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II-1B-P4. Geomagnetic Pulsations and Hydromagnetic Oscillations of Exosphere

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As is well known, the geomagnetic micropulsation have become of significant importance in geophysics as shown by the recent theoretical investigation.

According to the morphological study of the geomagnetic pulsation, it can be devided into two main classes, one is continuous pulsation and the other is *pt* pulsation.

Of course besides these two main class pulsations there is the storm time pulsation which is considered to appear simultaneously overlapped above two kinds of pulsation by each other.

Continuous pulsation appears mainly in the day hemisphere while *pt* pulsations appear only in the night hemisphere.

It is very clear that there are a few kinds of the continuous pulsation and the characteristics of each kind of pulsation are illustrated in the Table I.

The *pc* pulsation (period 10~50 sec), the continuous pulsation type II (period 50~150 sec) and the continuous pulsation type III (period 150~900 sec) are the most typical continuous pulsations.

The most essential characteristics for the continuous pulsation are that the activity become maximum in auroral zone, especially remarkable for type II and type III, that is, the long period continuous pulsation appears mostly in the high latitude and the amplitude attains maximum in the auroral zone, and the mode of oscillation becomes torsional in high latitude while in lower and middle latitudes the oscillation is mainly poloidal.

The primary sources of these daytime continuous pulsations are attributed to the

Table I.

	Period (sec)	Notation (IAGA)	Characteristics	Remarks
Continuous pulsation	1~6		Appears in evening, night and early morning.	Pulsations are excited during the sharp increases in cosmic-ray intensity in the stratosphere. *PP* (Toroitskaya).
〃	1~10		The pulsation has largest amplitude in auroral region.	Close correlation with appearance of aurora. *ps* (Oguti).
〃	10~50	*pc*	Daytime pulsation. The activity becomes large with the latitude.	Continuous pulsation. Type I (Kato *et al.*)
〃	50~150		Daytime pulsation. Amplitude increases with latitude and reaches maximum in auroral zone.	Continuous pulsation. Type II (Kato *et al.*)
〃	150~600	(*pg*)?	Appears in daytime and night-time. Amplitude attains maximum in auroral zone. Daytime T=150~300 Night-time T=300~600	Continuous pulsation. Type III (Kato *et al.*) *Lpc* (Jacobs and Sinno)
Damped type pulsation	60~120	*pt*	Appears in night hemisphere. Amplitude attains maximum in auroral zone.	Close correlation with X-ray burst. (Brown and Campbell) (Kato) *S.I.P.* (Toroitskaya) *Spt* (Yanagihara)

large hydromagnetic disturbances with the spectra of 1~300 sec in the outermost exosphere found by Sonett *et al.* in the distant magnetic surveys.

The emission of hydromagnetic wave from this region may consist of two kinds of waves, that is the transverse mode propagating only to the direction parallel to the lines of magnetic force from the source region and the other one is the isotropic mode propagating into all directions, though these two mode are coupled in general.

There are total or partial reflections for the propagation of isotropic mode in the normal direction of lines of force, and a part of the energy of these reflected waves will be transformed into transverse waves and be propagated to the higher latitudes along the lines of geomagnetic force through this level.

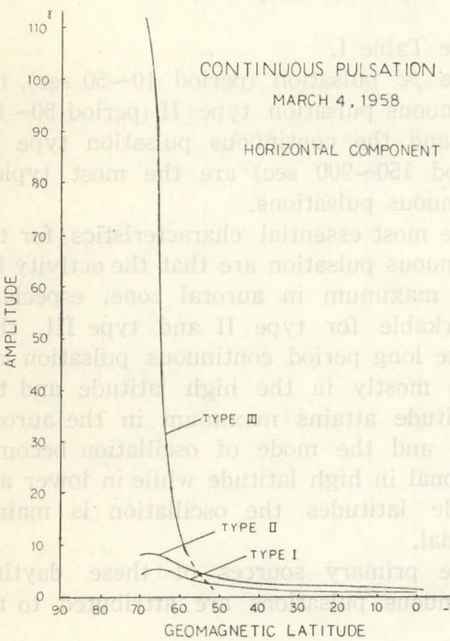

Fig. 1. Latitude dependence of amplitude of continuous pulsation, horizontal component.

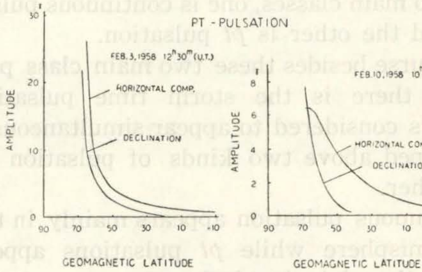

Fig. 3. Latitude dependence of amplitude of *pt*-pulsation.

