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The characteristics of Pi2 pulsations at Great Wall Station, Antarctica*

Yang Shaofeng(杨少峰) and Xiao Fuhui (肖福辉)
Institute of Geophysics, Academia Sinica, Beijing 100101, China

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Abstract In this paper Pi2 pulsation events at Great Wall Station of Antarctica are analyzed from August 16, 1990 to November 20, 1990. Their main characteristics e. g. occurrence frequency, frequency, and polarizations are recognized. The mechanism of excitation for Pi2 pulsations at Great Wall Station is here discussed theoretically.
Key words Antarctica, Pi2 pulsations.

1 Introduction

There is a close relation between Pi2 pulsation and substorm(Sakurai and McPherron, 1983). Studying of Pi2 pulsations in the antarctic region is very important to understand the generation process of magnetospheric substorm and to obtain a lot of information about spatial electromagnetic environment in the magnetotail. Pi2 geomagnetic pulsation is a kind of damped pulsations that has a period from 40 to 150 s and a duration from 5 to 7 min. This phenomenon is observed not only at high and middle latitudes but also at low latitude. However, the characteristics of Pi2 pulsations are different at different regions.

The characteristics of Pi2 pulsations at high latitude($L>4$) are as follows: (1) Azimuthal wave number m of Pi2 pulsation propagation is 10～20(Samson and Harrold, 1985); (2) $\boldsymbol{H}$ components of Pi2 pulsations are in phase and $\boldsymbol{D}$ components are out of phase at conjugate observation(Sugiura and Wilson, 1964); (3) The right- handed polarizations are dominant(Kuwashima, 1978).

The characteristics of Pi2 pulsations at middle latitude($4 \geqslant L \geqslant 2$)(Lester *et al.*, 1983) are as follows: (1) Azimuthal wave number m of Pi2 pulsations is about 3 and the phase propagations of both $\boldsymbol{H}$ and $\boldsymbol{D}$ components along longitudinal direction are different; (2) The left-handed polarizations are dominant; (3) The distribution pattern of Pi2 polarizations ellipses is that the orientation of major axes rotates clockwise along longitudinal direction from east to west.

The characteristics of Pi2 pulsations at low latitude(Yumoto, 1986) are as follows:

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(1) The polarization distribution is relative with local time and geomagnetic latitude; (2) Azimuthal wave number is related with latitude and longitude; (3) Pi2 pulsation occur simultaneously in a wide region; (4) Daytime Pi2 pulsations have equatorial enhancement.

This paper is to study Pi2 events selected from the observed data of geomagnetic pulsations at Great Wall Station of Antarctica during August 16, 1990 to November 20, 1990. The occurrence frequency, frequency and polarization of Pi2 pulsations are analyzed, and the generation mechanism of Pi2 pulsations recorded at Great Wall Station is studied theoretically.

Fig. 1 gives an example of selected Pi2 pulsation events at Great Wall Station of Antarctica. The standards for selecting Pi2 pulsation events are those: Pi2 pulsations have obvious damped oscillated waveforms and the major amplitudes are obviously greater than the Pc pulsations at other intervals; the major frequencies are from 45 s to 150 s; the durations are from 5 min to 7 min generally. 25 Pi2 pulsation events are selected in this period, as seen in Table 1.

