Proc. NIPR Symp. Upper Atmos. Phys., **4**, 79–85, 1991

OPTICAL CHARACTERISTICS OF LOW LATITUDE AURORAE ON OCTOBER 21, 1989 (EXTENDED ABSTRACT)

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Optical observations of low latitude aurorae were made at low latitudes as Niigata, Japan (geographic latitude 37.7°N, longitude 138.8°E, geomagnetic latitude 27.7°N), by means of all sky camera with a high speed color film and an airglow photometer with changeable filters. Fabry-Perot scanning spectrometer observations of the Doppler temperature of [OI] 5577 Å emission line also showed important information on parameters of the upper atmosphere during the auroral active night.

Magnetic variations of the geomagnetic storm observed at Kakioka and Moshiri on October 21, 1989, showed that low latitude aurora events appeared during the two intervals of 1140–1200 UT and 1410–1425 UT in the northern area of Hokkaido, Japan (KUWASHIMA *et al.*, 1990; MIYAOKA *et al.*, 1990). In the present paper we will discuss the first event, because during the second event, sky conditions at Niigata were relatively bad. However, at Niigata, auroral feature could not be seen by naked eye throughout the night.

The airglow photometer of the Niigata Airglow Observatory, placed at the top of Mt. Yahiko (640 m) near Niigata, has been operative routinely, since 1957 (SAITO and KIYAMA, 1987). The photometer has five filters with 20 to 30 Å band widths. Optical characteristics of the photometer are summarized in Table 1.

Table 1. Characteristics of airglow photometer.

Photometer	Aperture	70 mm, *F*/2.1
	Field of view	4.6°
	Photomultiplier Hamamatsu	R-374, S-20,
Filters		
Peak transmission wavelength	Half width	
5317 Å	23.4 Å	Background
5579 Å	26.6 Å	Airglow 5577 Å
5890 Å	29.8 Å	Airglow 5890-96 Å
6238 Å	29.0 Å	Airglow OH Meinel (9-3) band, R branch
6298 Å	31.8 Å	Airglow 6300 Å
Standard light	Built-in small lamp electrically regulated	

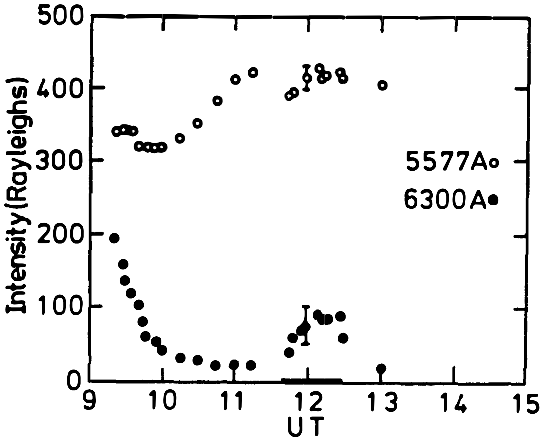

Fig. 1. Time variations of airglow intensity photometrically observed in the zenith direction. The auroral active period is indicated by a solid line on the abscissa. Observations were made at the Niigata Airglow Observatory, Niigata University, at Mt. Yahiko near Niigata.

As shown in Fig. 1, auroral emissions of 6300 Å of [OI] (^1D-^3P) and 5577 Å of (^1S-^1D) certainly appeared during 1140–1230 UT. Photometrical observations of airglow in the zenith direction showed small increases of 80 Rayleighs of 6300 Å emission line in the maximum phase of aurorae. The other emissions of 5890 Å of Na I (^2P-^2S) and 6238 Å of OH Meinel (9-3) band R branch could not be identified by the photometer, so that they are not shown in Fig. 1.

All sky photographs obtained at Niigata indicate almost uniform brightness with enhanced red color and without any dynamical motions. Rayed structures with colors of white and yellow were not detected by the all sky camera.

Figures 2.1 and 2.2 show one of the five all sky photographs of low latitude aurorae taken by a Nikon Fish Eye Lens of $f=8$ mm and $F/2.8$ with Kodak Ektachrome P 800/1600 films. Start and exposure times of the five photographs of aurorae are listed in Table 2. Aurorae appeared fortunately above the Japan Sea, without contaminations from city lights of Niigata. The sky was very clear during the main phase of geomagnetic storm around 1145 UT. The auroral photographs also show fairy clear Milky Way lights as shown in Fig. 3.

