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SUMMARY

The geomagnetic micropulsations of the type Pc 2-4, are used for the determinations of the dimension of the magnetosphere as measured by the subsolar distance, since they are, in fact, the magnetosphere's proper hydromagnetic oscillations excited at its periphery by solar corpuscular streams. This method is considerably improved by simultaneous measurements in a wide range of magnetic field sudden impulses at the equator.

* * *

One of the promising directions of the investigation of micropulsations, is the study of the possibility of their use for the diagnostics of the magnetosphere and solar wind parameters. Inasmuch as up to the present time, only the general principles of physical interpretations of the micropulsations were contemplated, so the various empirical and semi empirical methods (1,3) are being widely used alongside with the theoretical approach to the diagnostics problem (2).

Amid the diversity of the geomagnetic micropulsations the oscillations of the type Pc 2-4 with periods T = 10-150 sec., stand out; they are practically continuously observed on the Earth's surface facing the Sun. According to contemporary representations they are the magnetosphere's proper hydromagnetic oscillations, excited on its periphery by solar corpuscular streams. The oscillation period naturally depends on the dimensions of the resonator, the "walls" of which are the Earth's surface and the shock-wave front, which occurs during solar wind flow past the magnetosphere, and limits the geomagnetic field from the subsolar side at an average distance of about ten Earth's radii.

The direct measurements of the magnetic field and of fluxes of particles on satellites and rockets show that the magnetosphere boundary is in a continuous motion, approaching the Earth's surface with the increase of solar wind and receding, when the wind weakens and the normal pressure on the magnetosphere's surface decreases. Consequently the periods of Pc 2-4 micropulsations vary. Thus the micropulsations of this type may be considered as a simple ground indicator, which allows to observe continuously the position of magnetosphere boundary.

If we represent the dependence of the micropulsation period T on the magnetosphere dimensions on the line of Earth-Sun in the form $T = \text{const} \cdot R^{\nu}$, the basic problem will consist in determining the exponent ν. The proportionality factor is estimated from the condition, that to the average magnetosphere dimension $R_0 \approx 10$ (in the units of Earth's radius) correspond the typical periods $T_0 \approx 30$ sec. Thus

$$T = T_0 (R/R_0)^{\nu}, \tag{1}$$

where T_0 and R_0 are assumed to be known, while ν is a quantity subject to determination.

In the work [1], the exponent $\nu \sim 4.8$ was found by direct comparison of satellite data about the dimensions of the magnetosphere with periods of Pc 2-4 micropulsations. In the proposed work attempt is made to determine ν only by means of ground data. For this purpose we shall make use of cases of sharp variation of Pc 2-4 micropulsation period during a sudden magnetosphere deformations, taking place under the action of solar wind's inhomogeneities. At sudden contraction or expansion of the magnetosphere, the superficial currents flowing along its boundary correspondingly increase or weaken and a positive (negative) impulse of magnetic field Si (Fig.1-a) is observed on the Earth's surface. It is interesting to note that sometimes following a negative impulse, the micropulsations disappear completely (Fig.1-b,c).

The evaluation method of the exponent ν is based on the comparison of the sudden impulse's magnitude ΔB with the micropulsation periods T and T', which were observed before and after the sudden impulse.

According to Mead [4] the magnitude of the sudden impulse Si*, recorded at the equator is linked with the dimensions of magnetosphere in the following manner

$$\Delta B = \frac{B_1}{R^3}\left[\left(\frac{R}{R'}\right)^3 - 1\right]; \tag{2}$$

where $B_1 = 25.000\gamma$ ($1\ \gamma = 10^{-5}$ gauss). Eliminating from (2) by means of (1) the quantities R and R' we find

$$\lg\left(\frac{T}{T'}\right) = \frac{\nu}{3}\lg\left[1 + R_0^3 \frac{\Delta B}{B_1}\left(\frac{T}{T_0}\right)^{3/\nu}\right]. \tag{3}$$

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* It should be noted that at the investigation of Earth's surface, the value of Si will be somewhat higher owing to the induction effect in Earth's crust. As is well known, this effect is approximately accounted for by multiplication of the measured values Si by coefficient 2/3.