Talbe 1. General survey of Pi2 pulsation events

	Date	Beginning time (LT)	Duration (min)	Main frequency (mHz)	Ellipticity	Polarization	Major axis (°)
1	Aug. 16,1990	11 38	6	16.57	2/7	0.28RH	42
2	Aug. 16,1990	19 31	6	11.83	3/7	0.42RH	28
3	Aug. 16,1990	19 38	6	26.03	1/11	0.09LH	20
4	Aug. 16,1990	22 03	6	21.30	4/10	0.4LH	−35
5	Aug. 17,1990	19 53	6	21.30	3.5/14	0.25LH	88
6	Aug. 17.1990	22 24	8	23.67	6/13	−0.46RH	−75
7	Aug. 18,1990	20 15	5	16.57	5/10	0.50LH	−52
8	Aug. 18,1990	23 58	6	16.57	3/9	−0.33RH	−26
9	Aug. 19,1990	00 06	7	14.20	2.5/14	0.18LH	−19
10	Aug. 19,1990	00 21	5	14.61	2/8	−0.25RH	80
11	Aug. 19,1990	23 10	9	18.93	3.5/12	0.29LH	−75
12	Aug. 19,1990	23 38	6	11.83	6/15	−0.40RH	33
13	Aug. 19,1990	23 45	4	14.16	1/6	0.17LH	58
14	Sep. 12,1990	21 54	6	14.20	7/16	−0.44RH	−58
15	Sep. 12,1990	22 08	5	14.20	4/12	−0.33RH	−83
16	Sep. 22,1990	00 03	6	11.83	5/9	−0.56RH	88
17	Sep. 22,1990	01 16	5	11.83	4/9	−0.44RH	85
18	Oct. 15,1990	22 32	6	23.67	6/12.5	−0.48RH	−82
19	Oct. 18,1990	21 45	3	26.04	2.5/9	−0.28RH	−56
20	Oct. 18,1990	21 54	3	28.40	1.5/6	−0.25RH	−67
21	Oct. 18,1990	22 12	8	21.30	5/9	−0.56RH	−46
22	Oct. 24,1990	02 02	7	9.46	3/9	0.33LH	21
23	Oct. 30,1990	23 50	5	14.20	2.5/13	−0.19RH	−53
24	Oct. 31,1990	00 45	6	14.20	5/8.5	−0.59RH	84
25	Nov. 19,1990	23 56	5	14.20	5/14	0.36RH	63

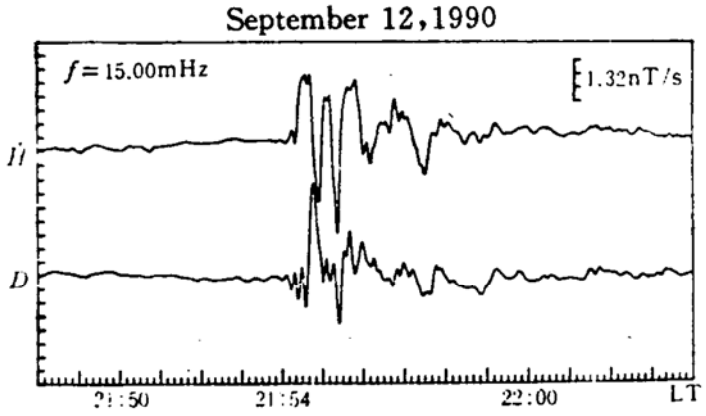

Fig. 1. An example of Pi2 pulsations at Great Wall Station, Antarctica.

2 The characteristics of occurrence frequency of Pi2 pulsations at Great Wall Station

Pi2 pulsations recorded in an interval of each hour are analyzed statistically according to the local time of Great Wall Station. So the diurnal variation curve of Pi2 pulsation occurrence frequency has got(see Fig. 2).

It can be seen from Fig. 2 that in the occurrence frequency there are 25 altogether from August 16, 1990 to November 20, 1990 and they mainly occur from 2100 LT to 0200 LT, and count 18, accounting for 72% of the total occurrence frequency. The highest occurrence frequency of Pi2 pulsations happens at midnight from 2300 LT to 0000 LT, there are 6 in total, which amount to 24% of total occurrence frequency. This implies that Pi2 pulsations mainly occur at midnight or near zero o'clock.

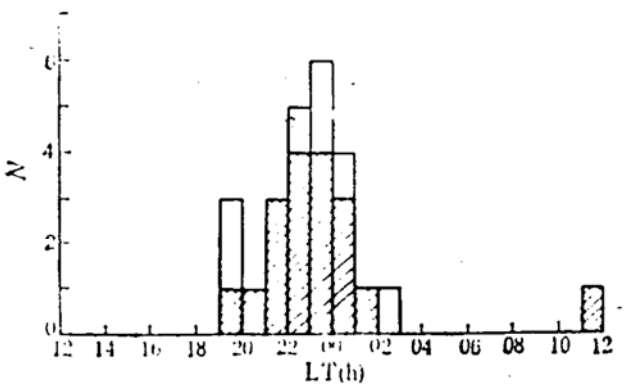

Fig. 2. The diurnal variation curve of occurrence frequency of Pi2 pulsations at Great Wall Station.

