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HIGH LATITUDE AURORA OBSERVED AT GODHAVN

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Abstract: On the basis of ground observations at Godhavn (77°INV) during the period from September 1988 to March 1989, we studied the characteristics of auroras on the higher latitude side of the aurora oval. Four typical kinds of auroras are seen in this region during this period. They are (a) bright poleward expansion auroras, (b) transpolar auroras, (c) sun-aligned arcs, and (d) morning side bright auroras. The intensity of (a), (b) and (d) auroras are very strong and these auroras are similar to those observed along the auroral oval. The sun-aligned arcs (c) are the typical aurora seen only on the high latitude side of the auroral oval. The relationships between these auroral features and other related phenomena are also discussed.

1. Introduction

Recently, several research workers have studied the sun-aligned arc and transpolar aurora (theta aurora), which appear on the higher latitude side of the auroral oval during northward IMF period. These auroras are traditionally called as the polar cap aurora. However, PETERSON and SHELLY (1984) reported that the precipitating electrons for the transpolar arc are identical with the boundary plasmasheet electrons described by WINNINGHAM *et al.* (1975). It suggests that the origin of this aurora is situated at the closed field line region. On the other hand, LASSEN and DANIELSEN (1978) examined the characteristics of sun-aligned arcs using Greenland auroral chain data. They showed that the higher latitude side of auroral oval were covered by multiple arcs when the IMF B_Z component was positive. LUNDIN and EVANS (1985) proposed that the low latitude boundary layer plasma is a source for high latitude auroral arcs. These studies indicate that the particle precipitations in the region of extremely high latitude are originated from various regions.

In order to study the source of these particle precipitation and their relationship to the interplanetary magnetic field, we carried out the auroral observation at Godhavn in 1988.

2. Observation

There are several auroral observatories in Greenland and they are distributed from

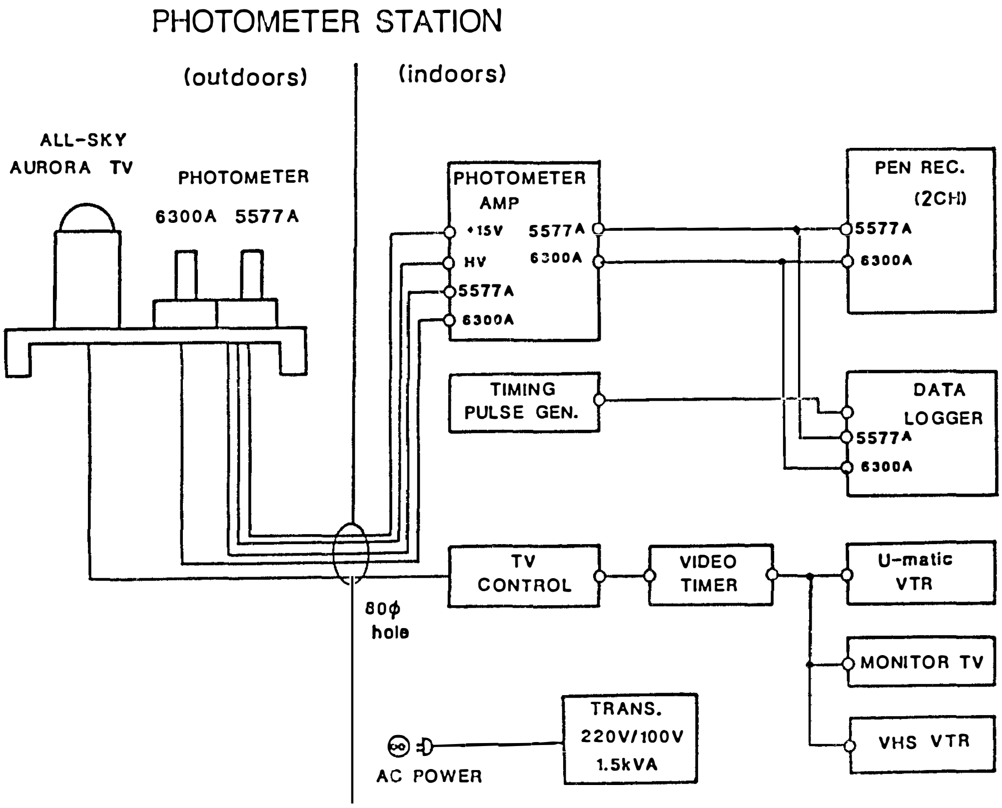

Fig. 1. Auroral observation system at Godhavn. All sky TV and photometer (6300A and 5577A line) are operated in order to study the dynamics of polar cap aurora and its luminosity.

the auroral oval to the polar cap region. These observatories are operated by the Danish Meteorological Institute (DMI) and our instruments were installed at Godhavn in cooperation with DMI. The invariant latitude at Godhavn is about 77° INV and thus its location is near the poleward boundary of the auroral oval.

