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Day and Night Time Auroral Structures in the Antarctic

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Abstract. Multichannel auroral photometer measurements have been made at the Chinese Antarctic station Zhong Shan (CGMLAT 74.5° S). Photometer was recording proton H_β, oxygen red (630.0 nm) and three different nitrogen N_2^+ emissions during the nighttime but also of the daytime aurora in the vicinity of local magnetic noon. In this paper results of photometer measurements of aurorae during day and nighttime from the day June 17th, 1999 are presented.

1 Introduction

Auroral oval is a ring, which is located about 2000 km from magnetic poles in Northern as well as in Southern hemisphere. The oval is elongated in noon-midnight direction so that it is closest to the magnetic pole in the noon and furthest in the midnight. The geomagnetic latitude of the typical daytime oval is 75° at magnetic noon and of the nigthtime aurora 69° at magnetic midnight (Bond and Akasofu (1979)).

In the daytime the solar wind particles, electrons and protons, penetrate into the magnetosphere via magnetospheric cusp/cleft. The energy of the solar wind particles is low (of the order of 200 eV) compared to the energy of electrons producing night side aurora (1-10 keV). This means that the intensities and the nature of the daytime and nighttime aurorae are very different.

In the daytime the dominant emission is from atomic oxygen at 630.0 nm, which has often an intensity of several kR. The oxygen green emission at 557.7 nm and thus also the nitrogen N_2^+ emissions are very weak, less than 0.5 kR. The intensity ratio I(630.0 nm)/I(557.7 nm) > 2 (Sandholt (1990)). Typical emission on the daytime is also weak H_β-emission due to proton precipitation. In the nighttime oxygen red emission is considerably weaker, often less than 1 kR. The green emission instead has intensity of several to tens of kR and the intensity of nitrogen N_2^+ emission is mostly much higher than the red emission.

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Several studies about the daytime auroral behaviour has been carried out during the past decades (e.g. Sandholt et al. (1989)). Beside the optical emissions there has been observed also indications of periodic events with tailward (poleward on the sky) moving filamets of field-aligned current (Sandholt and Lockwood (1990)).

2 Instrumentation

University of Oulu, department of Physics, has made a PC-controlled multichannel auroral photometer which was brought to The Chinese Antarctic station Zhong Shan in 1997. The photometer had 5 chanels and their properties are described in Table 1. The fields of view are identical 2° except in the H_β channel which has a field of view of 3°.

Zhong Shan is located in the Polar Cap, at the edge of the auroral region (Figure 1). Its geographic coordinates are 69.37°S, 76.37°E (CGM 74.5°S). The L-value is 14.0 and geomagnetic coordinates are 74.54°S and 96.47°E CGM after NSSDC transformation.

The local magnetic noon is close to 1030 UT. Due to the geometry of the south geographic and geomagnetic poles it is possible to measure daytime aurora close to the noon during the darkest months in June and July. Before noon the daylight prevents the optical measurements totally, but immediately after noon the measurements are possible.

The photometer is a half automatic instrument, where the measurement parameters are prewritten in a file. The integration time can be selected from 10 ms upward. Typically integration times of 0.2 or 0.3 seconds have been used. There are three measurement modes: 1) normal mode with scanning the sky for a wanted angle interval or measuring toward a fixed direction, 2) fast mode where one channel is measured with higher speed than the other channels and 3) mixed mode where the photometer is measuring toward a fixed direction for a wanted time and then making a full back and forth scan over the sky.

Similar photometers are in use in Scandinavia since 1984.