Five isophotes of the auroral displays listed in Table 2 are shown in Fig. 4. They are obtained from the Joyce Loebl Microdensitometer traces of monochromatic films which are made from the original color films through a red color filter of Fuji SC 64. Clouded structures on the original photographs of Fig. 2 are interporated, and effects of scattered city lights are eliminated after comparing them with the night photographs without aurora. Intensities are calibrated with the results of airglow intensities of 6300 Å photometrically observed in the same night. Corrections are carried out for the lower atmospheric extinctions and for deformations of the projected pattern on the film.

During the period of maximum activity of low-latitude aurorae, *i.e.*, 1140–1200 UT, a series of five photos were obtained by all sky camera. Distinct red color displays of aurorae appeared around geomagnetic north at Niigata, and their forms were diffused arc. The brightness of aurorae was approximately uniform, and the intensity amounted even to above 10 kR for [OI] 6300 Å around the maximum stage.

Doppler temperatures of the airglow [OI] 5577 Å line were observed by the Fabry-Perot Piezo Electric scanning spectrometer in the night of the low-latitude aurorae

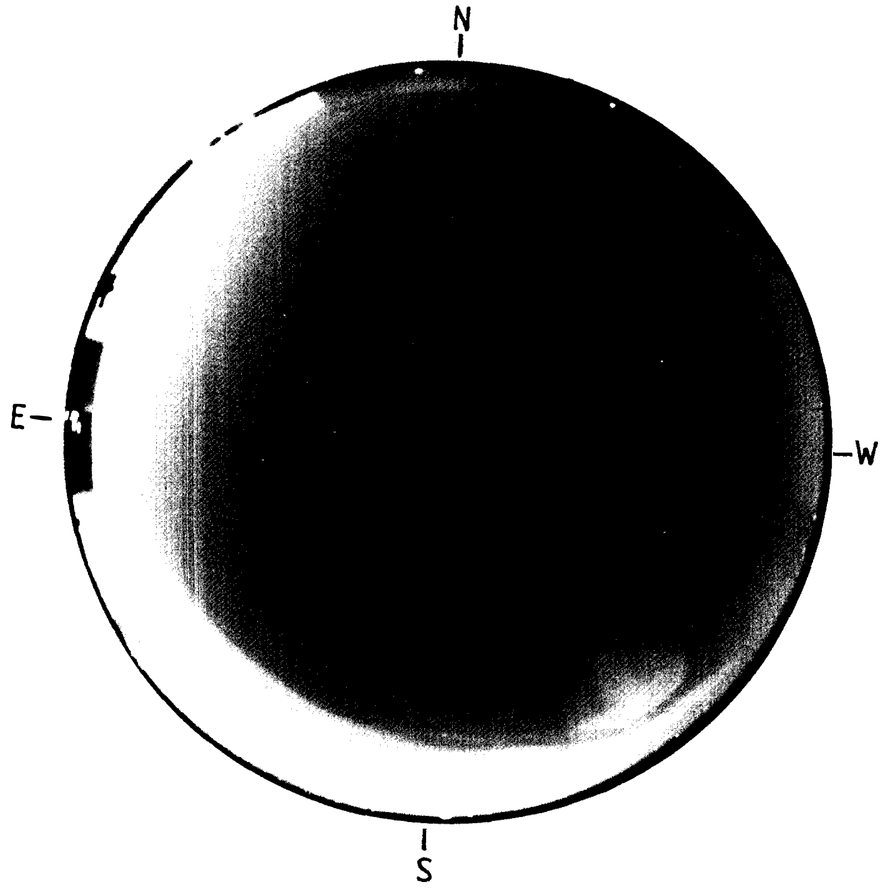

Fig. 2.1. All sky photograph of low latitude aurorae at the most active period of geomagnetic disturbances 1145–1147 UT on October 21, 1989.