Figure 1 illustrates the auroral observation system at Godhavn. All-sky auroral TV and photometer for two lines (5577A and 6300A) were installed in order to examine auroral dynamics and its luminosity. TV data were recorded with a video tape recorder (VHS and U-matic) and photometer data were recorded with a data logger.

Figure 2 illustrates the observation system for geomagnetic activities, micropulsation, natural waves and cosmic noise absorption. Magnetic activities were detected by a fluxgate magnetometer, micropulsations by a search coil induction magnetometer, and natural VLF waves by a loop antenna. Spatial distribution of cosmic noise absorption was observed by a scanning-beam riometer. This riometer observed the sky within an area of 200 km by 200 km at 90 km altitude. Most of these data were recorded by a 16-channel digital data recorder with a sampling rate of 1 Hz. Some of the signals were also recorded with a 7-channel FM data recorder. Our observation started in middle September, 1988 and continued until the end of March 1989.

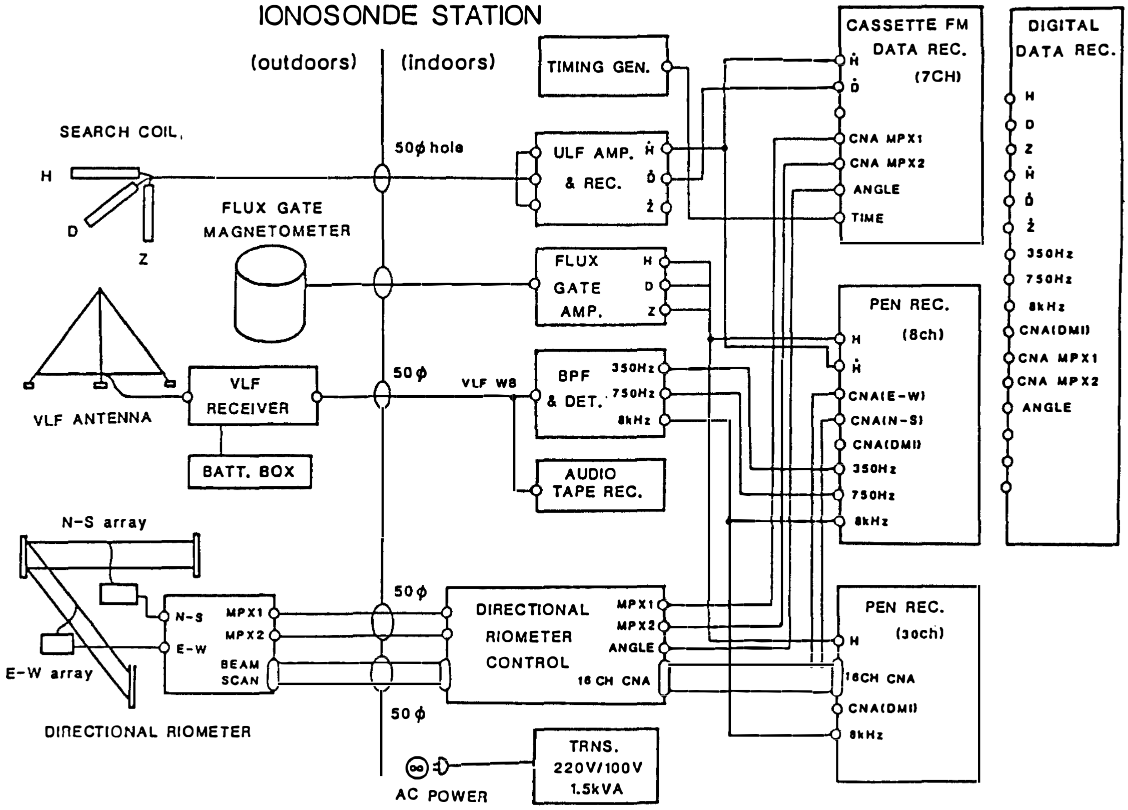

Fig. 2. Geomagnetic activities and natural waves observation system. VLF waves are detected by a loop antenna and the spatial distribution of cosmic noise absorption are detected by a directional riometer.

