EXCITATION OF PI3 TYPE PULSATIONS DURING SUBSTORM

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Abstract: Two types of long-period geomagnetic pulsations within the Pi3 range (Pip and Ps6) are examined by the comparative analysis of their properties and their places in the development of substorms at high latitudes. Based on various properties differing between Pip and Ps6 pulsations which are clarified in the present paper, it is concluded that these pulsations are accompanied by different types of waves in the magnetosphere and have different generation mechanisms.

Introduction

Long-period geomagnetic pulsations are typical manifestation of magnetospheric substorms in the auroral zone. These pulsations with period greater than 150 sec were called Pi3 type by new classification adopted at the preceding Assembly of IAGA in Kyoto.

New two types of irregular pulsations within the Pi3 range are studied (Fig. 1).

The first type is polar irregular pulsations Pip, with periods from 150 to 400 sec. They were studied by RASPOPOV (1970) and RASPOPOV *et al.* (1971) at Leningrad State University.

The second type is the pulsations of the substorm, Ps6, with periods more than 10 minutes. These pulsations were studied by SAITO and MORIOKA (1971) and SAITO (1972).

We tried to answer some questions. Is the nature of these two types of pulsations same or different? Are there any principal features in behavior and distribution of their parameters? With what structural elements of the magnetosphere the generation of these pulsations is connected?

This report is devoted to the comparative analysis of properties of Pip and Ps6 and their place in the development of substorms at high latitudes.

Comparison between Pip and Ps6 Pulsations

1. Examples of pulsations of Pip and Ps6 during substorm are shown in Fig. 1. One can see that the excitation of pulsations takes place both with periods more than 10 minutes and less than 10 minutes. The Pip tends to be observed in all the three components, *H, D, Z,* and the clearest Ps6 is observed only in

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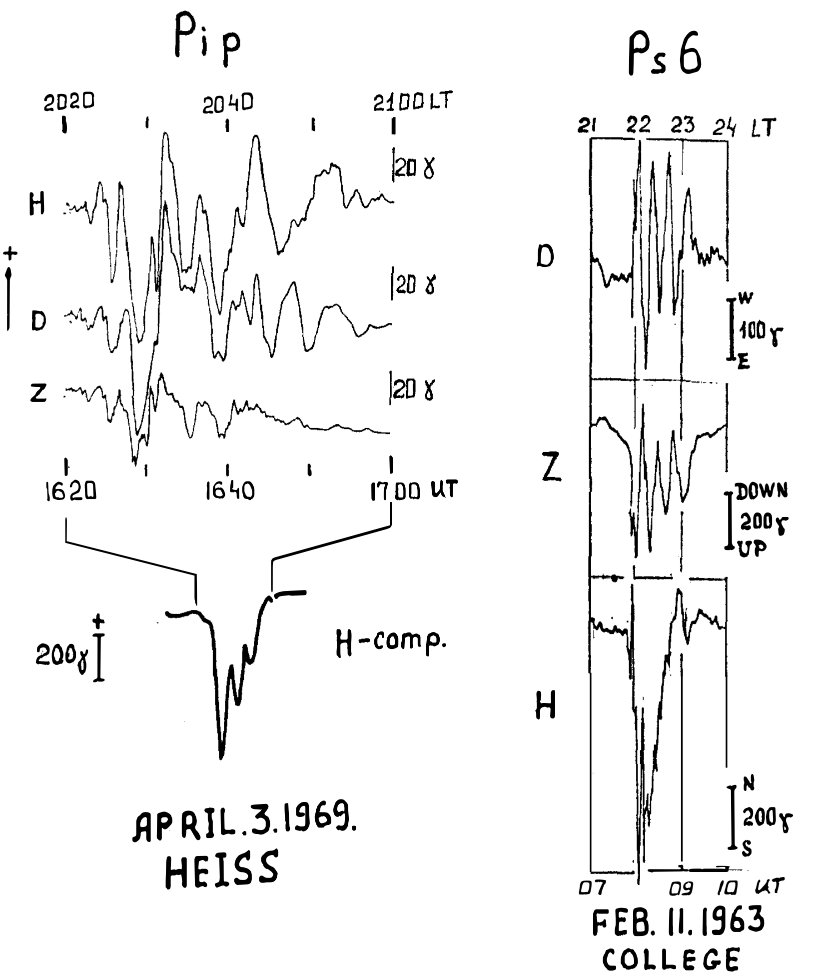