There are 3 Pi2 pulsation events recorded from 1900 LT to 2000 LT. Those Pi2 pulsations occur in the evening. Except for that at night, their occurrence frequency is more than that at other intervals. In addition, some Pi2 pulsations can be sometimes observed near noon 1200 LT.

The fact that Pi2 pulsations at Great Wall Station of Antarctica mainly occur at night implies the relation between Pi2 pulsation and magnetic substorm generated at the magnetotail. As to Pi2 pulsation event observed at daytime or even at noon, it might result from the global effects of substorm process.

3 The characteristics of frequency of Pi2 pulsations at Great Wall Station

Fourier spectrum analyses are made for each Pi2 pulsation event recorded in this period. The beginnig time of Pi2 pulsation events is the starting point of data for spectrum analyses. 512 points are sampled continually and sampling frequency is 1.2 Hz. Therefore, FFT spectrum analysis has been done for the sampling data. Fig. 3 gives a Fourier spectrum of ***H*** component for some Pi2 pulsation event. The peak value of the spectrum which has the greatest amplitude is called the main frequency of the Pi2 pulsation.

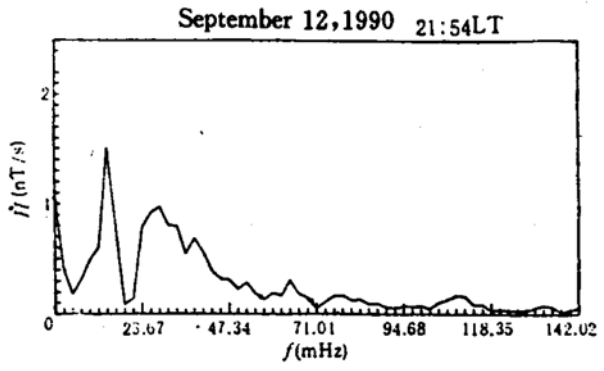

Fig. 3. The Fourier spectrum of a Pi2 pulsation at Great Wall Station.

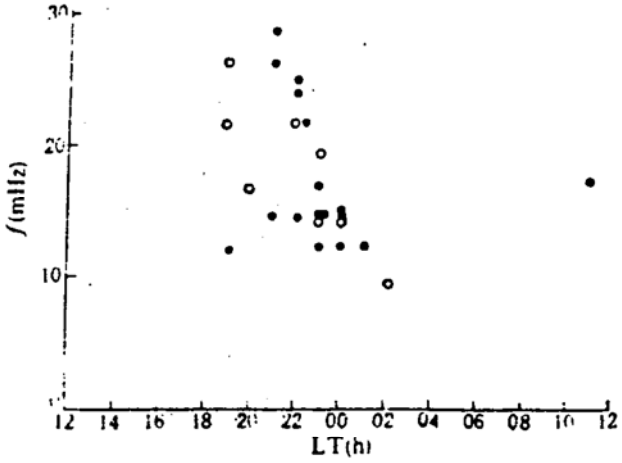

Fig. 4. The variation of main frequencies of Pi2 pulsations at Great Wall Station with local time.

If taking the main frequency of Pi2 pulsation as the ordinate and the local time as abscissa, we can draw a figure showing the change of frequency of Pi2 pulsations in the local time. Fig. 4 gives the main frequencies of Pi2 pulsations at Great Wall Station in the local time. It can be also seen that the main frequencies of Pi2 pulsations occur before 2300 LT at night with a wide range from 11.83 mHz to 28.40 mHz. The highest frequency has been in the the Pc3 pulsations. The nearer to midnight 0000 LT it is, the narrower the range of main frequencies becomes. After 0000 LT at midnight the range of main frequencies for Pi2 pulsations is from 11.83 mHz to 14.20 mHz.

The main frequencies of Pi2 pulsations at Great Wall Station range concentratedly between 11 mHz and 15 mHz, and count about 12, in number, amounting to 48% of the total number. Moreover, the occurrence frequencies of Pi2 pulsations between 20 mHz and 22 mHz are also higher than others, they are 3 altogether, accounting for 12% of the total number.

