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ON THE INTERVENING ROLE OF THE MAGNETIC FIELDS OF SOLAR CORPUSCULAR STREAMS IN THE DETERMINATION OF THE DEGREE OF THEIR GEOEFFECTIVENESS

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ON THE INTERVENING ROLE OF THE MAGNETIC FIELDS OF SOLAR CORPUSCULAR STREAMS IN THE DETERMINATION OF THE DEGREE OF THEIR GEOEFFECTIVENESS *

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ABSTRACT

The influence of the magnetic fields of solar corpuscular streams on the character of streams' interaction with the Earth's magnetosphere was discussed in the work [1] (ST - PF - GM - 10 494). Particular attention was then given the question of the impossibility of stream's magnetic field penetration inside the magnetosphere and of the requirement of magnetohydrodynamic treatment of the theory of geomagnetic disturbances.

The intermediate role of stream's magnetic field in the interaction with the magnetosphere of the incident plasma was then brought forth as one of the possible mechanisms determining the geoeffectiveness of corpuscular streams. This note constitutes a complement to [1], somewhat concretizing the indicated case.

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It is well known that in a series of cases the sharp variation in the solar plasma pressure upon the magnetosphere, while leading to the emergence of sudden commencement or sudden impulse in the geomagnetic field, still does not determine the subsequent development of the storm ([2], Figs 2 and 3), and thus cannot serve as a parameter, unilaterally determining the geomagnetic activity. At the same time, comparison of the results of direct measurements of solar wind velocity V_f on Mariner-2 with the general planetary K_p- index, ascertained the presence of proportionality between these two quantities ($K_p \sim V_f$) [3].

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* O POSREDNICHESKOY ROLI MAGNITNYKH POLEY SOLNECHNYKH KORPUSKULYARNYKH POTOKOV V OPREDELENII STEPENI IKH GEOEFFEKTIVNOSTI.

Without denying the necessity of pursuing search for mechanisms explaining the above experimental facts, one may attempt to give them an interpretation, basing oneself upon the case of the intervening role of the magnetic field of a corpuscular stream in the determination of the degree of geoeffectiveness of the latter.

The orientation of the axial line of the Earth's magnetosphere is determined by the plasma flow, radial relative to the Sun and not varying with the plasma flow velocity (Fig 1). Thus the geomagnetic field in the magnetosphere train is practically always radial relative to the Sun, coinciding with the line Sun - Earth. It should be noted that the action of magnetic flux's pressure may lead to the deflection of the axial line of the magnetosphere from the direction of solar plasma incidence by no more than 6 — 20° [4].

At the same time, the average direction of the magnetic field of the s.c.s. in the region of the Earth depends essentially on the velocity of the plasma flow ($\alpha_1 \approx 20^\circ$ for $V_{f1} \approx 1000$ km/sec, $\alpha_2 \approx 55^\circ$ for $V_{f2} \approx 300$ km/sec; see Figure 1). Such a variation of the mutual orientation of the geomagnetic field and of the magnetic field of the s.c.s. may serve as one of the possible causes of variation in the degree of stream's geoeffectiveness.

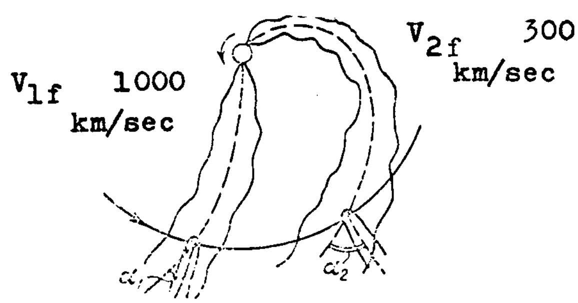

Fig. 1

Indeed, the surface of the magnetosphere may be viewed as the surface of the Kelvin- Helmholtz magnetohydrodynamic break, separating the Earth's magnetosphere from the flow of solar plasma with its proper magnetic field. Such break surface is found to be unsteady [5], if the value of the tangential component of the relative motion velocity of two media, V_t, is comprised within a certain range of values

$$V_{upp.cr.} > V_t > V_{low.cr.},$$

the upper value of the critical velocity $V_{upp.cr.}$ being then less than the unperturbed plasma flow velocity V_f.

Besides, and this is of particular importance, the instability parameter happens to be the value of the angle between the magnetic fields in the two considered media. The closer the fields in the two media to being parallel (or antiparallel), the nearer the surface of the break is to the instablity (the remaining conditions being equal).

In connection with the above considerations, a greater value of the angle $\alpha_2 > \alpha_1$, see Fig. 1) between the radial magnetic field in the magnetosphere train relative to the Sun, and the component of the magnetic field of the solar corpuscular stream, will lead to greater stability of the surface of the magentosphere train for a lesser value of flow velocity ($F_{f2} <$ $< V_{f1}$, see Fig. 1), and thereby to lesser disturbance of the geomagnetic field. To the contrary, other conditions being equal, at greater flow velocity the surface of the magnetosphere train is found to be nearer instability, which is attended by a great disturbance of the geomagnetic field, thus explaining the proportionality $K_p \sim V_f$, obtained in [3]. Obviously, for instability onset, the above limiting condition relative to the value of the tangential component of the flow velocity must be fulfilled. In this regard, the sufficiently slow increase in the directed plasma flow velocity beyond the magnetosphere boundary at passing from daytime to nighttime, revealed during measurements in AES IMP-2 [6], is found to be more favorable for our interpretation.

Nor do the measurements data of the magnetic field beyond the magnetosphere on AES IMP-1 [7] contradict the proposed interpretation. During these measurements a long-lasting sector structure of the interplanetary field in the vicinity of the Earth was detected (within the bounds of each sector, traversed by the Earth in the course of approximately 7.5 days, the magnetic field component in the ecliptic plane maintains, as an average, its direction either to the Sun or from the Sun). The small difference in the levels of geomagnetic disturbance during the periods when the Earth's magnetosphere was inside the sectors with different direction of the interplanetary field (mostly toward the Sun and from the Sun), corresponds to the small difference of cases of parallel and antiparallel states of the fields in relation to boundary surface instability (see [7], Fig. 4).

Let us note the possibility of utilizing the data of the work [7] for a fuller understanding of the possible physical transfer mechanisms from closed to open Earth's magnetosphere. In accord with the Dangy ideas, such a transition, attended by the development of inner motions in the magnetopshere, corresponds to the arrival of a magnetic field, perpendicular to the ecliptic plane and directed toward the South pole (see [8], Fig. 3). According to measurement data on IMP-1, the magnetic field component in a plane perpendicular to the ecliptic plane beyond the magnetosphere is mainly (that is, in 66% of cases) directed toward the south (transition to open magnetosphere possible). However, in a series of cases this field component beyond the magnetosphere was directed toward the north (transition to open magnetosphere forbidden). Comparison of curves, similar to those plotted in Fig. 4 of [7], but corresponding to two directions (to the north and south) of the field component, perpendicular to the ecliptic plane, would allow to judge more specifically about the possibility of the given transition, extremely important for the geoeffectiveness of solar corpuscular streams.

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*** THE END ***

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