Fig. 1. Examples of two long-period pulsation types accompanying the substorm development.
Left: an example of Pip pulsations recorded at Isle of Heiss observatory, April 3, 1969 (RASPOPOV et al., 1971).
Right: an example of Ps6 pulsations (normal magnetogram), College, February 11, 1963 (SAITO, 1972).

the declination (D-components), as SAITO has pointed out. This is the first difference in the behavior of the pulsations.

2. Example of the dynamic spectrum (the frequency–time diagram) of the pulsations during the substorm on November 18, 1968 is given in Fig. 2. One can see some important differences in the behavior of oscillations with the periods more than 400–600 sec and those with the periods less than 400–600 sec. The Pip pulsations have unstationary spectrum. The period of Pip usually increases during substorm. The period of Ps6 is nearly constant during the substorm.

These differences of spectral characteristics determine the frequency ranges of Pip and Ps6 pulsations. The boundary between these pulsations lies at the

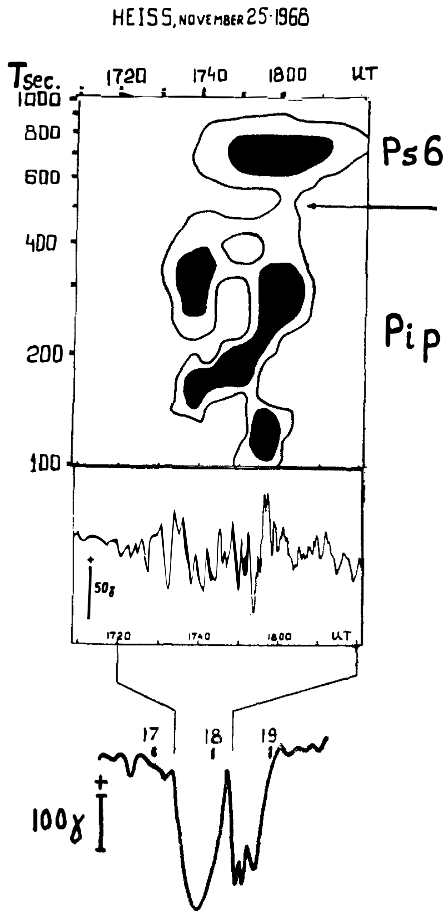

Fig. 2. Example of the dynamic spectrum of the pulsations during substorm on November 18, 1968, Heiss.

level of periods 400–600 sec. This is the second difference in the behavior of the pulsations.

3. Analysis of Pip and Ps6 pulsations in space and time shows that there are differences in location and motion of sources of the pulsations of both types in the auroral zone during substorm. We define the source as the region where the amplitude of the pulsations is maximal.

According to SAITO, the region of maximum amplitudes of Ps6 is located either under the center of the auroral electrojet or at the lower latitudes than auroral electrojet (see Fig. 3a). The wave packet of Ps6 drifts from the midnight auroral zone towards both the dusk- and dawn sides with the velocity of about 1–2 km/sec along the auroral oval and also polewards.

Observation along the meridional chain of stations shows that the maximum amplitude of Pip takes place where the bulge is in the zenith above the observation point (Fig. 3b). The source of Pip is connected with force tubes of the