4 The characteristics of polarizations of Pi2 pulsations at Great Wall Station

The five point smoothing average has been made for each waveform curve of Pi2 pulsation events. ***H*** components of new data for smoothing filtered waveform curves are regarded as components of Y axis and ***D*** components of new data as those of X axis. So the polarization ellipses of Pi2 pulsation events are obtained. Fig. 5 gives the waveforms

of filtered Pi2 pulsations and corresponding polarization ellipses.

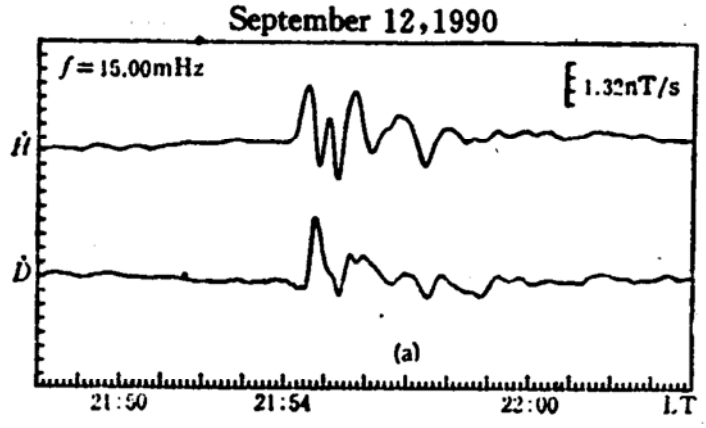

Fig. 5 (a) The filtered waveform curves of a Pi2 pulsation at Great Wall Station; (b) Corresponding polarization ellipse.

In Fig. 5 the histogram expresses the occurrence frequencies of Pi2 pulsations and shaded part of them indicates the left-handed polarization. It can be seen from Fig. 5 that the left-handed polarization of Pi2 pulsations are dominant at night because the events with left-handed polarization occur 16 times, occupying 64% of 24 Pi2 pulsation events from 1900 LT to 0200 LT.

Fig. 6 gives the oriented variation of major axes of polarization ellipses for Pi2 pulsations at Great Wall Station with the local time. It can be seen from Fig. 6 that at night the Pi2 pulsations of Great Wall Station is mainly in a direction of NW-SE before 2300 LT and that in a direction of NE-SW after 2300 LT. The orientation of major axis of polarization ellipses with the local time is converse distributionally to that in the northern hemisphere. Such a fact proves that at Great Wall Station the formation of Pi2 pulsation can be explained with the theory of electric current wedge of magnetospheric substorm.

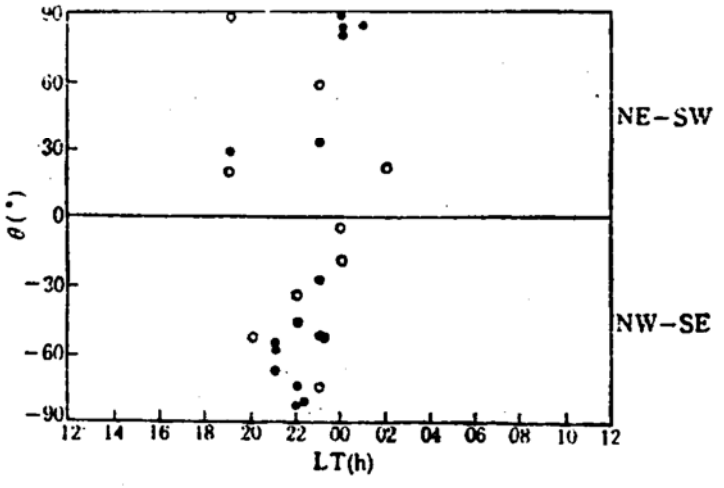

Fig. 6. The oriented variation of major axes of polarization ellipses with local time for Pi2 pulsations at Great Wall Station.

Fig. 7 gives the distribution of polarization ellipticity with the local time. The ellipticities of left-handed polarization are distributed between −0.19 and −0.59 and those of right-handed polarization are distributed between 0.09 and 0.5. Generally speaking, the absolute polarization ellipticities of Pi2 pulsations at Great Wall Station are often less than 0.5. This implies that the ellipticities of Pi2 pulsations are rather slender and long.