3. Characteristics of Auroras at Godhavn

We found several interesting auroras in this region. Some of these auroras were identical to those observed in the auroral oval and others are typically observed on high-latitude side of the auroral oval. For example, poleward-expanding auroras were frequently observed in this region. They expanded from the auroral oval. Hence their features were similar to bright active auroras appeared in the nightside oval. Transpolar auroras extending from the nightside to the dayside were sometimes observed in this region, as shown by FRANK *et al.* (1982). At present, it is not well understood whether these auroras accompany the nightside substorm or not. Faint sun-aligned arcs were often observed in the morning region, and these are unique auroras observed in this high latitude region. We describe characteristics of these auroras in the following. It is noted that the time difference between the magnetic local time and the universal time is about two hours (MLT=UT−2h) at Godhavn.

(a) Bright poleward-expanding aurora at midnight hours

Poleward-expanding auroras were frequently observed at Godhavn after an onset of substorm. Figure 3 illustrates an example obtained on October 14, 1988. In the top panel, a bright active aurora was seen on the equatorward side of the zenith over Godhavn at 0002 UT. The middle panel indicates that the bright aurora gradually

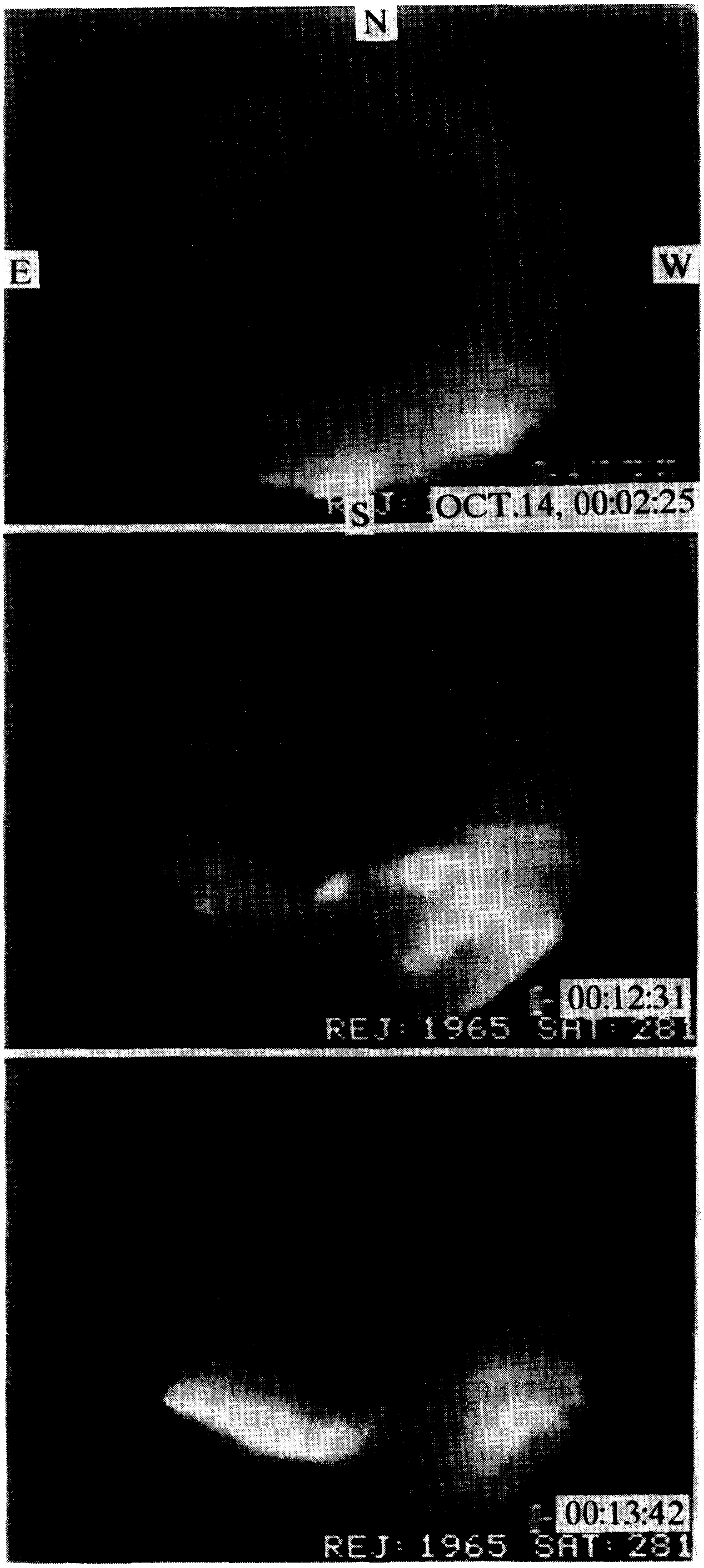

Fig. 3. An example of poleward expansion aurora. A bright aurora was seen on the equatorward side of the auroral oval (top panel) and after 10 min it appeared near the zenith (middle and bottom panel).