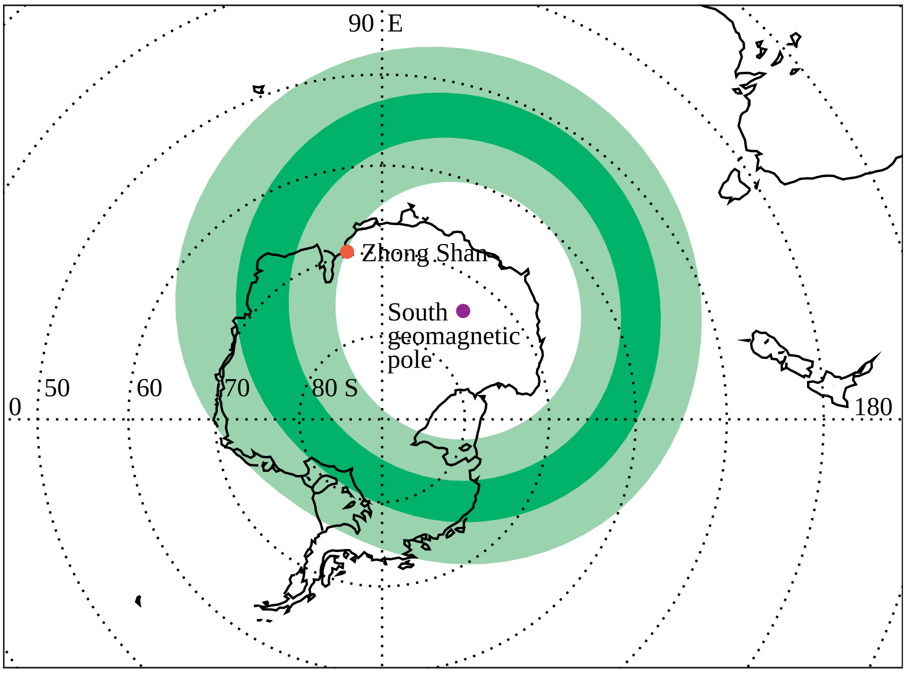

Fig. 1. The southern auroral region around Antarctic is plotted with green colour. The region, where the aurorae are most probable to be seen is marked with dark green. Zhong Shan station in located in the Polar Cap edge of the auroral region. Due to the geometry of the south geographic and geomagnetic poles it is possible to measure daytime aurora close to the noon.

Table 1. Properties of the photometer channels

Channel number	wavelength [nm]	field of view [°]
1	486.1	3.0
2	630.0	2.0
3	427.8	2.0
4	426.7	2.0
5	425.2	2.0

They have been revised and improved during the years. Three other photometers are measuring auroral emissions in Northern Scandinavia during northern winter months.

3 Photometer observations

In this event study the day June 17th, 1999 has been selected. During this day the K_p-value started with 2o but has been from noon to midnight 1o - 1+. This means that the magnetic conditions have been quiet. Photometer has been scanning through the whole night.

3.1 Daytime aurora

The daytime auroral measurements started from 1100 UT. The main feature in the Figure 2 is the varying but intense red 630.0 nm emission, which lasted until 17 UT. At the beginning of the time interval the last dusk phenomena are seen in the top and bottom left channels. The overall feature shown about no or very weak N_2^+ emission before 1630 UT.

There is some faint H_β emission due to the proton precipitation. The wide band in Figure 2 is partly due to a faint reflection from some near light in the vicinity of the photometer. This means that the typical daytime aurora consists of low energy electrons penetrating from the solar wind throug magnetospheric cusp into the ionosphere.

The position of the red emission is seen in Figure 4, where the emission is plotted as a function of magnetic latitude and where the emission is color coded. There can be seen that the emission is in rather narrow band at geomagnetic latitude of 77°S. Also the emission changes with a period of about 10 minutes. This kinds of variations has been explained by tailward moving filaments of field-aligned current. They create poleward moving discrete auroral arc fragments which have been mentioned also in paper by (Sandholt and Lockwood, 1990). At the same time very faint N_2^+-emission (below 300 R) is visible.

3.2 Nighttime aurora

Nighttime aurorae have been studied widely. The typical features are low intensity diffuse aurora, discrete aurorae with growth phase, expansion phase and recovery phase. The auroral intensities are low to moderate during the growth phase and the main feature is the equatorward motion of arclike auroral forms. The most intensive phase is the expansion phase, where bright auroral forms move westward, poleward and eastward.

Red oxygen emission takes place often at the beginning of auroral substorm. During the expansion phase the energy of the particles is usually several keV, which create better oxygen green aurora and different N_2 and N_2^+ bands. During the recovery phase auroral pulsations are typical and the energy of electrons penetrating into the atmosphere is higher than during the growth and expansion phase. A substorm

