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POSTNOON AURORA OBSERVED AT ZHONGSHAN STATION, ANTARCTICA—A CASE STUDY—

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Abstract: The characteristics of postnoon auroras are examined with all-sky TV data at Zhongshan (invariant latitude 74.49° in Antarctica). From a comparison between ground aurora and DMSP particle data, energetic electrons higher than 1 keV are responsible for the postnoon band aurora. It is remarkable that the postnoon band aurora shows a periodic latitudinal movement with its period about 125 s to 160 s. It is also noted that a bright region moves from the west to the east along the longitudinal direction within the band aurora. These charactreristics are partly similar to auroral behavior obtained in our previous observations at Ny-Ålesund in Spitzbergen.

1. Introduction

Auroral observation started in 1995 at Zhongshan Station, Antarctica which is located at 69.37°S, 76.38°E . The invariant latitude of this station is 74.49° (L=13.98), and the dayside auroras are observable there during the mid-winter period.

For the study of dayside auroral phenomena, EATHER *et al.* (1979) examined the all-sky camera data observed at South Pole Station (74° INV lat.) in the southern hemisphere. He reported that the occurrence of dayside aurora showed a good correlation with the nightside auroral activity rather than Interplanetary Magnetic Field (IMF) Bz polarity. On the other hand, LEONTYEV *et al.* (1992) reported that the latitudinal movement of dayside auroras is related to IMF Bz polarity. SANDHOLT *et al.* (1993) showed that the IMF By polarity controls the longitudinal shift of dayside auroral enhancement region. Recently, AYUKAWA and MAKITA (1996) examined the characteristics of dayside aurora obtained at South Pole Station and showed that the latitudinal movement of dayside aurora were related to IMF Bz polarity. They also considered that Eather's examination result might contain a certain type of aurora which propagated from the nighside region.

On the basis of Greenland and Svalbard auroral data, AYUKAWA *et al.* (1997) examined the characteristics of dayside auroral phenomena and concluded that dayside auroras in the prenoon and the postnoon sectors would be quite different each other. From their examination, corona auroras with ray structure were observed in the prenoon sector and band auroras are in the postnoon sector. The band aurora in the postnoon sector frequently showed a periodic movement. The mechanism of this movement seems to be related to the temporal magnetic field fluctuation in the dayside magnetopause. The characteristics of postnoon aurora are interesting, but this phenomenon has not well been understood yet.

From statistical examinations of DMSP particle data, NEWELL *et al.* (1991) reported that there are four distinct types of plasma in the dayside zone. They are the cusp, the mantle, the low-latitude boundary layer (LLBL) and the dayside extension of the BPS (Boundary Plasma sheet). According to their result, the average electron energy of cusp precipitation is below 200 eV and ions above a few keV energy are dropped out. LUNDIN (1988) and BURCH *et al.* (1982) examined the particle in the cusp region and showed that electrons are isotropic and ions have pitch angle "V" pattern in which the peak energy flux occurs at higher energies for larger pitch angles. Characteristics of LLBL precipitation are similar to those at the cusp, but usually more thermarized and average electron energy is less than 400 eV. Mantle particles are de-energized in comparison with those in the cusp and LLBL; their energies are quantitatively more than a few tens of eV up to about 100 eV. BPS is characterized by the soft precipitation in the poleward region of nightside oval and is embedded by discrete auroras. The dayside extension of the BPS is originated in the nightside BPS. Generally, average electron energy of BPS is higher than 1 keV. Although several researchers examined the characteristics of dayside particle precipitation, the mutual relationship between ground aurora and characteristics of particle precipitation has not been understood yet (BURKE *et al.*, 1993).

On the other hand, UV images obtained by the Viking satellite often showed bright spot in the east-west direction between noon and 1800 MLT (LUI *et al.*, 1989). Viking UV image data showed a distinctive series of periodic bright feature in this region. Magnetic field and hot plasma measurements obtained by Viking confirmed that the UV emissions collocated with the upward-flowing region 1 Birkeland current and precipitating energetic (~200 eV) electrons (POTEMRA *et al.*, 1990). The magnetic field and electric field measurements showed transverse oscillations (predominantly in the westward and southward components) with a nearly constant period of about 3.5 min. They interpreted that the observed oscillations lead the magnetic field oscillations as standing Alfven waves driven by a large scale wave in the boundary layer. Precipitating electrons seemed to be modulated by the boundary wave to produce the periodic UV emission features.