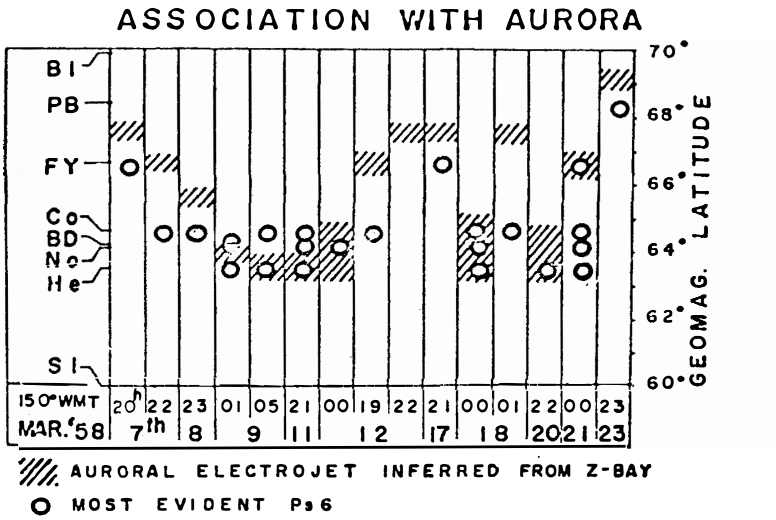

Fig. 3(*a*). *The location of the source of Ps6 and of auroral electrojet* (*SAITO*).

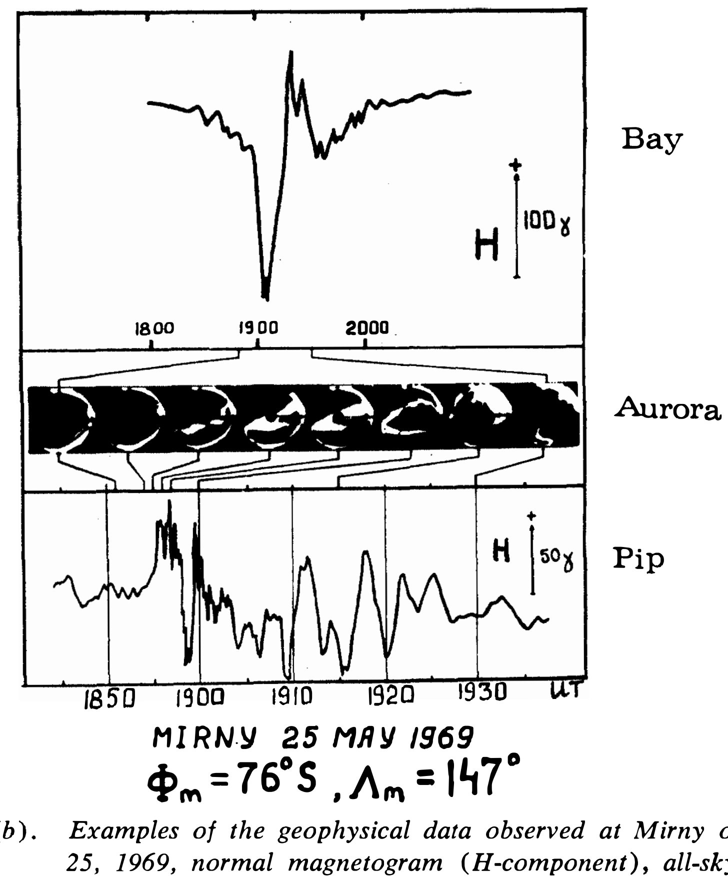

Fig. 3(*b*). *Examples of the geophysical data observed at Mirny on May 25, 1969, normal magnetogram* (*H-component*), *all-sky films, micropulsations of Pip* (*RASPOPOV et al., 1971*).