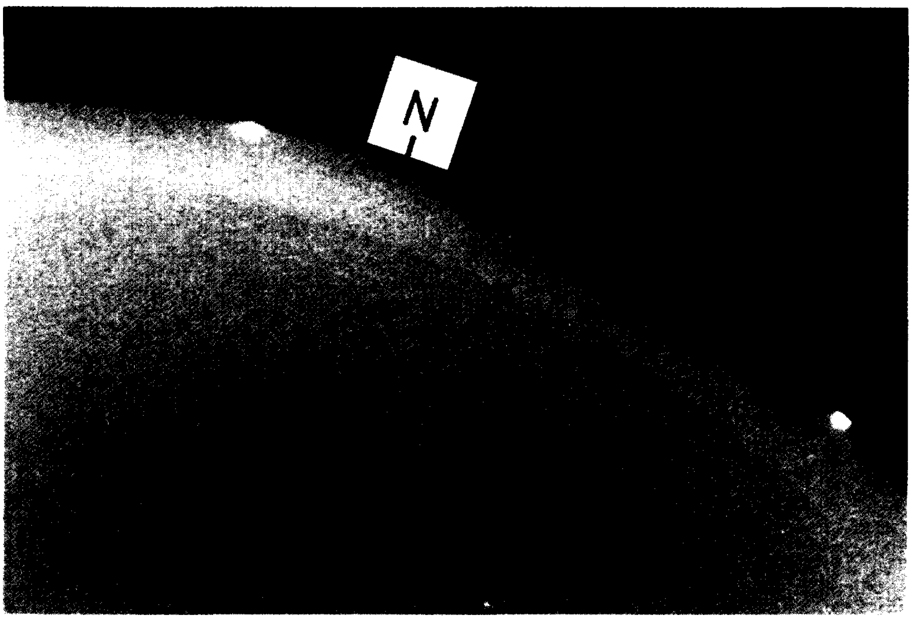

Fig. 2.2. An enlarged photograph of Fig. 2.1.

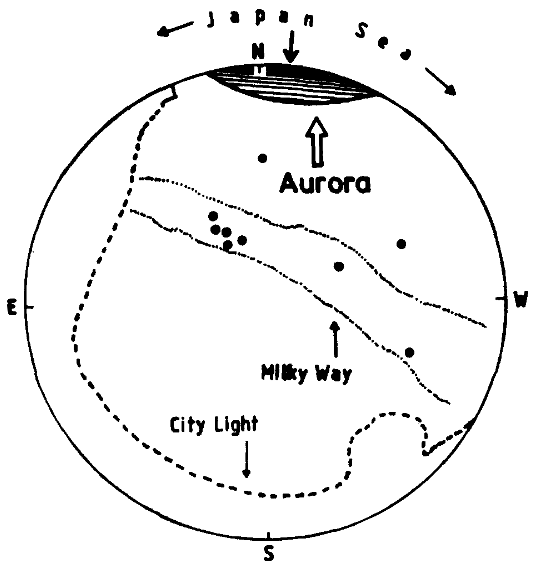

Fig. 3. Schematic illustration of the all sky photograph of aurorae in Fig. 2.1, where clear red color features extend to 16° above the horizon in the E-W width of about 50°. Japan Sea, city lights of Niigata and Milky Way are illustrated in the figure. The large arrow at the edge of the horizon circle indicates the geomagnetic north.