FASEL *et al.* (1994) examined the poleward-moving dayside auroral forms (PMAF). They defined the lifetimes for the PMAF were visible, and the average time between successive PMAF intervals was 6 min. They proposed that the formation, motion and brightening history of PMAF's might be explained by the patchy multiple X-line reconnections.

Since the location of Zhongshan Station is suitable for observing the postnoon aurora, we focused to examine the characteristics of such dayside aurora on the basis of TV data in the mid-winter season. We also compared simultaneous particle data in order to make clear the source region of the postnoon aurora. Since the total amount of data we could examined is not so great, the result obtained in this paper is a preliminary one.

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2. Observation

Auroral TV observations were carried out at Zhongshan Station, Antarctica during the period from March to June, 1995. All-sky TV image data were sampled every 2 s and recorded by video recorder and also by optical video recorder. Total auroral data recorded by 8 mm cassette tapes covered 100 nights. In this paper, we show a preliminary result for a case study of June 21, 1995 event.

Figure 1 illustrates a dynamic spectrum of aurora showing the latitudinal movement and Bz component of Interplanetary Magnetic Field (IMF) during the period from 12 h UT to 21 h UT on June 21, 1995. Since the magnetic local time is ahead of the universal time by about 1.3 hours (MLT=UT+1.3 h) at Zhongshan Station, the auroral event examined here took place in the period from 13.3 h MLT to 22.3 h MLT. The auroral dynamic spectrum shows the geomagnetic southward (poleward) and northward (equatorward) direction, respectively. The intense auroral regions correspond