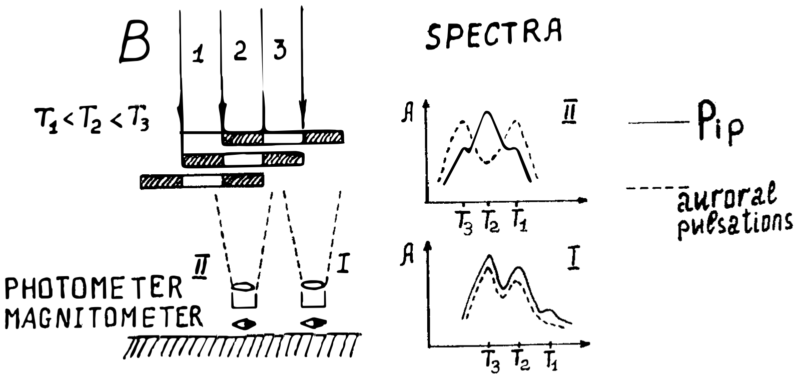

Fig. 4. *The scheme of excitation of Pip and pulsation aurora.*

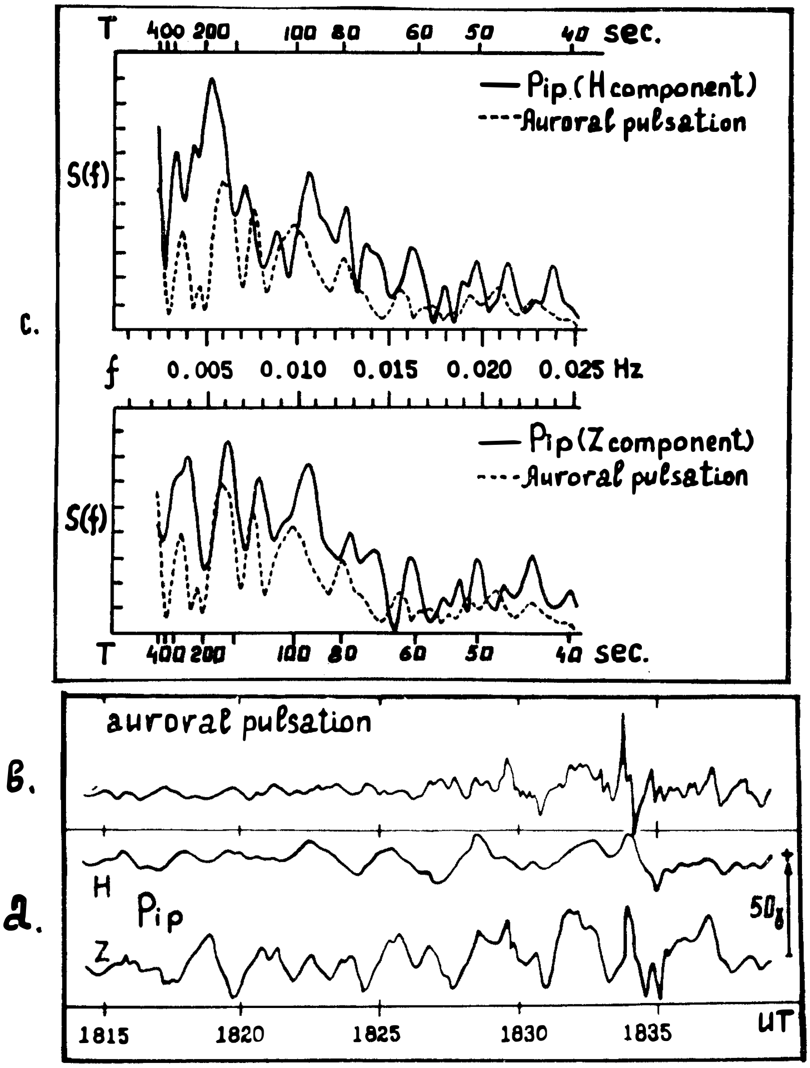

Fig. 5. *Examples of Pip and auroral pulsations observed at Mirny Station on May 9, 1970.*
a: Pip, b: auroral pulsations, c: spectra of Pip and auroral pulsations.

geomagnetic field connected with the bulge and moves polewards during substorm. We consider that this motion is the cause of the unstationarity of the spectrum of Pip (increasing the period of Pip). Predominant motion of the source of Ps6 along the auroral oval does not lead to the change of the spectrum of Ps6.

This is the third difference in the behavior of the pulsations.

4. Pip and Ps6 are accompanied by auroral pulsations. The joint analysis of Pip and auroral pulsations allows to get interesting data (Fig. 4). It was found that the region of auroral pulsations shifted with respect to the region of the maximum amplitude of *H*-component pulsations and was near the region of the maximum amplitude of *Z*-component. When the pulsation generation occurs in some force tubes of the geomagnetic field with different periods the spectra of auroral pulsations will coincide with the spectra of *Z*-component of geomagnetic pulsations, as it has been actually observed.

