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ALL SKY IMAGER OBSERVATION OF AURORA AND AIRGLOW AT SOUTH POLE: SYSTEM DESIGN AND THE INITIAL TEST RESULTS (EXTENDED ABSTRACT)

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Since 1957, when the Amundsen-Scott South Pole Station (SP) was opened as one of key stations of the program of the International Geophysical Year (IGY), the National Institute of Polar Research (NIPR) acting since 1980 as the World Data Center (WDC) C2 for aurora has equipped with the auroral image data at SP provided through the University of Alaska and the Utah State University (see Data Catalogue No. 5 issued by NIPR in February 1995). They have so far used an all-sky-camera of 35 mm films which has become obsolete.

We have developed an all sky optical imager (ASI) which was installed at the Amundsen-Scott South Pole Station (SP) in 1996–1997 austral summer season. ASI is a high sensitive (monochromatic and panchromatic) optical imager with high spatial and time resolutions. Another advantage of ASI is its role as a digital CCD imager, so that its digital image data can be stored and easily archived in a computer; through a computer network everybody can access the data, the instrument of ASI at SP itself being monitored and controlled by NIPR computer, Japan, *via* the satellite internet with a modern telescience technique.

The South Pole is a unique place for an auroral observation during austral winter season. We can observe (1) the dayside polar cusp/cleft aurora connected to the direct entry of the solar wind (*e.g.* AYUKAWA and MAKITA, 1996; EATHER *et al.*, 1979), (2) afternoon aurora closely associated with the night side magnetospheric storm/substorm activities (*e.g.* EATHER, 1985) and (3) the polar cap aurora dependent on the polarity of the interplanetary magnetic field. It remains still an open question how the polar cap aurora has the causal connection to the night side high latitude aurora (*e.g.* ELPHINSTONE *et al.*, 1996), although various studies have been done since IGY (International Geophysical Year in 1957). Furthermore, the South Pole is a singular point of the earth's rotation, which also provides us a unique opportunity to observe the airglow to study an effective multi-wavelength (different altitudes) characteristics of acoustic gravity waves at the polar region. With a recent improvement in the CCD imager sensitivity, the optical observations of aurora have been noticeably developed (TAYLOR and GARCIA, 1995; TAYLOR *et al.*, 1995a–d). However, above observational investigations at the South Pole cannot be performed in the northern hemisphere

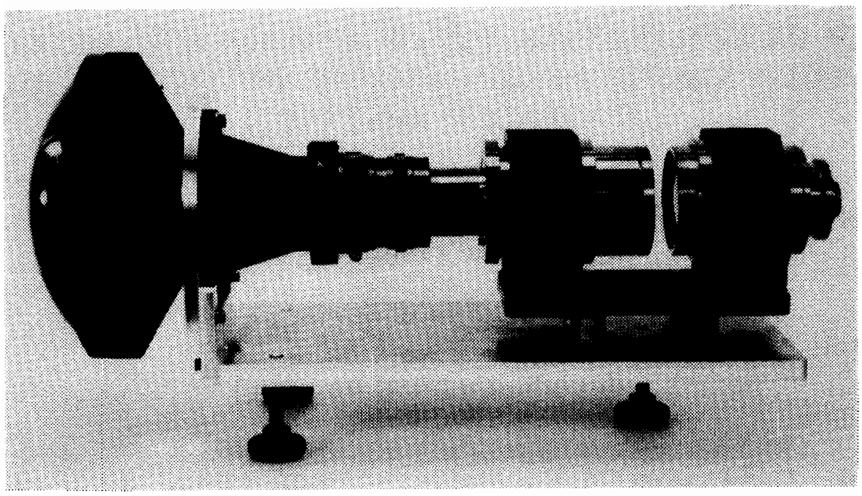

Fig. 1. A photograph of the ASI optics.