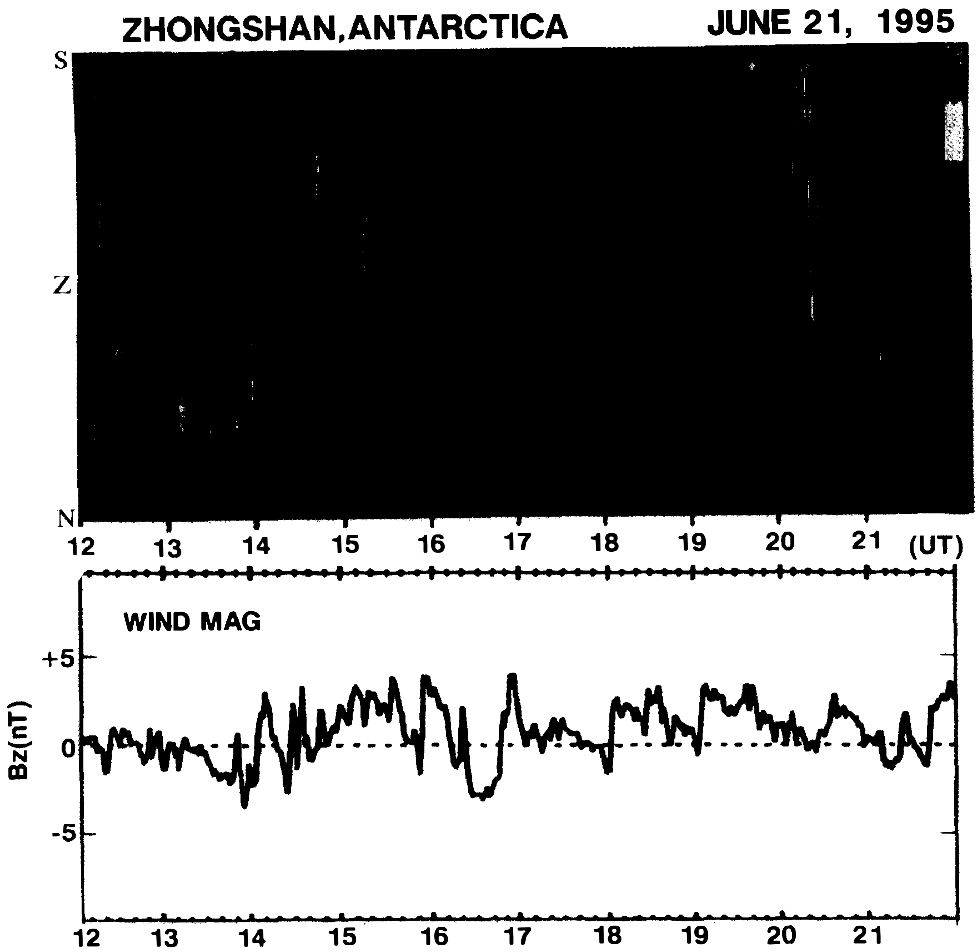

Fig. 1. Upper panel is auroral dynamic spectrum along the S-N geomagnetic meridian line. Lower panel is Bz component of interplanetary magnetic field (IMF) obtained by Wind Satellite. Postnoon auroral activity is seen during the period from 12 h to 16 h UT (13.3 h to 17.3 h MLT). The night side aurora appears after 19 h UT. Active auroral region seems to move equatorward when IMF Bz component becomes negative.

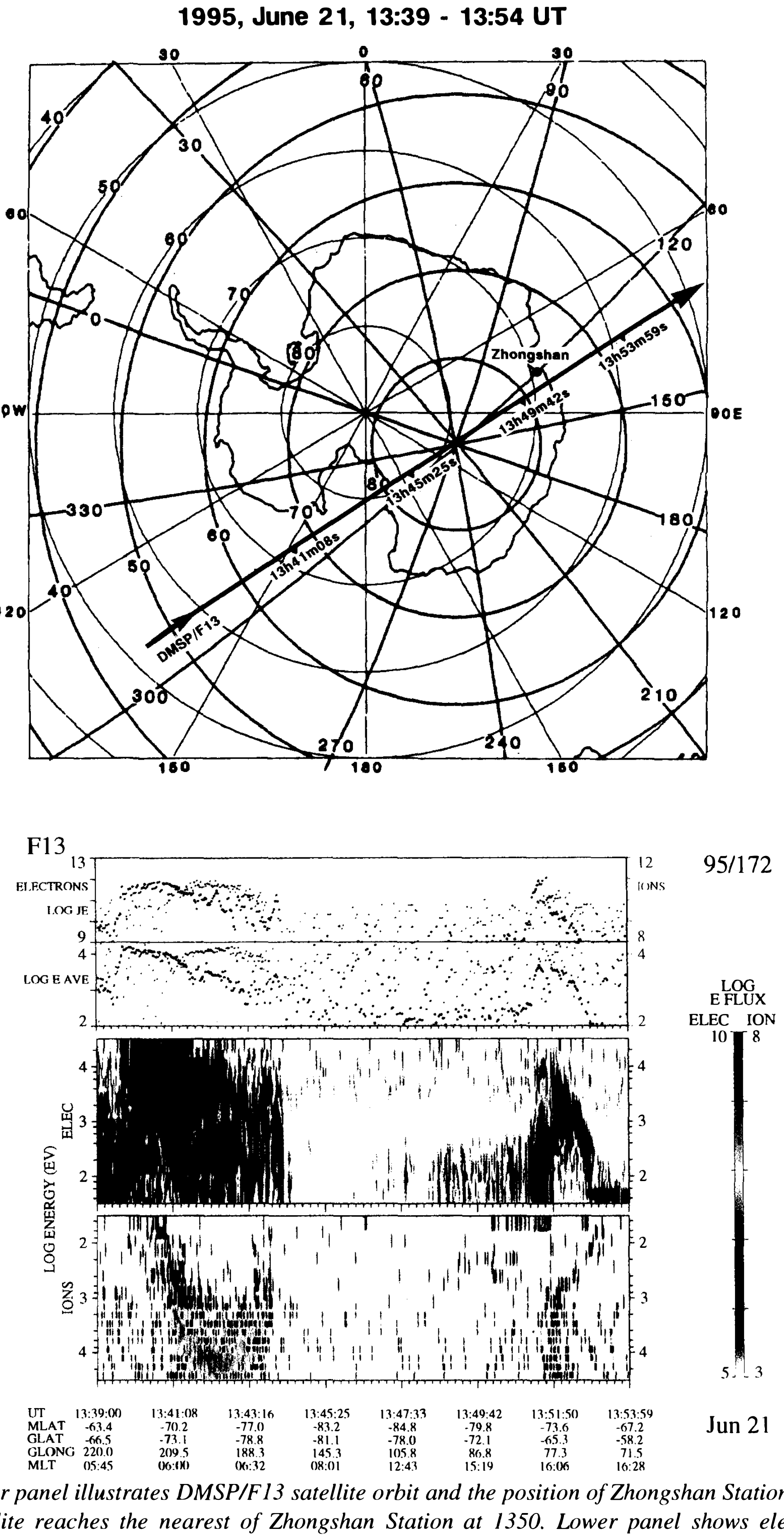

Fig. 2. Upper panel illustrates DMSP/F13 satellite orbit and the position of Zhongshan Station. DPSP/F3 satellite reaches the nearest of Zhongshan Station at 1350. Lower panel shows electrons and ions data. The enhancement of electron flux is seen at 1350.