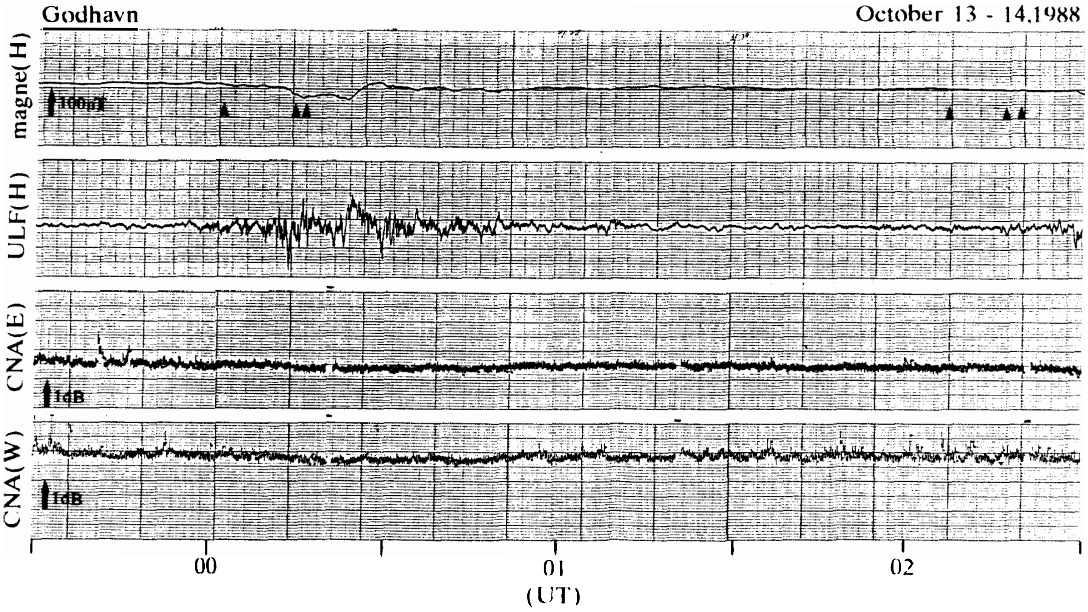

Fig. 4. Magnetogram, ULF waves and cosmic noise adsorption data are illustrated for the simultaneous auroral observation period. Remarkable magnetic disturbances were recognized at 0015 UT in association with poleward expansion aurora. However, there was no noticeable disturbance at 0215 UT, when the transpolar aurora appeared.

expanded to the zenith at 0012 UT. In the bottom panel, another bright aurora appeared in the east at 0013 UT, and after a few minutes this aurora moved to the west.

In this interval, a large geomagnetic disturbance was observed at Godhavn. Figure 4 illustrates the geomagnetic fluctuations, ULF micropulsations and CNA data at the time of the poleward-expanding aurora shown in Fig. 3. In these data, large geomagnetic disturbances and remarkable micropulsations were observed at Godhavn. However, there was no noticeable CNA absorption in this time interval and thus the particle energy associated with these auroras must have been lower than a few tens of keV. From DMSP/F8 particle data obtained at 2340 to 2354, October 13, the poleward boundary of auroral oval was at 76° in 21 MLT, consistently with the ground auroral observation at Godhavn.

(b) The transpolar aurora at pre-midnight hours

Figure 5 illustrates a bright aurora which was extending in the north-south direction. Although there was no simultaneous auroral image from satellites in this case, this aurora could correspond to the transpolar aurora reported by FRANK *et al.* (1982). In the top panel, a band like aurora was seen in the east at 0206 UT. The center of this aurora gradually moved to the zenith and the luminosity became high at 0215 UT as shown in the middle panel. The bright folding part propagated from the nightside to the dayside within a few minutes. In the bottom panel, the folding-like aurora became bright and expanded both poleward and equatorward.