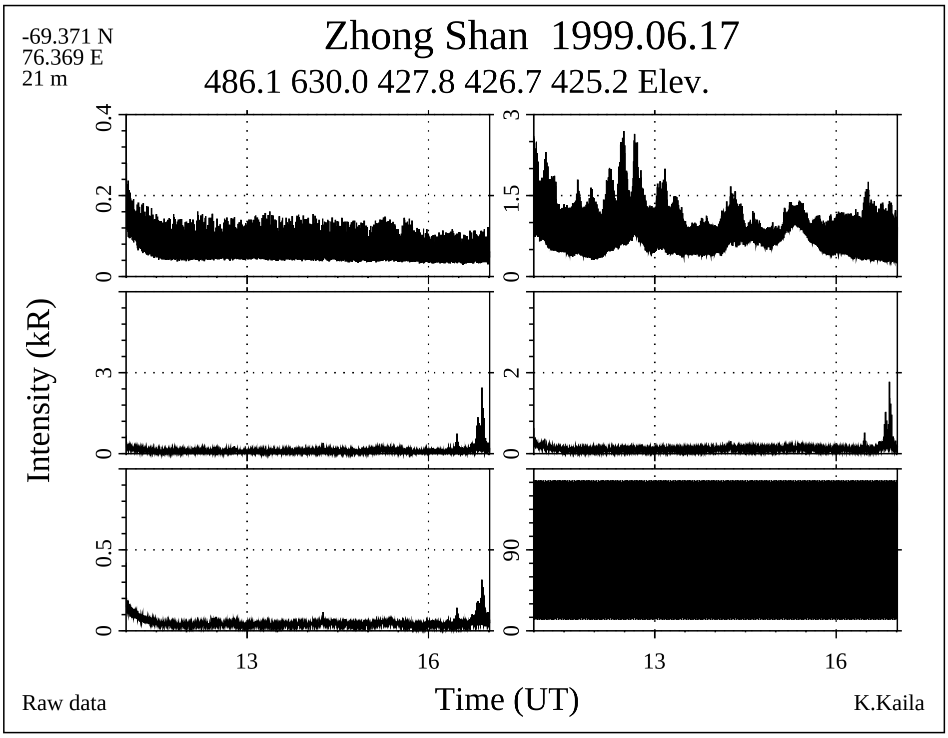

Fig. 2. The typical photometer measurements of the dayside aurora of June 17th, 1999 at 11-17 UT. The red 630.0 nm emission is dominant as can be seen in the top right panel. The nitrogen emissions are negligible in the middle panels and left bottom panel. Proton intensity is also very low. The photometer was scanning through the whole time interval as can be seen in the right bottom panel from the elevation angle. The sky at 11 UT is not yet fully dark which can be seen from the left top and bottom panels.

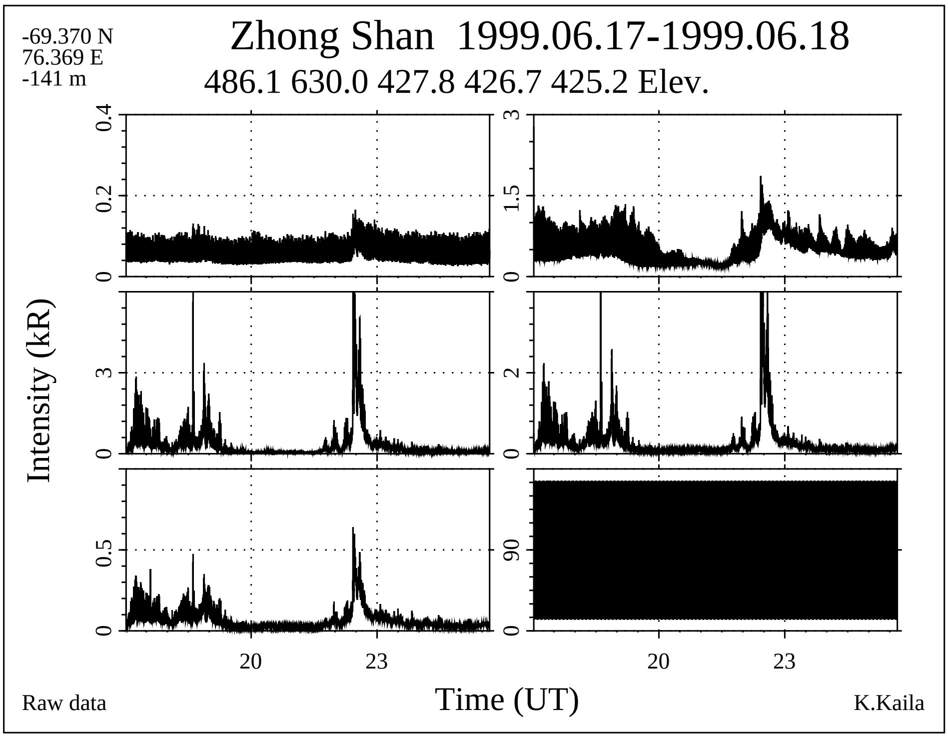

Fig. 3. The typical photometer measurements of the night time aurora of June 17th, 1999 at 17-02 UT. The red 630.0 nm emission at the top right panel has considerable smaller intensity than during the daytime aurora. The nitrogen emissions have rather high values in the middle panels and left bottom panel. Proton intensity is typically weak. The photometer has been scanning through the time interval.