This formula allows us to determine by combination of experimental data on T, T' and ΔB the exponent ν. The results of the preliminary measurements, according to 20 cases of micropulsation period variation during the time Si, lead to the value $\nu \approx 4.6$. This is rather close to the value, found by means of direct comparison of T and R.

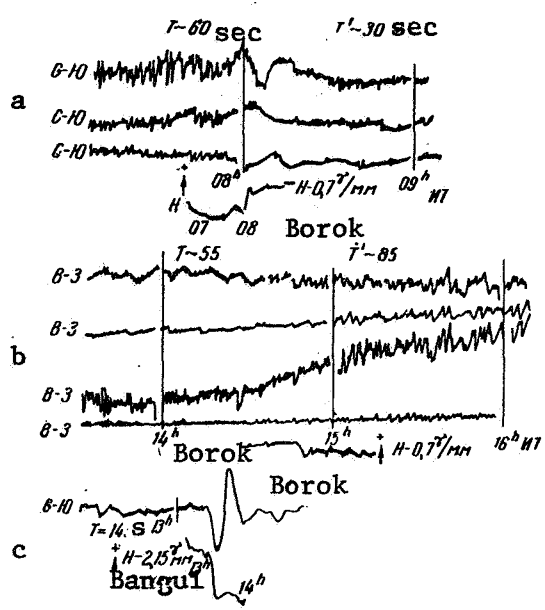

Fig. 1

Examples of micropulsation registration

a) <u>from top to bottom are</u>:

St. Borok ($\Phi = 52°$, $\Lambda = 123°20'$), Petropavlovsk ($\Phi' = 44°24'$, $\Lambda = 218°14'$) Soroa (CUBA) ($\Phi = 33°$; $\Lambda = 345°$) 2 August 1964;

b) <u>from top to bottom</u>:

Borok, Petropablovsk, Soroa (CUBA), Dallas (USA) 2 May, 1965;

c) <u>St. Borok, 14 December 1958.</u>

It is interesting to note, that for well known ν, there is a possibility to determine the magnetosphere dimensions before and after Si with a precision, independent of the exact choice of parameters R_0 and T_0. In reality, eliminating (R'/R) from (2) by means of (1), we obtain

$$R = 10\{[(T/T')^{3/\nu} - 1](25/\Delta B_\gamma)\}^{1/3}. \qquad (4)$$

The formula for the determination of R' has quite an analogous form.

A very specific peculiarity of the described measurement is the fact that the shift of micropulsation periods was analyzed by a net of obsevatories situated along the Earth's globe perimeter such as, for example, Borok, Petropavlovsk-on-Kamchatka (USSR), Soroa (CUBA), and by special experiments, conducted at antipode points (Borok, Hayt, Dallas).

The quantity ν will be defined more exactly by both methods. Therefore, let us take note that formula (3) rewritten in the form

$$B_1 = R_0^3 \Delta B (T / T_0)^{3/\nu} [(T / T')^{3/\nu} - 1]^{-1}, \quad (5)$$

could be used for the experimental determination of the quantity B_1.

The formation of magnetosphere boundary takes place under the action of solar corpuscular streams filling the interplanetary space. Therefore the data on the position and displacements of the boundary contain an indirect information about the properties of the interplanetary medium in the vicinity of the Earth.

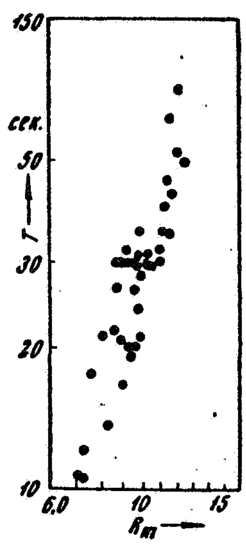

Fig.2

Dependence of type Pc 2-4 micropulsation period on the dimensions of magnetosphere.