An example of the spectra of auroral pulsations and Pip is shown in Fig. 5. One can see that the spectra of auroral pulsations and of *Z*-component are similar, whereas spectra of *H*-component and auroral pulsations are different.

5. MHD-waves corresponding to the Ps6 and Pip pulsations were recorded on satellites in the magnetosphere.

The magnetic field variations observed simultaneously in the space by OGO-5 and at the ground stations are shown in Fig. 6 (SAITO, 1972). One can see that on the ground and in the space the *D*-component of Ps6 pulsations dominates.

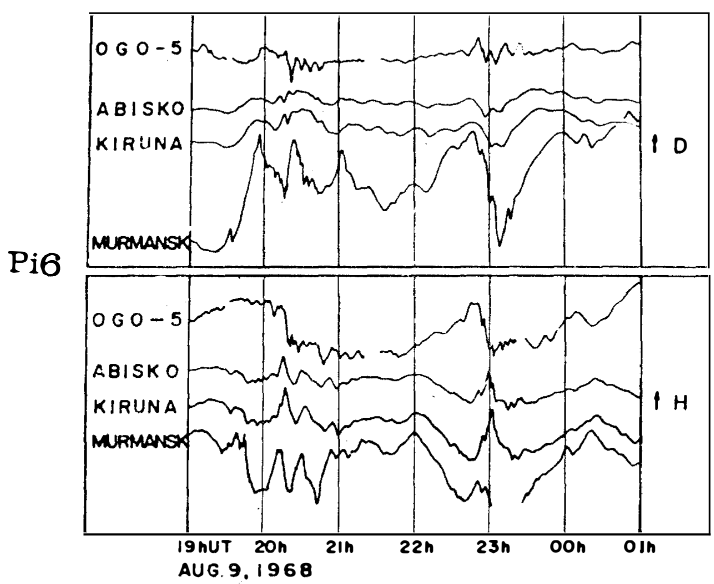

Fig. 6. The magnetic field variations observed simultaneously in the magnetotail by OGO-5 and at the three ground stations. The satellite and the stations were situated approximately around the same magnetic field-line during the observed period (SAITO, 1972).

In Fig. 7 an example of the pulsations recorded at the ATS-I when the satellite crossed the range of the bulge is given (MCPHERRON and COLEMAN, 1970). The pulsations recorded ATS-I in this case had only components along the geomagnetic field, *i.e.* magnetosonic waves. These pulsations can be identified with Pip pulsations.

Thus, in the space Pip and Ps6 pulsations are accompanied by the waves of different type. This is the fourth difference in the behavior of pulsations.

Conclusion

Thus, one can say that the behavior of parameters of Pip and Ps6 pulsations is different (see Table 1). These pulsations are accompanied by the different types of waves in the magnetosphere. This allows to suggest that the Ps6 and Pip pulsations have different generation mechanisms.

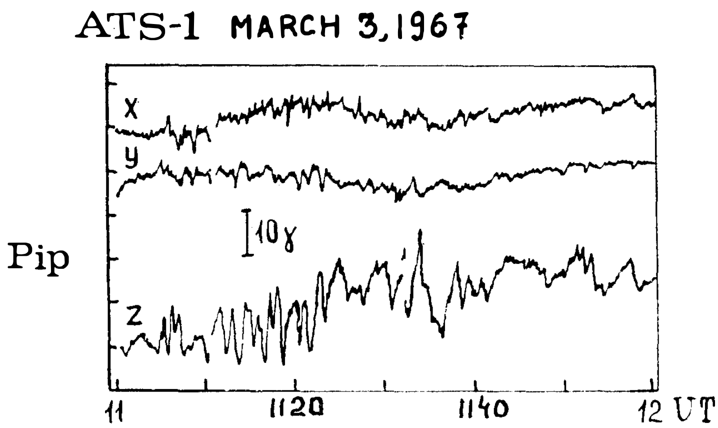

Fig. 7. *High time resolution data for magnetic fluctuations at ATS during substorm, U-12 UT, March 3, 1967. (MCPHERRON and COLEMAN, 1970).*
Z: Parallel to earth's rotation axis.
Y: Positive eastward in the equatorial plane.
X: Radially outward.