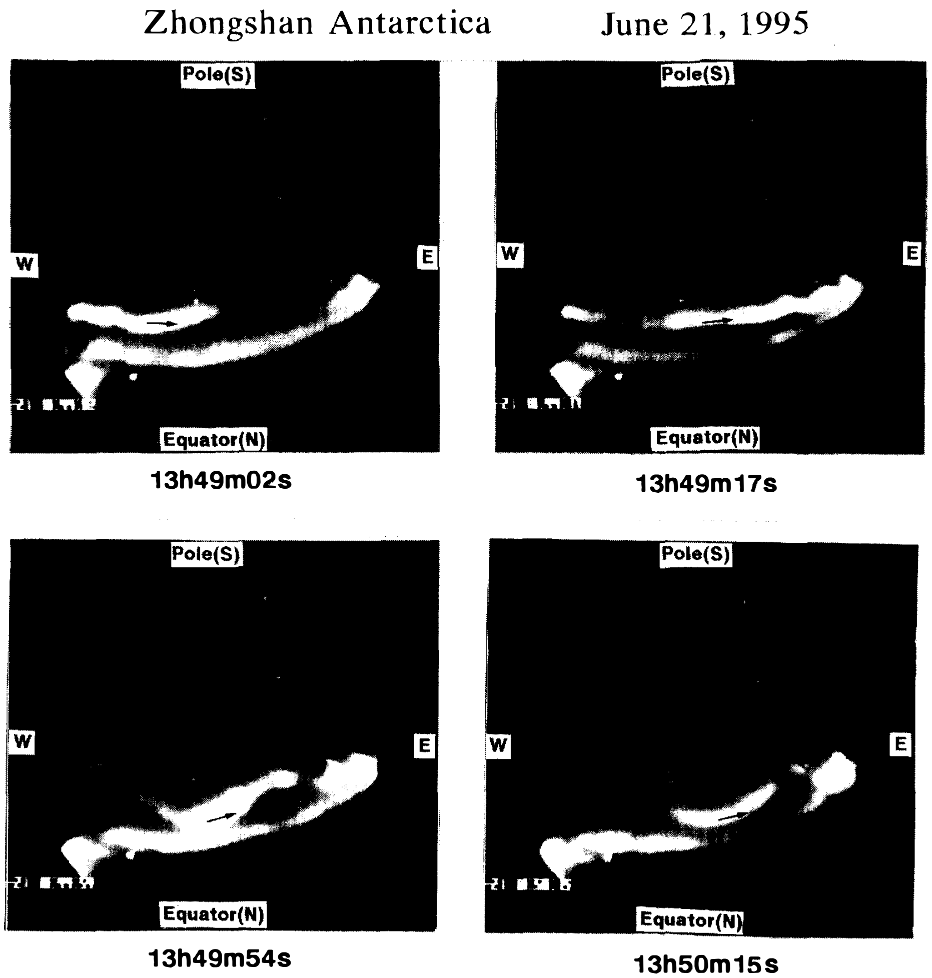

Fig. 3. *Upper panel illustrates two images observed at 1349:02 and 1349:17. Two band auroras are seen in these images with an drifting eastward of the active region. Lower panel also shows two images observed at 1349:54 and 1350:15, showing an eastward drifting of the active band aurora drifts to the eastward.*

to the yellow and red colors. From this data, intense auroral activities are seen during the period from 12 h to 16 h UT (13.3 h–17.3 h MLT). These auroral enhancements correspond to the postnoon dayside aurora which may be related to the direct entering of magnetosheath particles. The auroral activity becomes low after 16 h UT and increases again after 19 h UT near the poleward region. The bright auroras appeared near the zenith at 20 h UT. Since the direction of auroral movement is westward and its intensity is very strong, auroral phenomenon after 19 h UT seems to be originated from the plasma sheet particles. From the WIND IMF Bz data, Bz component fluctuates between positive and negative polarity during 12 h UT to 16 h UT. It seems difficult to find some clear relationships between Bz fluctuation and the auroral activity and it is necessary to examine the relationships between auroral appearance locations and IMF Bz variations in detail.