During the period from 0200 to 0220 UT, the magnetic activity was very low as shown in Fig. 4. Weak geomagnetic pulsations were recognizable in this interval. Therefore, the magnetic activity as well as other disturbances were fairly low when the

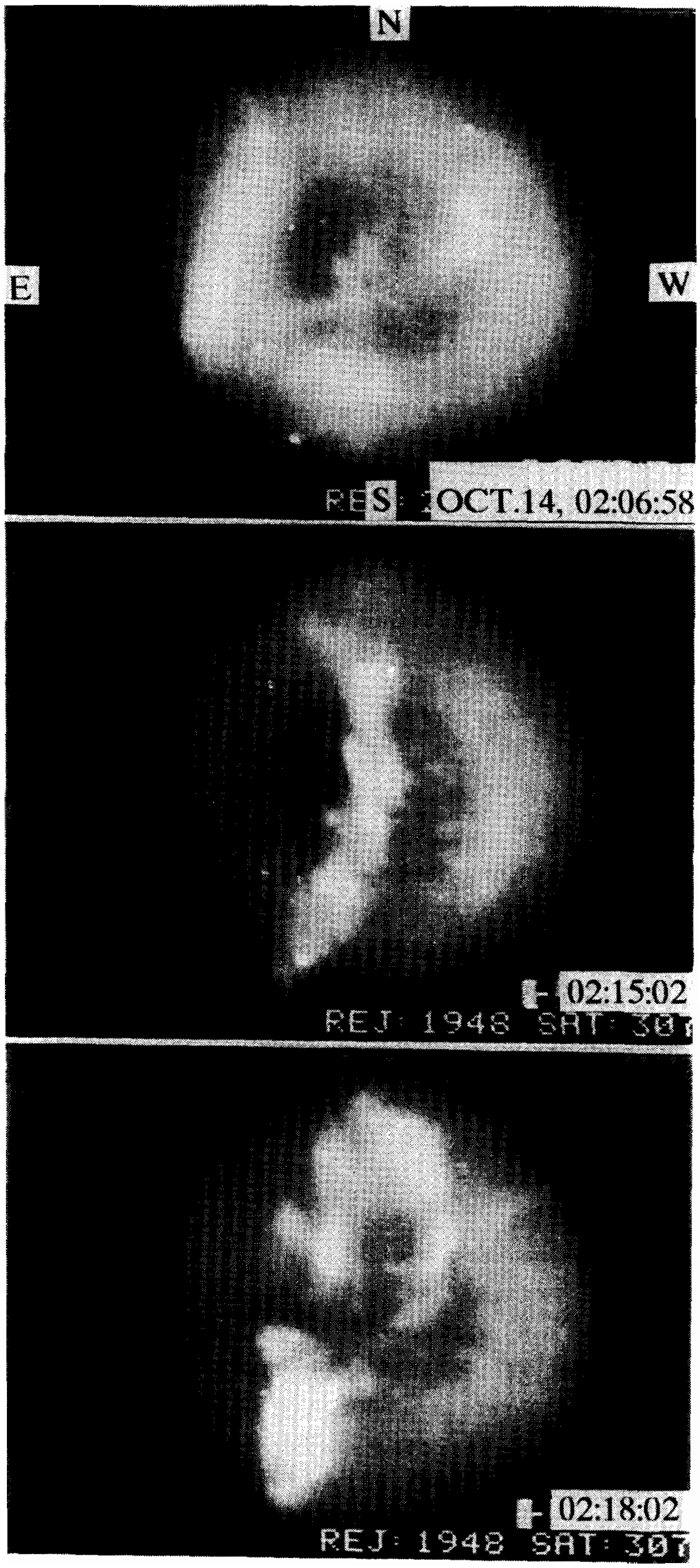

Fig. 5. An example of transpolar aurora. A bright aurora which was extending from the north to the south direction appeared at the eastward region (top panel). This aurora gradually moved to the zenith after 10 min (middle and bottom panels).