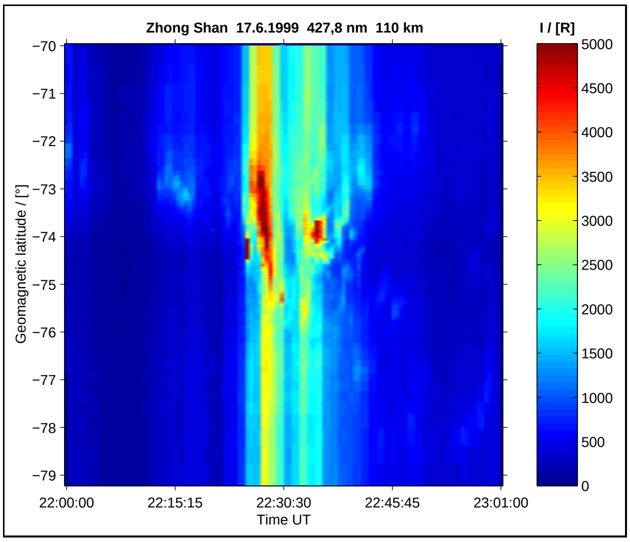

Fig. 5. The latitude of the nighttime N_2^+ aurora is plotted for a time interval of 22-23 UT. A typical auroral substorm has expanded to high latitudes and the duration of the event is only 15-20 minutes. N_2^+ intensity is high.

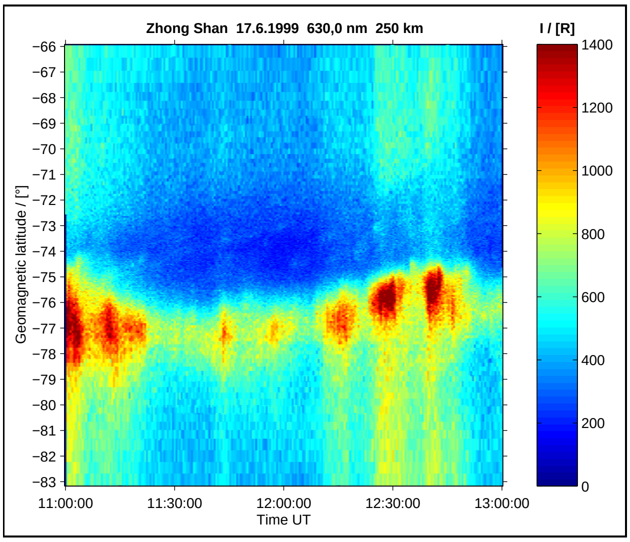

Fig. 4. The latitude of the daytime red aurora is plotted for an interval of 11-13 UT. The intensity is varying with a period of 10-15 minutes. This indicates tailward moving filaments of field-aligned currents.

has started at about 2215 UT at the auroral region further equatorward. In Figures 3 and 5 there is an example of high energy night time aurora which have been expanded to high latitudes. There the N_2^+ emission reaches over 5 kR, whereas the red emission is widely distributed and its intensity is considerable less than during the daytime oval. The whole substorm event lasts only 15-20 minutes after which the aurorae fade again. In this event there is only a faint proton H_β-emission.

4 Discussion and Conclusions

The behaviours of typical daytime and nighttime auroral features have been briefly described. The observations were made at Zhong Shan station in Antarctic. The intensive (3 kR) and relative stable auroal arc of atomic oxygen red emission (630.0 nm) has been observed just after noon for couple of hours. Other main auroral emissions have been faint (below 0.5 kR). A periodicity of about 10 minutes were observed in the red intesity indicating tailward moving filaments of discrete aurora. The daytime auroral electrons are low energy (below 500 eV) solar wind electrons which have entered into the ionosphere via magnetospheric cusp/cleft along magnetic field lines.

In the nighttime the red emission is fainter and it is no more the dominant emission. The energy of precipitatinfg electrons is higher due to the energy change in the magnetosphere. The energy of typical auroral electrons is some keV and the electrons mainly create oxygen green (557.7 nm) emission and N_2^+ emissions. A substorm at 2215 UT has been presented as an example.

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