat increased. This was especially noticeable in electrons with $E_e > 400$ kev.

In his study on the variations in electrons with $E_e > 500$ kev on $L = 3.6$-3.8, McIllwain could conclude that as compared to betatron acceleration, radial particle diffusion is an effect of second order [8]. However, this conclusion cannot be applied to the whole outer radiation zone, because, according to the data of the "ELEKTRON" satellites, radial diffusion in the $4.0 < L < 5.0$ region exerts an effective action on electrons with $E_e > 100$ kev and > 400 kev. It should be noted, that McIllwain observed rapid nonadiabatic variations by two orders in the whole outer radiation zone no more often than once in two or three months during strong magnetic storms. It may be considered that these processes are very vivid cases of instantaneous electron acceleration. It is interesting to compare the data on electron diffusion available in literature with the results obtained on the "ELEKTRON" satellites. To this and, it is convenient to compare coefficients a which characterize the diffusion of electrons in the outer belt.

According to the data of Frank obtained on "EXPLORER-14" in 1962-1963 [3], coefficient $a = 4.6 \cdot 10^{-7}$ $R_E \cdot day^{-1}$. According to Williams [6] for electrons with $E_e > 1.2$ Mev and $E_e > 2.4$ Mev, $a = 3.4 \cdot 10^{-7}$ $R_E \cdot day^{-1}$ in the second half of 1963. The results obtained on the "ELEKTRON" satellites in 1964 yield $a = 3.3 \cdot 10^{-7}$ $R_E \cdot day^{-1}$ for electrons with $E_e > 100$ kev and $E_e > 400$ kev both by the correlation method and by direct observation of diffusion waves. According to the McIllwain data [8], $a = 3 \cdot 10^{-7}$ $R_E \cdot day^{-1}$ for electrons with $E_e > 5$ Mev in the $4.0 > L > 3.4$ range. Fig.1 [8] shows also a tendency to intensity variations' lag in electrons $E_e > 500$ kev on $L = 4.0$ as compared to variations on $L = 5$. with a time lag $\sim$ 6 days, which does not contradict the abovementioned results. On the basis of this, it can be concluded that rate of electron diffusion in this region of the outer zone does not depend on the energy of the electron 0.1-5.0 Mev range.

The values of a obtained on the basis of numerous experimental data do not contradict one another. During the observations on satellite "ELEKTRON-3" of the diffusion waves of electrons with $E_e > 400$ kev, wave front displacement could be detected only up to $L \sim 4.0$. This is due to the fact that in the $L \lesssim 4.0$ region, the electron drift velocity decreases and wave observation in this region requires more time. However, recurrent disturbances in the Earth's magnetic field modified considerably the pattern of diffusion wave propagation. This concerns, in particular, the measurements carried out in September 1964 on satellite "KOSMOS-41" whose results lead to considerably lower diffusion velocities of electrons with $E > 1.6$ Mev in the outer belt [13]. The closes estimates of electron drift velocity to experimental results were obtained in [10]. From formula (18) of [10] $L = (100\ \Delta t)^{1}/_{8}$, linking the position of the leading electron wave front with time, it follows that at diffusion coefficient $D = 5 \cdot 10^{-14}$ sec, the electrons would drift from shell $L = 5.0$ to $L = 4.0$ in ~ 30 days. This is 5-6 times more than was obtained on the "ELEKTRON" satellites and in other experiments. Other theoretical estimates uield even lower values of drift velocity. Appararently, this is due to the fact that not all the types of geomagnetic disturbances causing radial particle diffusion in the magnetosphere have been theoretically investigated. Besides, numerous experimental data show that the theoretical estimates of electron lifetime in the outer belt are exaggerated.

The data of the present experiment are insufficient for a complete elucidation of the diffusion mechanism of electrons with $E_e > 100$ kev in the outer radiation belt. However, they make it possible to assert that transport of particles is due to radial diffusion directd inside the magnetosphere and not to ordinary diffusion. This is clear from Fig.5 showing the intensity increase of electrons with $E_e > 400$ kev in the maximum on $L = 3.8$. It is interesting to compare the intensity variations of protons with $E_p > 1$ Mev on $L = 5.0$ and 4.0 on the basis of measurements carried out by means of an n-p-detector on "ELEKTRON-4". A statistical analysis shows that the correlation coefficient has two maxima: $r_{ik} = 0.56$ at $\Delta t = 0$ and $r_{ik} = 0.51$ at $\Delta t = 5.5$ days. This means that the diffusion rates of protons and electrons are equal. The presence of a maximum at $\Delta t = 0$ may be linked with the adiabatic variations due to D_{st}-variations [14].

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