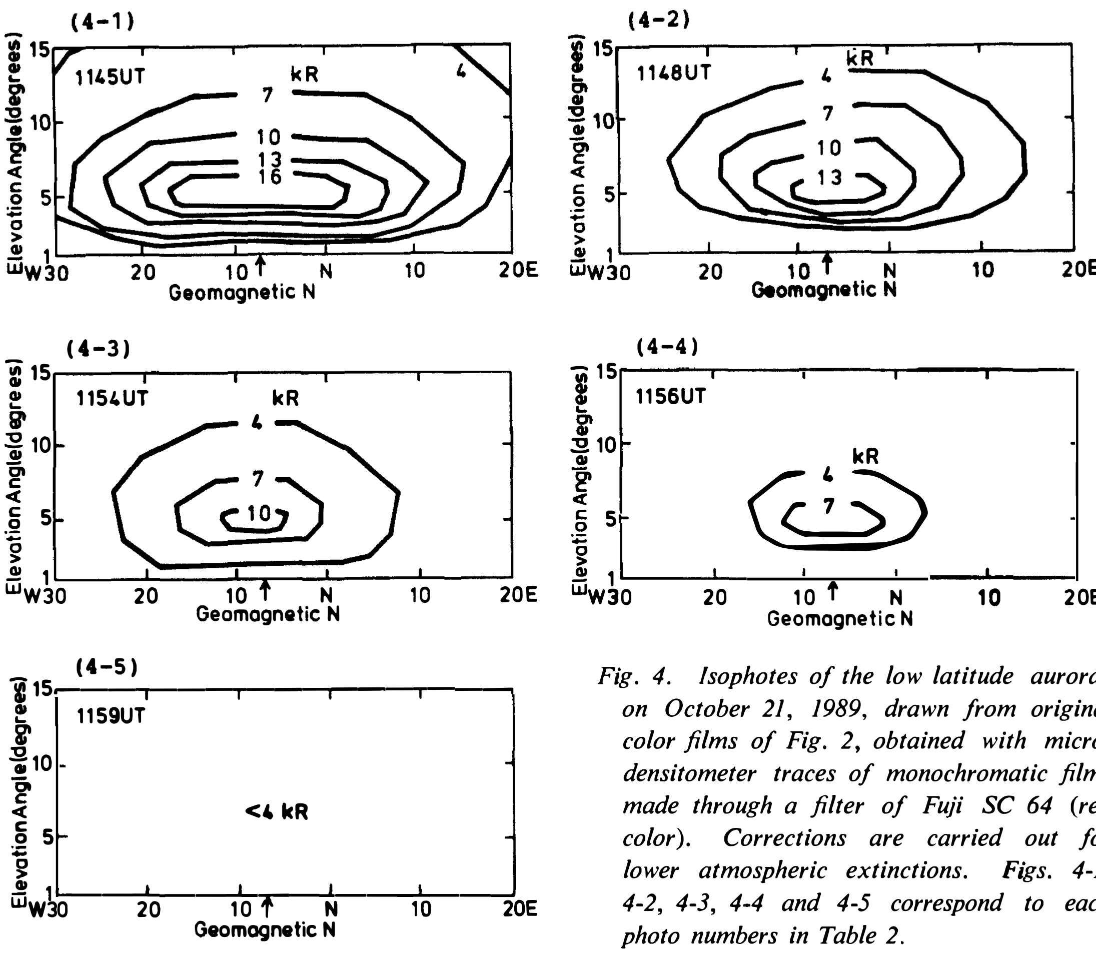

Fig. 4. Isophotes of the low latitude aurorae on October 21, 1989, drawn from original color films of Fig. 2, obtained with micro-densitometer traces of monochromatic films made through a filter of Fuji SC 64 (red color). Corrections are carried out for lower atmospheric extinctions. Figs. 4-1, 4-2, 4-3, 4-4 and 4-5 correspond to each photo numbers in Table 2.

Table 2. Series of five photographs of low latitude aurorae.

Photo No.	Start time, UT	Exposure time, min
1	1145	2
2	1148	5
3	1154	1
4	1156	2
5	1159	5

Table 3. Characteristics of Fabry-Perot scanning spectrometer.

Fabry-Perot spectrometer	TROPEL, Inc., Model 360	
	Piezo material	PZT Ceramic
	Scanning range	2000 nm/1500 V
	Sweep rate	16 Ways
	Scanning speed	533 nm/400 V/20 s
	Nonlinearities	0.986
Etalon plates	Effective diameter	50 nm
	Reflectivity	0.926 at 5577 Å
	Flatness	λ/400 at 3940 Å
	Flatness finess	83.9 at 5577 Å
	Spherical defect	30 nm
	Spacing	20 nm
Objective lens	Diameter	53 mm
	Focal length	198 mm
	Aperture	0.716 mm
	Instrumental field of view	0.21°
Interference filter	Diameter	50 mm
	Half-width	65 Å
	Peak transmission	81%
	Peak wavelength	5579 Å
Free spectral range		0.078 Å (0.25 cm)
Photon count	Photomultiplier	EMI-9558 B
	Pulse height analyzer	Ino-Tech, Inc., Model IT-5200
	Channel	1024

event. The spectrometer characteristics are summarized in Table 3.