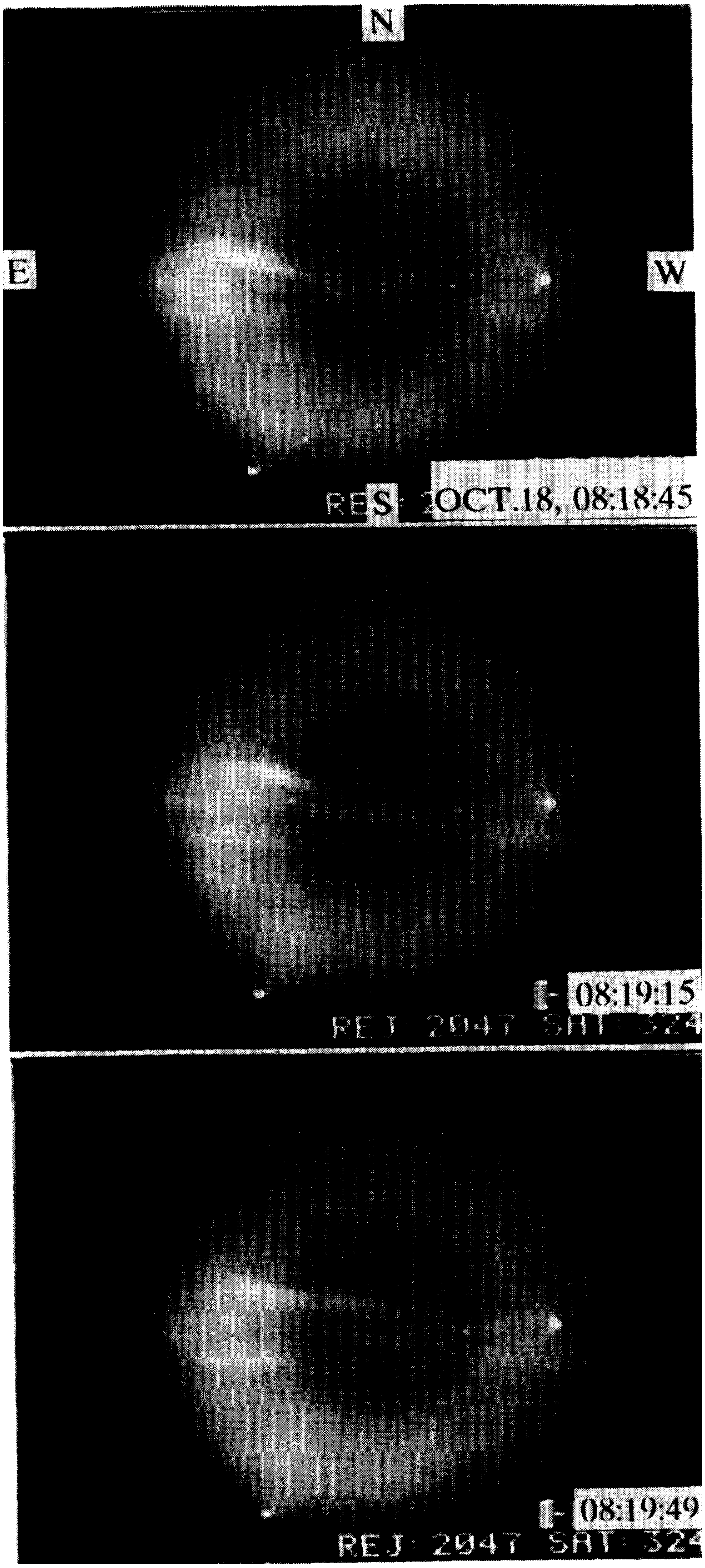

Fig. 6. An example of sun-aligned arc. Multiple faint arcs which were extending from the dayside to the night side at 0819 UT. After one minute, a bright part of the sun-aligned arcs propagated to the night side region.

transpolar aurora appeared in this case. In this period, DMSP/F8 satellite traversed far away from Godhavn, so that we could not compare the satellite particle data with the ground aurora.

(c) Sun-aligned arcs in the morning hours

Faint auroral arcs appeared frequently in the morning hours. The top panel in Fig. 6 illustrates a faint arc observed at 0818 UT. It shows that a bright auroral arc was visible in the eastward (dayside) region. After a few tens of seconds, the bright auroral arc region gradually shifted to the zenith in the middle panel. These tendencies are more clearly recognizable in the bottom panel. It is noticed that the faint auroral arc developed from the east (dayside) to the west (nightside). Although it is difficult to determine the origin of sun-aligned arcs with this data alone, the source region of these arcs was possibly located in the dayside region. Figure 7 illustrates the geomagnetic activity in this period. During the interval from 0818 to 0820 UT, a small magnetic activity and weak pulsations appeared. However, there was no distinct CNA. According to the electron precipitation data obtained by DMSP/F8 satellite at 0720, irregular electron precipitations were recognized at 77° INV at 06 MLT with average energy less than 1 keV. Such precipitations may have caused sun-aligned arcs observed at Godhavn. These data suggests that precipitating energy flux is not so high in the sun-aligned arcs.