In order to examine the characteristics of postnoon auroral phenomena, we compared auroral data at Zhongshan with simultaneous DMSP precipitating particles data.

Figure 2 illustrates DMSP/F13 satellite orbit and electron and ion data when the satellite passed through near Zhongshan Station. In the upper panel, DMSP/F13 satellite passed through near Zhongshan Station at about 1350:00 UT. In the lower panel, the enhancement of electron flux is seen at about 1351 UT. It is noted that peak electron energy was about a few keV and no ion precipitation at this time. The characteristics of electron precipitation is similar to the case of nightside discrete aurora appearance except no ion precipitation.

The auroral images during this interval are given in Fig. 3. Upper two panels show the all-sky TV data obtained at 1349:02 and 1349:17, respectively. During this period, two bright discrete auroras appeared from the westward (dayside) and propagated eastward. The intensity of those auroras were strong with their luminosity higher than a few kR. The lower two panels show two all-sky TV images obtained at

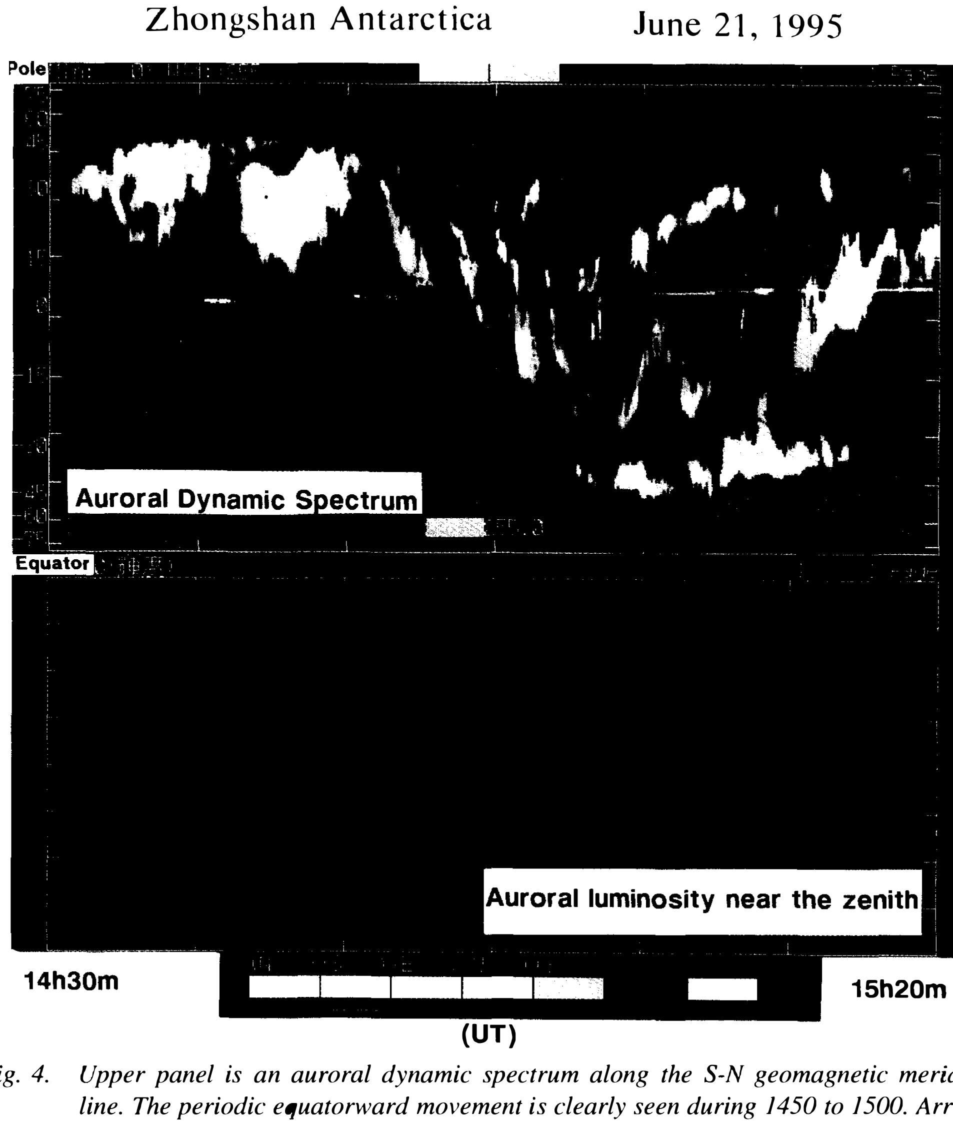

Fig. 4. Upper panel is an auroral dynamic spectrum along the S-N geomagnetic meridian line. The periodic equatorward movement is clearly seen during 1450 to 1500. Arrows indicate times of periodic auroral enhancements, respectively. Lower panel shows the temporal variation of auroral luminosity near the zenith region. The periodic interval is about 125 s to 160 s in this case.

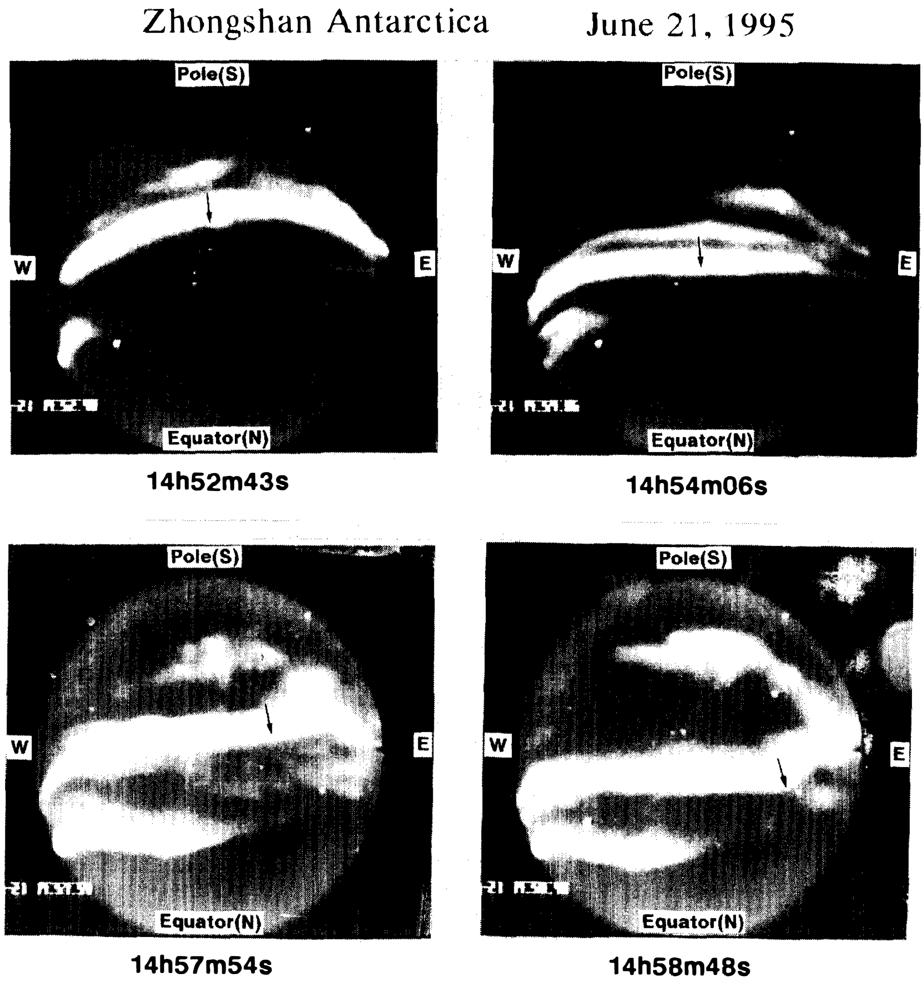

Fig. 5. Upper panel shows two all-sky TV images obtained at 1452:43 and 1454:06. Band aurora shifts equatorward from the high latitude side. Lower panel shows two images obtained at 1457:54 and 1458:48. New band aurora appeared near the poleward region and shifted equatorward.