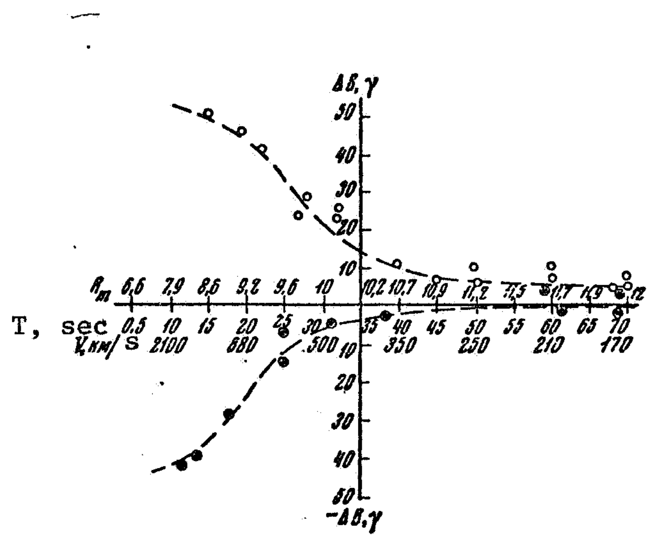

Fig.3

Dependence of micropulsations period and the magnitude of the impulse ΔB on the magnetosphere's dimensions and the solar wind velocity (upper curve at the contraction of magnetosphere, lower at expansion).

If we are to employ the ratio R = 1.068 $(M^2 / 4\pi m_p N V^2)^{1/6}$, which links the magnetosphere's dimensions with solar wind pressure on magnetosphere at the subsolar point (4), then by taking into account (1) we obtain:

$$V = \frac{M}{R_0^3 \sqrt{4\pi N m_p}} \left(\frac{T_0}{T}\right)^{3/\nu}. \tag{6}$$

Here M is the Earth's magnetic moment, m_p is the proton mass, V is the wind's velocity, N is the proton concentration. The utilization of formula (6) for the evaluation of solar wind velocity according to data on the periods of micropulsations is hampered by the variability of particle concentration in the interplanetary medium. If, however, we assume that NV = const (5), then $V = \text{const}\ T^{-6/\nu}$. The value $\nu = 4.6$ has been defined above, and the proportionality factor may be estimated from the condition that to the mean solar wind velocity $V \approx 500$ km/sec corresponds a typical period $T_0 \approx 30$ sec. With these admissions the values of solar wind corresponding to various periods of steady micropulsations (Table 1) were calculated. Naturally, the results of computation should be considered as preliminary. In the direct comparisons of data on the corpuscular stream parameters with the observed periods of micropulsations will allow to make more precise the character of the relationship between T and V.

TABLE I

T, sec.	R	V km/sec.	T, sec.	R	V km/sec.
10	7,9	2100	40	10,7	350
15	8,6	1250	45	10,9	300
20	9,2	880	50	11,2	250
25	9,6	650	55	11,5	230
30	10,0	500	60	11,7	210
35	10,2	420	65	11,9	185
			70	12,0	170

We have mentioned above the cases of cessation of micropulsations after negative Si (Fig.1-c). In Fig.3 (the lower curve) the values of negative impulses are plotted along the vertical axis, and the magnetosphere dimensions R to Si corresponding to them and computed by formula (1) with $\nu = 4.6$ are plotted along the horizontal axis. The value of R' cannot be determined by the same method, since after the considered negative Si, oscillations cease. However, inasmuch as R and ΔR are well known, it is possible to find R' by formula (2). It is interesting to note, that in all the cases of micropulsation cessation, after Si, the magnetosphere boundary drifted away to substantial distances $R' \approx 13\text{-}15$. If the relation $V \approx 1/T^{6/\nu}$, obtained at the condition NV = = const is correct, this will lead to rather small values of solar wind velocity:

$V \approx 150$ km/sec. Besides, it is not exluded that the cessation of micropulsations takes place with a sharp drop of solar wind velocity, as well as with the decrease in the particle concentration.*

The dependence between R and the value of ΔB is shown on the upper curve in Fig.3. In general case this dependence is not single-valued. Therefore, in the sorting of cases shown on the graph, a complementary link in the form of $T = 2T'$, was superimposed.

Thus concomitant analysis of micropulsations in a wide range of periods and sudden impulses of the magnetic field on equator, greatly improves the reliability of ground observation of the geomagnetic effects.

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* Furthermore, we do not consider in present case, the influence of interplanetary field orientation on the Pc excitation.