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Abstract

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GEOPHYSICS

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PULSATIONS *Pi2*, THE AURORAL OVAL, AND PLASMA DENSITY IN THE MAGNETOSPHERE

(Presented by Academician M. A. Sadovskii, 23 X 1968)

In addition to direct measurements, the plasma concentration in the magnetosphere is estimated from ground-based observations of natural electromagnetic emissions in the kilohertz range (whistling atmospherics) and in the millihertz range (geomagnetic micropulsations). For micropulsations, the method of estimating the concentration has been developed for giant pulsations, which are torsional oscillations whose characteristic feature is the dependence of their period on latitude ([1–3]).

Below, to estimate the plasma density, another type of geomagnetic micropulsations, *Pi2*, is used. According to ([4]), pulsations *Pi2* are a damped Alfvén wave propagating on the night side of the Earth, predominantly at 22–02 hr local time, along a field line resting on the auroral oval. It turned out that the period of *Pi2* is related to the position of the southern boundary of the oval.

The propagation mechanism of *Pi2* makes it possible to determine the period of the oscillations from the relation

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

where dS is an element of the arc of the field line; Φ_0 is the geomagnetic latitude of the projection onto the Earth' s surface of the field line along which the oscillation propagates; V_a is the Alfvén velocity of wave propagation along the field line. For the change in plasma concentration along the field line we take ([5])

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

where n_S is the plasma density at point S of the field line with field strength H_S; n_e is the density at the equator; α is the distribution parameter of the

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low-energy component of the plasma with respect to pitch angles. For a dipole magnetic field,

$$T = 3.68 \cdot 10^{-2} \frac{\sqrt{n_e}}{\cos^8 \Phi_0} I(\alpha, \Phi_0). \tag{3}$$

Fig. 1. Period of pulsations *Pi2* in the winter season as the intensity of magnetic disturbances changes in the near-midnight hours. 1 –1957, 2 –1961.

The values of the integral $I(\alpha, \Phi_0)$ for $45^\circ < \Phi_0 < 85^\circ$ and $0 \leq \alpha \leq 10$ are calculated in ([2]). The density of the low-energy plasma increases in the direc-

to the Earth; therefore the parameter α must be less than 1. The latitude of the projection onto the Earth's surface of the oscillating flux tube can be determined from data on the position of the southern boundary of the auroral oval. Then relation (3) determines the dependence of n_e on Φ_0 or on the geocentric distance $R = 1/\cos^2 \Phi_0$.

Figure 1 shows, on the basis of data from simultaneous measurements, the periods of $Pi2$ in the winter months of 1957 and 1961 as a function of the intensity of the magnetic disturbance at $\Phi \sim 65^\circ$ (index Q). The individual values are indicated by points; the dashed line is the linear approximation for 1961 obtained by the method of least squares. The analogous straight line for 1957 is shown by a solid line.

As the disturbance increases, the periods of the oscillations decrease. If $Pi2$ arise at the boundary of closed field lines of dipole type, then the decrease of T with increasing Q is due to the occurrence of oscillations on increasingly shorter field lines. In ([6,7]) it was shown from observations of low-altitude satellites that the boundary of the region of trapped radiation, reflecting the position of the boundary of closed field lines of dipole type, in the nighttime hours during magnetic disturbances does indeed approach the Earth. Assuming that Φ_0 of the oscillating field line coincides with the southern boundary of the auroral oval, which for the IGY period is obtained in ([8]), the dependences $n_e(R)$ for 1957 and 1961 were calculated from relation (3); they are given in Fig. 2. The obtained relation $n_e(R)$ in implicit form also contains the change in density with increasing magnetic disturbance. The position of the southern boundary of the oval is determined both by the intensity of polar magnetic disturbances (DP) and by the ring current in the magnetosphere (DR). Since the pulsation periods were not reduced to fixed values of DR, such a correction was also not introduced into the latitude of the oval. It was assumed that the intensity of DR for identical indices of magnetic activity Q remains at the same level both in determining T and in determining the southern boundary of the oval. This assumption is confirmed by a direct check.

Fig. 2. Plasma density in the equatorial plane at different geocentric distances. a–1957 ($\alpha = 0$); b–1957 ($\alpha = -2$); v–1961 ($\alpha = 0$); g–measurements of the IMP-1 satellite, 27 XI 1963.

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Figure 2

Figure 1: Figure 2

For 1957 the calculation is carried out for $\alpha = 0$ and $\alpha = -2$, i.e., the limiting possible values of α, since already at $\alpha = -2$ the plasma density according to relation (2) decreases along the field line by more than 3 orders of magnitude. At $\alpha = 0$ the decrease only slightly exceeds one order of magnitude, which differs substantially from theoretical estimates ([9]). The value $I(\alpha, \Phi_0)$ for $\alpha = 0$ was taken from ([2]); for $\alpha = -2$ it was found by numerical integration.

From the data presented in Fig. 2, in addition to an increase of density with decreasing geocentric distance, there follows a decrease of n_e by a factor of $1\frac{1}{2}$ with the decline of solar activity. Such a decrease continued into 1964 as well. The calculated values of n_e agree with the results of measurements on the IMP-1 satellite ([10]), which are also given in Fig. 2. Taking into account that in 1963, according to pulsation data, n_e is less than in 1961, it should be assumed that the variation of n_e with R at $\alpha = 0$ agrees better with the experimental data than at $\alpha = -2$. Apparently, a more accurate allowance for the propagation trajectory of $Pi2$, in particular for the deviation of the field line from a dipole one, will make it possible to draw a more definite conclusion

about the magnitude of the parameter α, which is an important characteristic of the low-energy plasma filling the magnetosphere.

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