Table 1. Differences in the behavior of pulsations.

	Pip	Ps6
1. Period	400 sec	400 sec
2. Diurnal variation (local time)	Before midnight	Before and after midnight
3. Polarization		
a. at the ground	H, D, Z-components	D-component
b. in the space	Magnetosonic waves	D-component
4. Location of the source	Bulge	Centre of auroral electrojet
5. Association with aurora	Accompanied by auroral pulsations.	

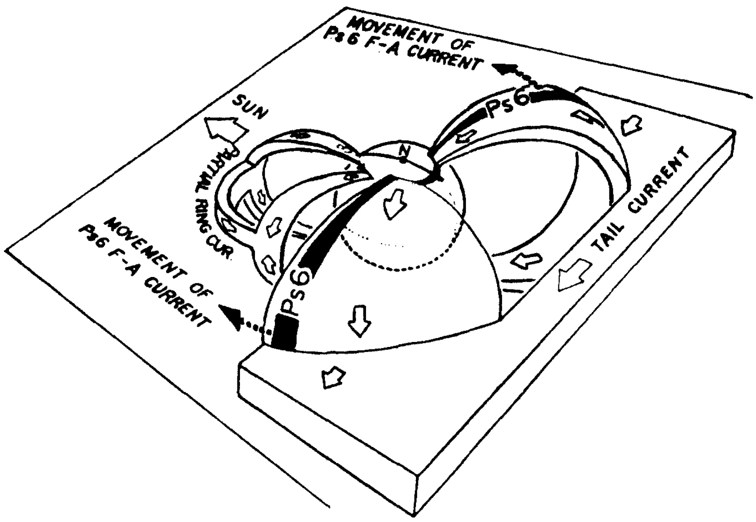

Fig. 8. The scheme of Ps6 generation (According to SAITO*).*

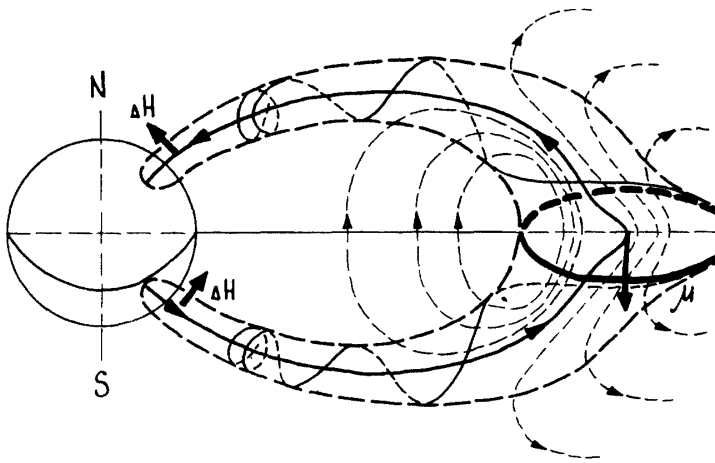

Fig. 9. The scheme of Pip generation (According to RASPOPOV *and* KISELEV*).*

According to SAITO, the Ps6 pulsations are the oscillations of three-dimensional current system of the substorm. The scheme of Ps6 generation is given in Fig. 8.

The Pip generation may be the result of the sharp decrease of the concentration at the warm plasma in geomagnetic tubes during the development of aurora in the bulge region (Fig. 9).

The change of the diamagnetic moment of particles in tube results in the appearance of MHD-disturbance of magnetosonic type. This disturbance leads to the resonance of transverse MHD-waves.

The difference of physical nature of Pip and Ps6 pulsations allows us to change the classification of geomagnetic pulsations, in our opinion, in the following way:

Pi1	$T<15$ sec
Pi2	$15<T<150$ sec
Pi3=Pip	$150<T<500$ sec
Pi4=Ps6	$500<T$

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