(d) Bright auroras in the morning hours

It is interesting that bright auroras are often observed in the morning hours. An example is shown in Fig. 8. The top panel shows a bright discrete aurora appeared on the equatorward side of the auroral oval at 0636 UT. This aurora rapidly moved

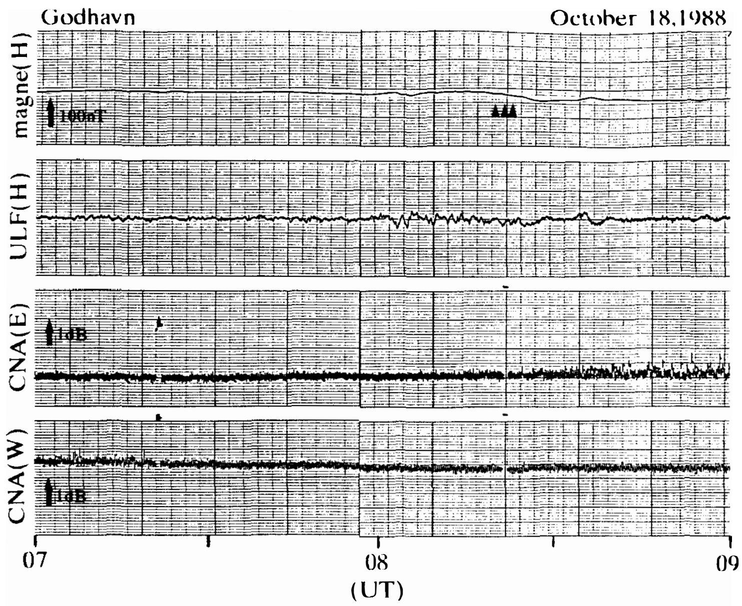

Fig. 7. Magnetogram, ULF waves and cosmic noise absorption data illustrated for the simultaneous sun-aligned arc appearance at 0919 UT. There was a weak magnetic disturbance in this interval.