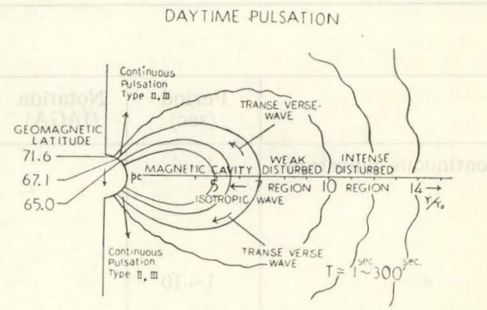

Fig. 4. Schematic illustration of behaviour of daytime pulsation.

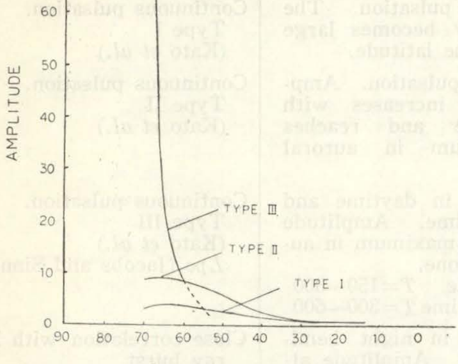

Fig. 2. Latitude dependence of amplitude of continuous pulsation, declination.

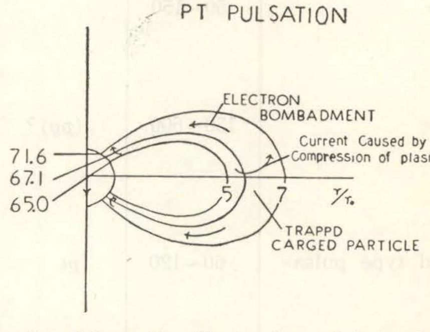

Fig. 5. Schematic illustration of behaviour of *pt*-pulsation.

There is no reflection for isotropic waves which can penetrate this level of maximum speed, therefore the oscillations are mainly poloidal in lower and middle latitudes, while in the higher latitude torsional oscillations become predominant.

The long period continuous pulsation (Type III) may be caused by the hydromagnetic disturbance of largest period and largest dimension excited in the weak disturbed exosphere, and the wave will propagate parallel to the magnetic lines of force to the higher latitude. Therefore we can observe these long period pulsation mainly in higher latitude or auroral zone.

The most essential characteristics of *pt* pulsation are that the *pt* pulsation is observed most frequently in the night hemisphere with the bay disturbance, and the amplitude of *pt* pulsation increases with the latitude and attains the maximum in the auroral zone and the occurrence of *pt* pulsation has close correlation with the X-ray burst which may be caused by the precipitation of energetic electrons with the energy of the order of 100 Kev and flux of $10^{10}\,\mathrm{cm}^{-2}\,\mathrm{sec}^{-1}$. It seems that these energetic electrons are trapped in the exosphere.

In the equilibrium state, there is mechanical balance between the outward pressure gradient and the inward magnetic force due to the diamagnetic current. Therefore if these trapped energetic electrons suddenly precipitate into the lower ionosphere, the pressure contribution due to these electrons will disappear and the local plasma in that region will be compressed by the inward magnetic force. Compression of the plasma causes the increase of the flux of field involved which is equivalent to the current of reverse direction of original diamagnetic current.

Increase of the field in the local plasma will be transported to the lower region as a hydromagnetic wave propagating parallel to the lines of magnetic force through that region.

It is suggested that *pt* pulsation may be caused by the above stated hydromagnetic disturbance.

Discussion

Jacobs, J. A.: K. Sinno and myself found a different latitude dependence of the amplitude of *pt*'s according to whether they were associated with positive or with negative bays.

Whitham, K.: It appears to me that observationally we are dealing in general with a wide band phenomenon and that much of the discussion of exospheric oscillation theories deals with a more or less subjective selection of narrow band examples. Could Dr. Kato explain if he believes that the background is excited differently or not, or whether his theory is effectively the application of an exospheric filter to a wide band source?

Kato, Y.: The minimum and maximum time scale of hydromagnetic disturbances in the outermost exosphere are estimated as follows,

$$T_{\min} \simeq 1 \text{ sec.}$$
$$T_{\max} \simeq 300 \text{ sec.}$$

This estimated range of the time scale covers well that of the observed pulsation in the day hemisphere (*pc* and other continuous pulsation) during the period without other appreciable geomagnetic disturbance. Therefore the pulsations with wide band spectrum which appear in day hemisphere can be explained by my theory. By my theory of the excitation mechanism of *pt* pulsation, the cause of the night-time pulsation can be explained. Oscillations under one second period may be caused by another mechanism in the ionosphere.