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Pi2-PULSATIONS, AURORA OVAL AND PLASMA DENSITY IN THE MAGNETOSPHERE

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SUMMARY

This work proposes the utilization of Pi2-pulsations in order to estimate the density of the plasma in the magnetosphere. This is done on the basis of the fact that the period of these pulsations is linked with the southern boundary of the aurora oval. A more accurate determination of plasma density in the magnetosphere is dependent on the magnitude of parameter α, which is its main characteristic.

* * *

Besides direct measurements, the concentration of plasma in the magnetosphere is estimated by ground observations of electromagnetic radiations in the KHz (whistlers) and millihertz (geomagnetic micropulsations) bands. For micropuslations the methods of estimate of concentration is worked out for gigantic pulsations, representing the toroidal oscillations, whose peculiar characteristic consists in the dependence of their period on latitude [1 - 3].

For the estimate of plasma density we utilized below another type of geomagnetic micropulsations (Pi2). According to [4], Pi2-pulsations constitute a damping Alfven wave propagating on the night side of the Earth, mostly between 2200 and 0200 hours local time, along a line of force resting in the aurora oval. It was found that the Pi2-period is linked with the position of the southern boundary of the oval.

The propagation mechanism of Pi2 allows us to determine the oscillation period from the relation

$$T = \int_{-\Phi_0}^{\Phi_0} \frac{2dS}{V_a}, \qquad (1)$$

where dS is an element of arc of the field line; Φ_0 is the geomagnetic latitude of the projection on the Earth's surface of the line of force, along which the oscillation propagates; V_a is the Alfvén velocity of wave propagation along the field line. For the variation of plasma concentration along the field line we shall assume [5]:

$$n_S = n_e \left[\frac{H_e}{H_S}\right]^{(\alpha-1)/2}, \ldots \qquad (2)$$

where n_S is the plasma density at the point S of the field line with field intensity H_S; n_e is the density at the equator; α is a parameter of low-energy plasma component's distribution by pitch-angles. For a dipole magnetic field

$$T = 3{,}68 \cdot 10^{-2} \frac{\sqrt{n_e}}{\cos^8 \Phi_0} I(\alpha, \Phi_0). \qquad (3)$$

The values of interval $I(\alpha, \Phi_0)$ for $45° < \Phi_0 < 85°$ and $0 < \alpha < 10$ are computed in [2]. The density of low-energy plasma rises in the direction to the Earth and this is why parameter α must be smaller than the unity. The latitude of the projection on the Earth's surface of the oscillatiog tube of force may be determined from the data on the position of the southern boundary of the aurora oval. Then, relation (3) will be determining the dependence of n_e on Φ_0 or the geocentric distance $R = 1/\cos^2\Phi_0$.

Plotted in Fig.1 on the basis of sumultaneous measurements are Pi2-periods in winter months of 1957 and 1961 as a function of magnetic disturbance intensity on $\Phi \sim 65°$ (Q-index). The dots indicate the individual values and the dashes — the linear approximation of 1961, obtained by the method of least squares. An analogous straight line for the year 1957 is figured by a solid line.

As the disturbance increases, the oscillation periods decrease.

If Pi2 occur at the boundary of closed field lines of the dipole type, the decrease of T with the rise of Q is conditioned by the onset of oscillations on shorter and shorter field lines.

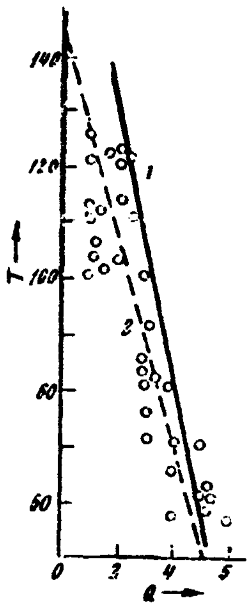

Fig.1. Period of Pi2-pulsations in winter season at intensity variation of magnetic disturbances in near-midnight hours. Solid line 1 indicates the year 1957 and the dashed line corresponds to 1961