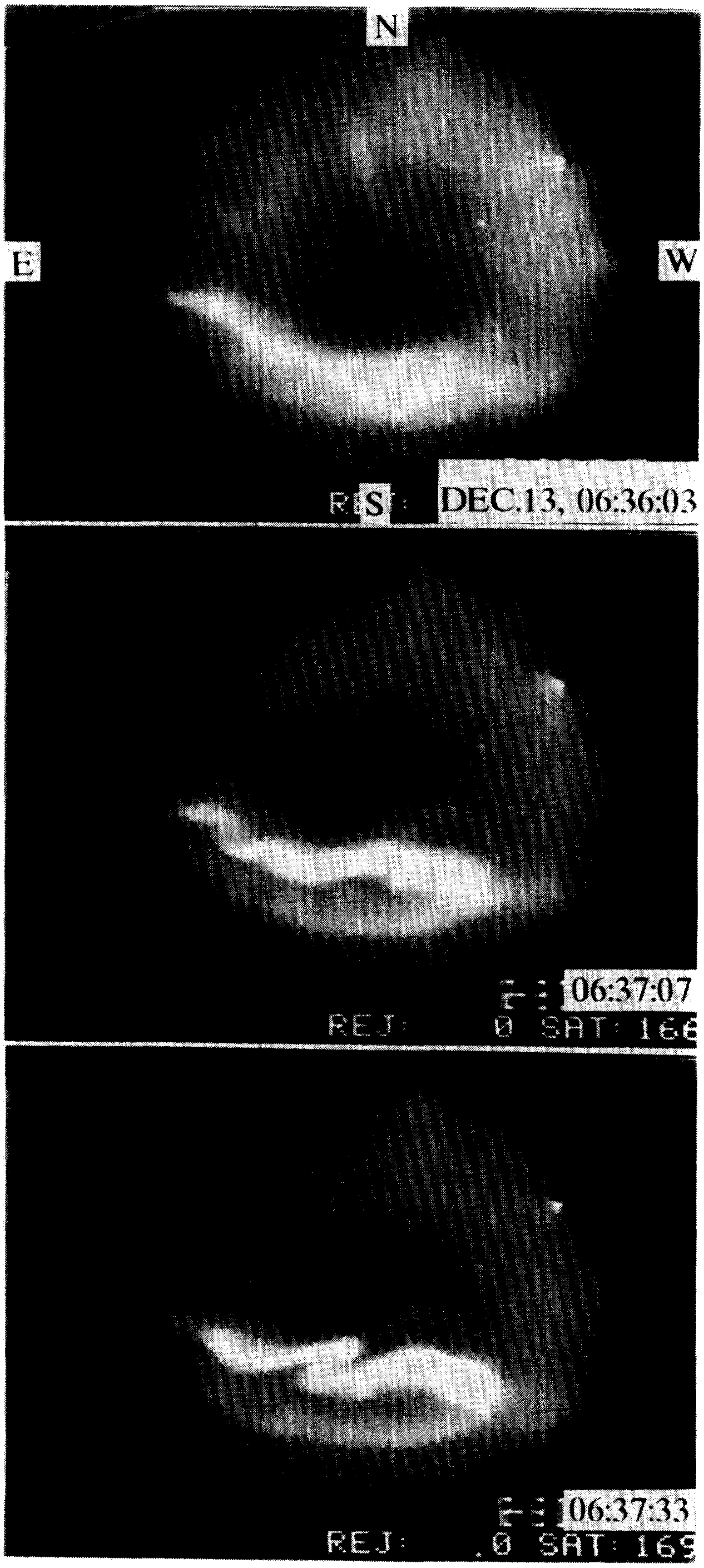

Fig. 8. An example of morning side bright aurora. A bright aurora appeared in the dawn sector at 0636 UT. In this case, the bright region prepagated from the eastside (day side) to the westside (night side).

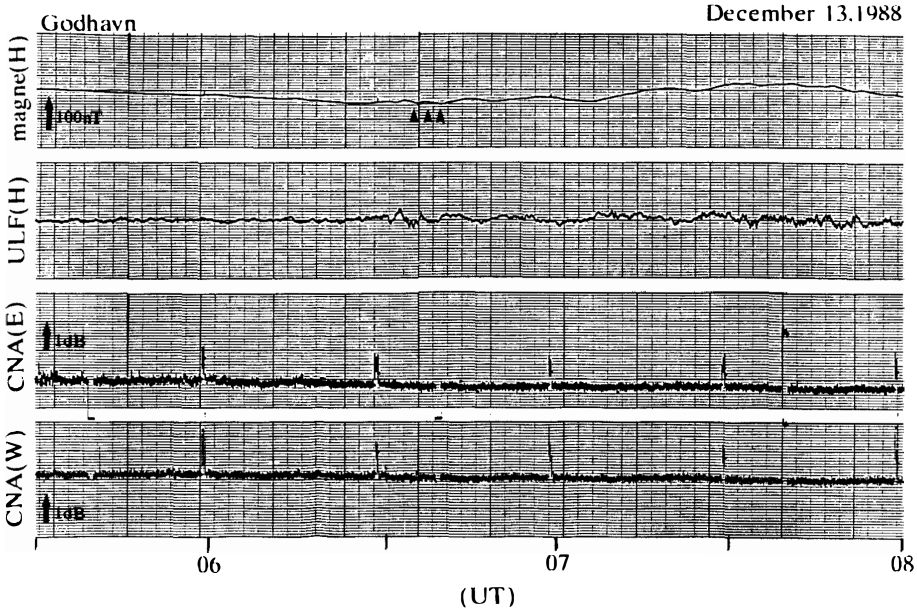

Fig. 9. Magnetogram, ULF waves and cosmic noise adsorption data were illustrated for the morning side; ULF waves were observed in this interval.

from the equatorward to the poleward side and it became bright at 0637 UT as shown in the middle and bottom panels. The active aurora looked like a surge traveling westward along in the auroral oval.

Figure 9 shows the magnetogram, micropulsation and CNA data simultaneously observed in this time period. In the interval from 0630 to 0640 UT, weak magnetic disturbances and micropulsation fluctuations were observed. However, there is no recognizable CNA absorption. Unfortunately, DMSP/F8 satellite data are not available in this case.

4. Summary and Discussion

We examined four different kinds of auroras in this paper. They are (a) bright poleward expansion aurora, (b) transpolar aurora, (c) sun-aligned arc and (d) morning side bright aurora. Among them, (a) and (b) auroras are related to the auroras in the auroral oval and they could be excited by the plasmasheet particles. For the sun-aligned arc (c), however, the source could be located in the dayside magnetosphere, because this arc develops from the dayside. In order to confirm this point, we must examine satellite auroral images as well as global ground auroral data. For the morning bright aurora (d), the characteristics are similar to those observed in the auroral oval. The origin of this aurora and its occurrence condition have not been clearly understood yet. Therefore we must examine the worldwide geomagnetic activity data and also the interplanetary magnetic field data for these events.

Since it is difficult to obtain any conclusive result about the source region of auroral particles by using data at only one ground station, we must compare satellite auroral images and particle data as well as multipoint ground observation data. Fortunately, DMSP satellites continuously observed auroral images and particle data in this period.

Thus, we can examine the simultaneous data of ground and satellite auroras in the next step.

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