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OBSERVATION OF A DIFFUSION WAVE OF RELATIVISTIC ELECTRONS IN THE OUTER RADIATION BELT

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SUMMARY

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The case of registration of a diffusion wave of relativistic electrons is considered in September 1964 with the aid of apparatuses installed on the satellite Cosmos-41. The diffusion wave is not accompanied by substantial intensity variations of low-energy protons in the outer proton belt. The estimate of progression velocity of the diffusion wave across L-shells is brought forth.

* * *

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The transfer theory of charged particles across drift shells explains the origin and dynamics of relativistic electrons in the outer radiation belt [1]. In agreement with this theory, electrons with energy 100 kev, trapped by the geomagnetic field at the boundary of the magnetosphere on $L \sim 10$, at the expense of the radial diffusion across L-shells (with the preservation of the first two adiabatic invariants of motion), are accelerated to energies $E_e > 1$ mev on $L \sim 4$. Predictable, in theory, that with the aid of threshold detectors placed on the satellites registering the energetic electrons, such displacement of accelerating electrons within the magnetosphere can be observed in the form of the so-called "diffusion wave." The theory, in particular, determines the displacement velocity of such a wave by the function of the parameter L.

Experimentally, the diffusion waves of electrons with $E_e > 1.6$ mev were observed at first on Explorer-14 [2]. The authors notice three cases of propagation of diffusion waves in the outer

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* HABLYUDENIYE DIFFUSIONNOY VOLNY RELYATIVISTSKIKH ELEKTRONOV VO VNESHNEM RADIATSIONNOM POYASE

radiation belt in the near-equatorial zone. The estimate of the progression velocity of the diffusion wave provided the value $\sim 0.4\ R_e$ in twenty four hours on $L = 4.7$ and $\sim 0.03\ R_e$ in twenty four hours on $L = 3.4$ [3].

By the analysis of the information [4], obtained from the satellite Cosmos-41, the case of propagation of a diffusion wave of relativistic electrons was also noted. It is natural to expect that at high geomagnetic latitudes (Cosmos-41 crossed the outer radiation belt in the region of the geomagnetic latitude $44 \div 54^o$), the propagation character of the diffusion wave can be substantially distorted by variations of pitch-angle propagation of hard electrons. In the observed case, however, the basic peculiarities become apparent, inherent in the dynamics of the diffusion wave of hard electrons:

a) a certain intensity decrease of relativistic electrons during the commencement of the geomagnetic disturbance;

b) the intensity increase of relativistic electrons on the remote L-shells (>5) within a few days after the geomagnetic disturbance;

c) the furthest progression of intensity maximum in the region of smaller L, attended by an intensity increase in the maximum (for the quiet geomagnetic condition);

d) the subsequent intensity drop (especially in the presence of a new geomagnetic disturbance) and the restoration of the original maximum position.

In Figure 1 the intensity variations of hard electrons (solid curves) and low-energy protons (dashed curves) are shown depending on the parameter L for 1, 3, 4, 10, 19 and 21 September 1964 by the variation of the geomagnetic latitude from 44 to 54^o. The intensities of electrons were measured by SI-ZBG counters [5], one of which with a shield of 0.84 g/cm^2, registered by the direct passage of electrons with $E_e > 2$ mev (upper curves of each graph), the other shielded by a layer of matter > 3 g/cm^2 registered in the fundamental background of bremmstrahlung of the energetic component of electrons in the outer radiation belt (lower curves). The geomagnetic factors of counters are essentially different for penetration of radiation and for bremmstrahlung. At the construction of the upper curves the counter readings were increased by the geomagnetic factor corresponding to the penetrating radiation. This conditioned the apparent difference in the intensities,

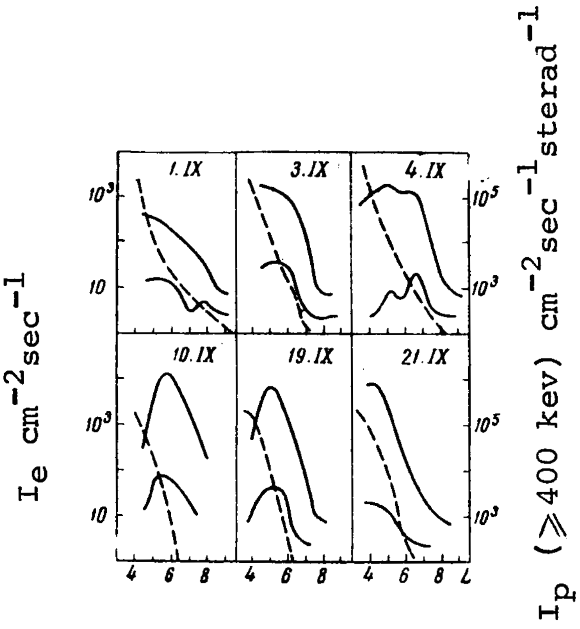

Figure 1

registered by two counters on L> 8 (practically--the cosmic radiation background). The protons with $E_p \geqslant 400$ kev were measured by the semi-conductor n-p counter [5].