5 Discussion

Accoding to the analyses of observed information for Pi2 pulsations at Great Wall Station mentioned above, the characteristics of Pi2 pulsations at Great Wall Station of Antarctica are as follows:

(1) Pi2 pulsations mainly occur at night from 2100 LT to 0200 LT at Great Wall Station of Antarctica.

(2) The frequencies of Pi2 pulsations at Great Wall Station range concentratedly between 11 mHz and 15 mHz.

(3) The variation range of frequency of Pi2 pulsations at Great Wall Station is wider before 2300 LT and narrower after 2300 LT.

(4) The polarization of Pi2 pulsations at Great Wall Station is mainly left-handed and the absolute value of polarization ellipticities is less than 0.5 generally.

(5) The major axes of polarization ellipticities for Pi2 pulsations at Great Wall Station are mainly in the orientation of NW- SE before 2300 LT but in the orientation of NE-SW after 2300 LT.

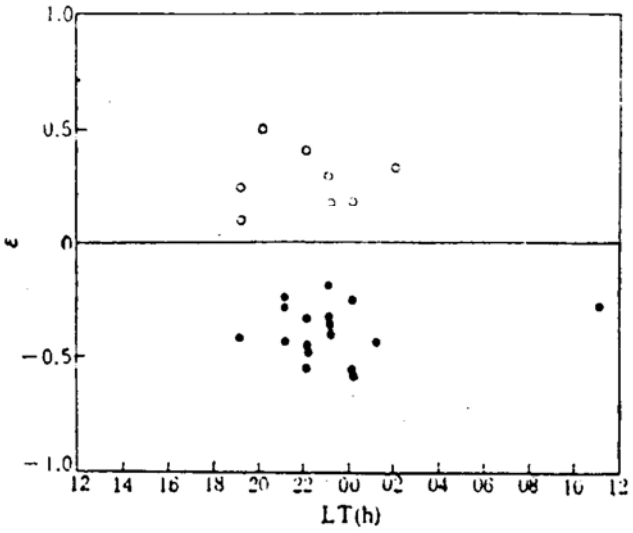

Fig. 7. The distribution of polarized ellipticities of Pi2 pulsations at Great Wall Station with local time.

It can be seen from Pi2 pulsations at Great Wall Station of Antarctica that there is a universal relationship between Pi2 pulsation and magnetospheric storm. The occurrence of magnetospheric substorm in the magnetotail region, either in the southern hemisphere or in the northern hemisphere, exerts a worldwide influence mainly on the night side. So we can see the first characteristic of Pi2 pulsation at Great Wall Station.

The problem whether other three characteristics of Pi2 pulsations at Great Wall Station are local or global must be studied further. Comparing with the basic features of Pi2 pulsations at high, middle and low latitudes, Pi2 pulsations at Great Wall Station belong to that at middle and low latitudes. On the basis of the multistation observation of Pi2 pulsations at low latitude region of our country(Yang, 1991), the frequency range of low latitude Pi2 pulsations is 8.8～19.55 mHz, the frequencies range widely at about midnight, polarization ellipticities are usually less than 0.5, and the polarizations are mostly left-handed at night.

The last characteristic of Pi2 pulsations at Great Wall Sation is favourable to theory of generated mechanism of Pi2 pulsations that the disturbed field-aligned current in the substorm current wedge can product the Pi2 pulsations(Yang, 1992). According to this theory, the global Pi2 pulsations can be formed when there is a damped oscillated field-aligned current in the substorm current wedge. When the angle of substorm current wedge is less than 180°, the effect on the earth's surface at nightside is obvious. The meridian through the centre of current wedge is the line of demarcation. The major axes of polarization ellipses for Pi2 pulsations are in the orientation of NE-SW on the west of the centre and in the orientation of NW-SE on the east of the centre. The case is contrary to that in southern hemisphere. These results are similar to those obtained in our observation.

Here are preliminary results about the problem how Pi2 pulsations on earth are formed at Great Wall Station of Antarctica. Some information needs to be analyzed in detail. Studying of characteristics of Pi2 pulsations about phase propagation at Great Wall Station needs to be made on multistation observation in Antarctica, or even in a world-wide observation. Only in this way can we achieve reliable research results.

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