1349:54 and 1350:15. The similar longitudinal movements (West to East direction) were also seen in these images. It is noted that the latitudinal auroral movements were not clearly recognized at this time.

The latitudinal movements of postnoon aurora were examined in detail and a typical event is illustrated in Fig. 4. The upper panel shows the auroral dynamic spectrum for the geomagnetic south (pole) to north (equator) direction during 1430 to 1520 UT. The periodic equatorward movement of band aurora is clearly seen during 1450 to 1500. Arrows in the panels indicate an enhancement of auroral luminosity near the zenith region. As band auroras shifted towards near the zenith or the equatorward side, their luminosity became week and gradually disappeared. In order to make clear this periodicity, temporal variation of auroral luminosity near the zenith region were examined and this time variation was illustrated in the lower panel. The periodic interval of multiple band aurora near the zenith region was about 125–160 s in this case.

All-sky TV images to this event are shown in Fig. 5. Upper two images show band aurora indicated by the first two arrows in the upper panel of Fig. 4. This band aurora was observed on the poleward side at 1452:43 and then gradually shifted toward the zenith at 1454:06. The lower two images show new band aurora appeared 3 min later. This band was seen near the zenith at 1457:54 and gradually shifted equatorward at 1458:48. It is also noted that the bright region in the band aurora moved eastward during this time interval.

3. Summary and Discussions

Auroral data obtained at Zhongshan Station, Antarctica were examined, and preliminary results are summarized as follows.

(1) Postnoon aurora (12–17 MLT) are frequently observed at Zhonghan Station. We compared precipitating particle data with the observed postnoon aurora and found that electrons with energy of higher than 1 keV were simultaneously precipitating, however no ion precipitation was clearly seen during that time.

(2) Postnoon aurora sometimes shows periodic latitudinal movements. The periodicity is between 125 s and 160 s. It is also noted that bright region in the band aurora also shows a longitudinal movement from the west to the east direction.

From the simultaneous comparison between particle and optical data, the results obtained here are similar to those in our previous work (AYUKAWA *et al.*, 1997). It is noted that high energy electrons (>1 keV) are observed in the postnoon aurora. These particles related to the postnoon aurora must have their origin different from the auroral oval. From our studies, the postnoon aurora and evening/nightside aurora are not continuously connected along the auroral oval. Generally, postnoon auroras are mainly observed between 12 MLT and 16 MLT. On the other hand, evening/nightside auroras appeared after 18 MLT. We consider that postnoon auroral particles would precipitate from the dayside magnetosheath, directly. However, the precipitating process of these particles is not clear at present. Since the electron energy is higher (>1 keV) than the magnetosheath particle and no ion precipitation is associated, this feature seems to be different from LLBL which NEWELL *et al.* (1991) categorized dayside precipitation.

It is another interesting result that the band aurora at Zhongshan moves equatoward and its direction is different from the band aurora seen at Ny-Ålesund. Namely, the postnoon band aurora at Ny-Ålesund shows the poleward movement. Furthermore, the longitudinal traveling of active region in the band aurora is also different. In the northern hemisphere, active region travels from the evening to the dayside along the band aurora. On the other hand, the opposite direction of drifting is seen at Zhongshan. Since we examined only one postnoon auroral event in this paper, it is difficult to say whether these differences depend on the IMF polarity or other factors. It is necessary to examine several more events in order to explain such differences in the both hemispheres.

The periodic movement of band aurora has been reported by several researchers. However, our periodic interval is different from that obtained by previous researchers. For example, the periodicity of bright spot observed by Viking imager (POTEMRA *et* *al.*, 1990) is about 3.5 min (~220 s). According to the ground dayside aurora examined by FASEL *et al.* (1994), the average periodic times of PMAF is about 6 min. If PMAF and the postnoon auroras examined here are the same phenomena, the periodicity (125–169 s) obtained in our analysis mostly looks like shorter than the results by previous researchers. We consider that a frequency of standing wave near the magnetopause boundary layer relates to the periodicity of auroral enhancement. The different periodicity obtained by other researchers may depend on the periodicity of such standing wave near the boundary layer under the different solar wind condition. It is important to make clear what factor determines the periodicity of auroral movement. We are now examining the Interplanetary Magnetic Field fluctuation near the dayside magnetopause boundary layer to compare it with the periodic movements of dayside band aurora.

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