From twenty two hours (Moscow time), 31 August to five hours, 2 September, a magnetic storm with gradual commencement [6] was noted by the ground stations. The summary K_p-index for 1 September was equal to 26 [7]. From twenty three hours, 6 September to four hours, 9 September, a magnetic storm with sudden commencement was noted. The maximum $\Sigma K_p = 31$ was observed on 7 September 1964. Further, to 22 September (when $\Sigma K_p = 29$), a relatively quiet geomagnetic condition was observed.

It is evident from Figure 1 that during the period of magnetic disturbance on 1 September, the intensity of electrons with $E_e > 2$ mev on L = 5 constituted $\sim 3.5 \cdot 10^2$ cm^{-2}sec^{-1}. Between 3 and 4 September the intensity peak of hard electrons $\sim 10^3$ cm^{-2} sec^{-1} is in the region L = 6 ÷ 7. Further, on 10 and 19 September, the subsequent displacement of this peak is observed in the region of smaller L with the intensity increase in the maximum to $\sim 10^4$ cm^{-2}sec^{-1}. The profile of the outer radiation belt of 21 September became similar to the profile of 1 September with a certain higher intensity. After the disturbances of 22 and 29 September, an intensity drop of relativistic electrons took place to the level $\sim 3 \cdot 10^2$cm^{-2}sec^{-1}. It may be traced in Figure 1 that at the time the intensity of relativistic electrons of the outer radiation belt underwent such substantial variations, the outer part of the protonosphere (L_m = 3.5 [4]) felt the insignificant variations within the limits of the factor of 2 commonly noted for the protonosphere in the region of the higher geomagnetic latitudes [8]. Therefore, it can be stated

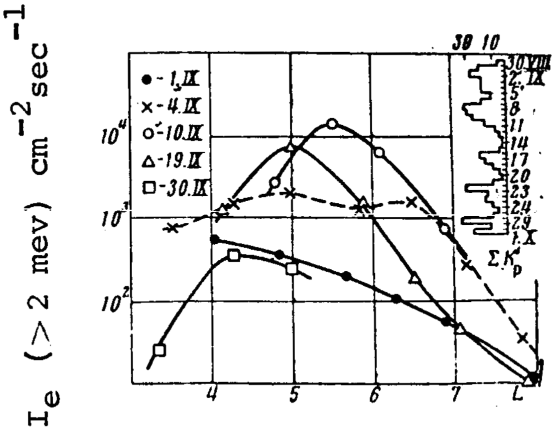

Figure 2

that the observed diffusion wave of relativistic electrons of September 1964 was not attended by an analogical wave of low-energy protons ($\geqslant$400 kev).

More detailed data is presented in Figure 2 by the displacement of a diffusion wave of hard electrons. In the graph the registered profiles of 1, 4, 10, 19 and 30 September of the outer radiation belt are plotted by the measurements of the counter SI-ZBG (shielded by a layer of matter 0.84 g/cm^2). A histogram of the variation ΣK_p for September 1964 is presented [7]. Estimates of progression velocity of the diffusion wave provide on $L \sim 6$ the value 0.17 R_e in a day, on $L \sim 5$ — 0.06 R_e in a day. These estimates, however, can have an ambiguous character, for having experimental material does not give the possibility to determine the influence of the recurrent geomagnetic disturbance of 6 -- 9 September, after which a new diffusion wave of hard electrons could be created. In addition, it is not clear how for this time the pitch-angle distribution of diffusion particles varied. Data, brought forth in work [9] on the measurement of the absolute intensity of hard electrons on the satellite Cosmos-41 in the equatorial region ($L = 5$) for certain days of August and September, indicate that the angular redistribution did not play a substantial role in the above described case. In particular, from 1 to 11 September 1964 the intensity of electrons with $E_e > 2$ mev in the equatorial region increased to $L = 5$ nearly 20 times, which agrees well with the measurements in the high geomagnetic latitudes.

The basic conclusions of the given work are the following:

1) At first, the diffusion wave of relativistic electrons of the outer radiation belt was observed in the region of the high geomagnetic latitudes.

2) The observed diffusion wave is not attended by an analogical wave (or even by somewhat substantial variations) of low-energy protons ($\geqslant$400 kev) of the outer proton belt.

3) In agreement with the estimates brought forth in $L = 5 \div 6$, the diffusion velocity was found to be less than that observed in 1962 - 1963 on the satellite Explorer-14. By the strength of the indicated, however, the above circumstances cannot be ascribed great significance regarding the noted discrepancy.

* * * THE END * * *

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