RELATION BETWEEN SOLAR-WIND PARAMETERS AND THE PERIODS OF STEADY MICROPULSATIONS OF THE EARTH’ S ELECTROMAGNETIC FIELD

GEOPHYSICS

1970

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Fig. 1

Figure 1: Fig. 1

Abstract

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UDC 550.3

GEOPHYSICS

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RELATION BETWEEN SOLAR-WIND PARAMETERS AND THE PERIODS OF STEADY MICROPULSATIONS OF THE EARTH' S ELECTROMAGNETIC FIELD

(Presented by Academician A. L. Mints, 31 III 1970)

The results of measurements of solar-wind ion fluxes, carried out with charged-particle traps on the interplanetary stations Venera-2 (^1) (in 1965), Venera-4 (1967) ([1],2), and also Venera-5 and Venera-6 (^3) (1969), were compared with simultaneous measurements of the periods T of steady micropulsations of the Earth' s electromagnetic field. For the comparison, observation intervals of duration ~ 1 month from the launch of each of the interplanetary stations were selected, when they were sufficiently close to the Earth. In this case the time shift between the moment of measuring the parameters of the solar-wind flux on the spacecraft and the action of this flux on the boundary of the Earth' s magnetosphere could practically be disregarded. Figure 1 shows the values, averaged over 3-hour intervals, of the periods T of micropulsations, determined from records of telluric currents at the observatories Borok ($\Phi = 52°53'$, $\Lambda = 123°20'$), Petropavlovsk ($\Phi = 44°24'$, $\Lambda = 218°14'$) and Soroa (Cuba) ($\Phi = 33°$, $\Lambda \sim 345°$), as a function of the ion flux in the solar wind nv cm$^{-2} \cdot$ s^{-1} (n is the ion concentration in the solar wind, v is the flow velocity). For all four space probes the dependences of T on nv are different for two ranges of values of T: for $T \leq 40$ s there is a decrease of T with increasing nv, while for $T \geq 40$ s, conversely, T increases with increasing nv. The same regularity is observed in the data of each observatory taken separately.

Fig. 1

To check this phenomenon, discovered at different phases of solar activity, and to clarify the separate influence on the value of T of the particle concentration n

Fig. 2

Figure 2: Fig. 2

in the solar wind and the velocity v, the results of measurements of solar-wind parameters on the American Earth satellite IMP-1 in December 1963-March 1964 (^5) were used (Fig. 2). The value of T was taken from the data of the Borok and Petropavlovsk observatories. Fig. 2a fully confirms the existence of differences in the dependences of T on nv for periods $T \leq 40$ s and $T \geq 40$ s, shown in Fig. 1.

Of particular interest is the comparison of the dependences $T(v)$ and $T(n)$ (Fig. 2b and c), which shows that T is practically independent of the solar-wind velocity and is determined mainly by the particle concentration. In these plots, in the first case (2b) the value was not fixed ···

n, and in the second case (2b), the value of v. The authors constructed the dependences $T(v)$ for $n = 5 \div 10$ cm^{-3} and $T(n)$ for $v = 300 \div 350$ km $\cdot$ s^{-1}. These graphs are not presented here, but their character is entirely analogous to Figs. 2b and c.

This result is, to some extent, unexpected, since until now the literature has often considered dependences of various geophysical phenomena on the solar-wind velocity (beginning with ([6])), whereas little attention has been paid to the influence of the solar-wind ion concentration n on phenomena in near-Earth space (although, for example, in ([7]) a case of a strong geomagnetic storm caused precisely by an increase in n, and not in v, is described). It was assumed that variations in the solar-wind pressure

$$p \equiv \frac{nv^2}{2}$$

are determined mainly by variations in v, since the dependence of p on v is quadratic and on n linear. At the same time, it was not taken into account that near the Earth' s orbit v usually changes by no more than a factor of 3 (from ~ 250 to ~ 750 km/s), whereas variations in n may exceed two orders of magnitude (from fractions of a particle in 1 cm^3 to ~ 100 cm^{-3}).

Fig. 2

The dependences shown in Fig. 2 indicate the need for further study of the influence of variations in the magnitude of n on phenomena in the magnetosphere. They also suggest that micropulsations with $T < 40$ s and with $T > 40$ s are generated in different regions of the magnetosphere.

The decrease of T with increasing nv for $T < 40$ s agrees well with ideas about the generation of micropulsations of this group (Pc-2-3) inside the Earth' s cold plasma envelope (the plasmasphere), since, as is known ([8],[9]), its boundary—the plasmapause—approaches as geomagnetic activity increases, with compression of the magnetosphere, and recedes from it when the pressure on the magnetosphere decreases. A decrease in the size of the resonator, whose outer wall is the plasmapause and whose inner wall is the lower boundary of the ionosphere, naturally decreases the period of the oscillations arising in this resonator. Arguments in favor of the fact that pulsations of type Pc-2, Pc-3 (with period $T < 40$ s) are formed precisely in the plasmasphere were also presented earlier in ([10]). However, the possibility is not excluded that these oscillations are generated throughout the entire volume of the magnetosphere changing under the influence of the solar-wind action.

It is more difficult to explain the increase in the value of T with increasing nv for periods $T > 40$ s, corresponding to oscillations of type Pc-4. According to existing ideas, these pulsations may be generated in a comparatively narrow flux tube resting on the auroral zone ([11]), and represent Alfvén waves propagating along

of this tube. If this is so, then the period of pulsations must be related to the plasma concentration n at the apex of the flux tube in the following way: $T \sim \sqrt{n}/\cos^2\Phi_0$ [(12)], where Φ_0 is the geomagnetic latitude on which the tube rests.

It is seen from Fig. 2 that the periods of pulsations with $T > 40$ sec increase with increasing plasma concentration n in interplanetary space. If it is assumed that an increase in the concentration of the plasma acting on the boundary of the magnetosphere can cause an increase in the plasma concentration in the dayside part of the outer region of the magnetosphere (for example, owing to large-scale displacements (convection) of magnetospheric plasma or by means of penetration of the solar wind into the magnetosphere through some mechanism), then, proceeding from [(12)], one can qualitatively explain the upper part of the graphs in Fig. 1 and Fig. 2 and (for $T > 40$ sec). We note that, according to measurements carried out on the American geostationary satellite ATS-1, it was precisely in this region of the magnetosphere (at the geocentric distance $R = 6.6R_E$, near local noon) during the compression of the magnetosphere on 13 I 1967 that the ion concentration varied from $n = 1.8$ cm^{-3} to $n = 14.8$ cm^{-3} [(13)].

Thus, the results presented indicate that the principal parameter of the solar wind affecting the character of the oscillatory regimes of the electromagnetic field excited at the Earth' s surface is the concentration of the proton component of the flow. In this case, on the one hand, a change in the density of the solar wind determines a change in the volume of the resonator in the magnetosphere in which Pc-2–3 oscillations are formed. On the other hand, the character of the dependence of the periods of stable oscillations of the Pc-4 type, formed in the outer regions of the magnetosphere, may be evidence of an increase in the plasma concentration on the dayside of the magnetosphere.

Figs. 1 and 2 and allow one to suppose that stable micropulsations with two different periods (corresponding to the two branches of the graphs) may exist simultaneously (under the action on the magnetosphere of one and the same solar-wind flow); however, these periods must be in the ratios determined by the indicated graphs.

Received
17 III 1970

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