Figure 5 shows temperature-time record of the airglow spectral line, where temperatures are estimated from 10 minutes accumulated photon rates. Considering that the layer of 5577 Å airglow was located around the height of 100 km, it is concluded that no auroral effect appeared in the lower thermosphere during the expansion phase of the geomagnetic substorm of 1140–1200 UT.

Figure 6 shows an expected location of the low latitude aurorae in the meridian plane. The central region of strong auroral emission is considered to be located at the height of 400 km, and its southern border is in the vicinity of 43° geomagnetic line of force.

It is interesting to compare Fig. 6 with that of February 11, 1958 event, which is known as the lowest latitude aurora ever observed (BELON and CLARK, 1959; CLARK and BELON, 1959). By Japanese observations its southern border was estimated ap-

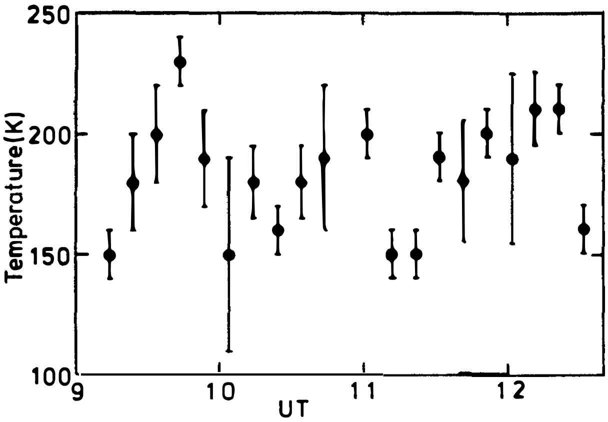

Fig. 5. Time variations of the Doppler temperature of the airglow 5577 Å emission in the zenith direction, observed by the Fabry-Perot scanning spectrometer during the low-latitude aurora event on October 21, 1989, at Niigta. The most active period of the geomagnetic disturbance at 1140–1200 UT is indicated by a bold line on the abscissa.

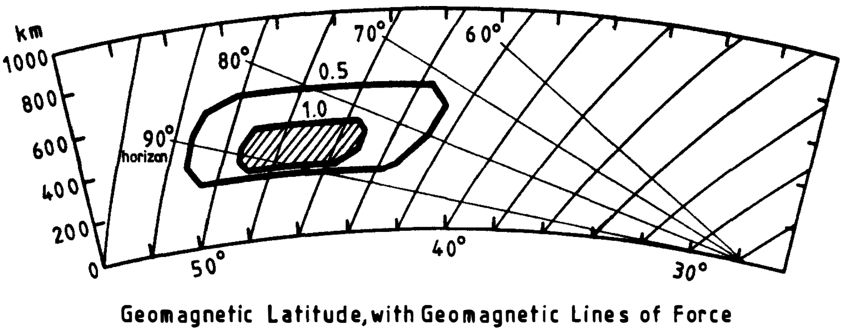

Fig. 6. An expected location of the low latitude aurora on October 21, 1989, in the meridian plane. In this photometric cross-section, the central region of strong auroral emission is located at the height of 400 km and its southern border is in the vicinity of 43° geomagnetic line of force.

proximately to be on the 40° geomagnetic line of force (HIKOSAKA, 1958). With TINSLEY's model of low latitude aurorae (TINSLEY *et al.*, 1982, 1984), the location of the aurorae on October 21, 1989, is believed to be 3° higher in geomagnetic latitude than that of February 11, 1958 event.

In conclusion, from the series of all-sky photographs observed on October 21, 1989, the central emission region with the intensity above 10 kR was located around the height of 400 km and its southern border was in the vicinity of geomagnetic line of force at 43° during 1140–1147 UT, the most active period of geomagnetic storm. The airglow photometer in the zenith direction showed a small increase of 80 Rayleighs in 6300 Å emission during the active period. From the Doppler temperature of the airglow 5577 Å line obtained by Fabry-Perot scanning spectrometer at the zenith, it can be concluded that no auroral effect appeared in the lower thermosphere near 100 km during the night.

Acknowledgments

The authors would like to acknowledge to Miss N. WAKIYA and Mr. S. NUMAZAWA, of Japan Planet Laboratory, for their excellent work of photographic procedures.

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(Received July 31, 1990; Revised manuscript received November 8, 1990)