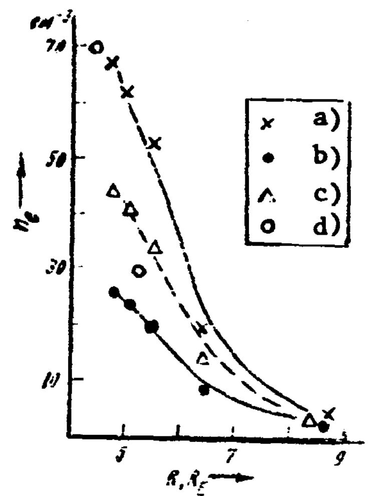

Fig.2. Density of the plasma in the equatoiial plane at different geocentrical distances. a) 1957; ($\alpha = 0$); b) 1957 with ($\alpha = -2$); c) 1961. ($d = 0$); e) measurements by AES IMP-1 on 27 November 1963

It was shown in the works [6, 7] according to observations by low satellites, that the boundary of the region of trapped radiation, reflecting the position of the boundary of closed field lines of dipole type, does indeed approach the Earth in nighttime and during magnetic disturbances. Assuming that the Φ_0 of the oscillating field line coincides with the southern boundary of aurora oval, which was obtained for the IGY period in the work [8], we computed by relation (3) the dependences $n_e(R)$ for 1957 and 1961, which are plotted in Fig.2. The obtained relation $n_e(R)$ contains also, but in an implicit form, the variation of density with the increase of magnetic disturbance. The position of the southern boundary of the oval is conditioned by both the intensity of polar magnetic disturbances (DP) and the ring current in the magnetosphere (DR).

Since the periods of pulsations have not been reduced to fixed values of DR, neither was such a relation introduced in the latitude of the oval. It was assumed that, for identical Q-indices of magnetic activity, the intensity of DR is maintained at one level in both cases of determination of T and of the southern boundary of the oval. This assumption is corroborated by a direct verification.

For 1957 the calculation is conducted for $\alpha = 0$ and $\alpha = -2$, that is of possible limiting values of α, for the density of the plasma, judging from relation (2), decreases along the field line by more than 3 orders. At $\alpha = 0$ the decrease exceeds insignificantly one order, which is essentially different from theoretical estimates of [9]. The value of $I(\alpha, \Phi_0)$ at $\alpha = 0$, was borrowed from [2], while for $\alpha = -2$, it was found by numerical integration.

It follows from the data brought in Fig.2 that decrease of n_e by a factor of 1.5 at solar activity drop follows besides the density increase with the decrease of the geocentric distance. Such a decrease was continued in 1964 too. The computed values of n_e agree well with the results of measurements on AES IMP-1 [10], which are also plotted in Fig.2. Taking into account that in 1963, judging from the data on pulsations, n_e is lower than in 1961, one should assume that the variation of n_e with R at $\alpha = 0$ agrees better with the experimental data than at $\alpha = -2$. Apparently, more accurate accounting of the trajectory of Pi2 propagation and, in particular, of field line deviation from the dipole, will allow us to derive a more specific conclusion on the magnitude of parameter α, constituting an important characteristic of low-energy plasma filling the magnetosphere.

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*** THE END ***

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References follow...

REFERENCES

1. T. OBAYASHI. Ann. Geophys., 14, No.14, 464, 1958.
2. A. I. OL'. Dissertatsiya, L. 1964.
3. A. V. GULEL'MI. Geom. i Aeronomiya, 7, No.3, 442, 1967.
4. o. M. RASPOPOV. Ibid., 8, No.2, 325, 1968
5. E. N. PARKER. Phys. Rev. 107, No.4, 924, 1957.
6. B. MAELHUM, B. J. O'BRIEN. JGR, 68, No.4, 997, 1963.
7. D. J. WILLIAMS. Ib. 72, No.5, 1644, 1967.
8. G. V. STARKOV, YA. I. FEL'DSHTEYN. Geom. i Aeronomiya, 7, No.1, 62, 1967.
9. A. EVIATOR, A. M. LENCHEK, S. F. FINGER. Phys.Fluids, 7, 11, 1775, 1964.
10. G. P. SERBU, E. J. MAIER. JGR 71, No.15, 3755, 1966.

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