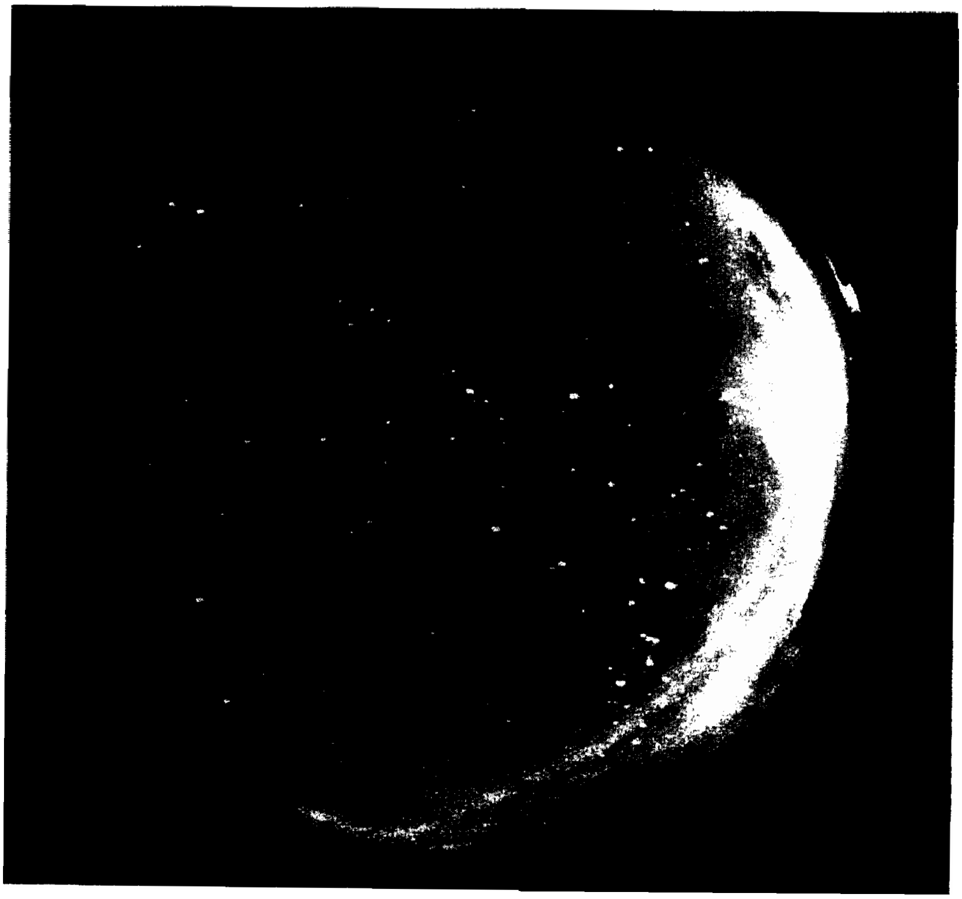

Fig. 2. A typical example of the fish-eye image of airglow (OI 557.7 nm) observed at the Zao Observatory on October 10, 1996. The top is north and the right-hand side is east. The van Rhijn effect is clearly observed as the airglow intensification near the horizon. A strong contamination at the east side is due to the light from Sendai City.

because of no observational site on land.

It is evident that the ground-based optical imagings of aurora/airglow can distinguish temporal and spatial changes of the phenomena, which cannot be separated in the *in-situ* observations by the rockets and satellites. However, in order to investigate the physical causalities of these geophysical phenomena, the data analysis of ASI at SP will be closely cooperated with the satellite experiments of EXOS-D (Akebono), DMSP, NOAA, GEOTAIL, POLAR and WIND. HF radars at Halley Bay, Sanae and Syowa Station also give us the vector velocity of ionospheric plasma over the South Pole. AGOs developed in the polar cap region, Antarctica, will be collaborated with ASI at SP. NIPR has installed an all-sky camera at Chinese Zhongshan Station, Antarctica, located in the polar cap. These international collaborations will contribute to full understandings of the magnetosphere, ionosphere and upper/middle atmosphere physics.

The ASI is equipped with interference filters for auroral emissions of N_2^+ 427.8 nm, OI 557.7 nm, OI 630.0 nm. The diameter and the FWHM of the filters are 80 mm and 3 nm, respectively. OH (730 nm) filter is also assembled and a panchromatic image can be obtained without the filter. An objective lens is a Fish-eye Nikkor with F1.4 and f=6 mm. The optics producing parallel beam (maximum deviation of 7° from the optical axis) is usable also as an interference filter. The image sensor is a back-illuminated air-cooled CCD camera (HAMAMATSU C-4880-72) with 512× 512 pixels. Size of each pixel is 24 μm×24 μm. The time required to read out a full frame is only 1.2 s. The ASI has been calibrated for absolute intensity with a standard tungsten lamp and a diffuser plate at NIPR. The sensitivity at OI 557.7 nm is approximately 0.11 cts/Rayleigh·s. An exterior view of the optics is shown in Fig. 1.

The field test of the ASI was carried out at the Zao Observatory of Tohoku University on the night of October 10, 1996. The OI 557.7 nm airglow emissions were imaged every 2 min with an exposure time of 60 s. On this night, the ASI could detect a moving wave structure on the OI 557.7 nm images with a spatial extent of as small as about 4 km, in addition to large-scale structures of a few tens of kilometer. A typical snapshot of the dynamical behavior of the observed airglow is shown in Fig. 2.

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References

AYUKAWA, M. and MAKITA, K. (1996): The characteristics of daytime aurora at South Pole Station. Nankyoku Shiryô (Antarct. Rec.), **40**, 267–305 (in Japanese with English abstract).

EATHER, R. H. (1985): Polar cusp dynamics. The Polar Cusp, ed. by J. A. HOLTET and A. EGELAND. Dordrecht, D. Reidel, 149–162.

EATHER, R. H., MENDE, S. B. and WEBER, E. J. (1979): Dayside aurora and relevance to substorm current systems and dayside merging. J. Geophys. Res., **84**, 3339–3359.

ELPHINSTONE, R. D., MURPHREE, J. S. and COGGER, L. L. (1996): What is a global auroral substorm? Rev. Geophys., **34**, 169–232.

TAYLOR, M. J. and GARCIA, F. J. (1995): A two-dimensional spectral analysis of short period gravity waves imaged in the OI (557.7 nm) and near infrared OH nightglow emissions over Arecibo, Puerto Rico. Geophys. Res. Lett., **22**, 2473–2476.

TAYLOR, M. J., BISHOP, M. B. and TAYLOR, V. (1995a): All sky measurements of short period waves imaged in the OI (557.7nm), Na (589.2nm) and near infrared OH and O_2 (0, 1) nightglow emissions during the ALOHA-93 campaign. Geophys. Res. Lett., **22**, 2833–2836.

TAYLOR, M. J., FRITTS, D. C. and ISLER, J. R. (1995b): Determination of horizontal and vertical structure of an unusual pattern of short period gravity waves imaged during ALOHA-93. Geophys. Res. Lett., **22**, 2837–2840.

TAYLOR, M. J., TURNBULL, D. N. and LOWE, W. P. (1995c): Spectrometric and imaging measurements of a spectacular gravity wave event observed during ALOHA-93 campaign. Geophys. Res. Lett., **22**, 2849–2852.

TAYLOR, M. J., GU, Y. Y., TAO, X., GARDNER, C. S. and BISHOP, M. B. (1995d): An investigation of intrinsic wave signatures using coordinated lidar and nightglow image measurements. Geophys. Res. Lett., **22**, 2853–2856.

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