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SYSTEMATIC ANALYSIS OF AURORAL CONJUGACY: AN APPLICATION TO PERIODIC PULSATING AURORA (EXTENDED ABSTRACT)

Hirokazu MINATOYA[1], Natsuo SATO[2], Thorsteinn SAEMUNDSSON[3] and Takeo YOSHINO[1]

[1] *University of Electro-Communications, 5-1, Chofugaoka 1-chome, Chofu-shi, Tokyo 182*
[2] *National Institute of Polar Research, 9-10, Kaga 1-chome, Itabashi-ku, Tokyo 173*
[3] *Science Institute, University of Iceland, Dunhaga 3, Reykjavik 107, Iceland*

Previous studies have revealed that auroras near the conjugate regions in both hemispheres did not necessarily show conjugacy (BELON *et al.*, 1969; STENDAEK-NIELSEN *et al.*, 1972; SATO *et al.*, 1987; FUJII *et al.*, 1987). These results were obtained mainly from qualitative analyses using simultaneous all-sky images observed in both hemispheres. However, this kind of qualitative analysis does not provide a quantitative measure of the degree of conjugacy.

We have developed an analysis system which is useful for the quantitative study of auroral conjugacy (MINATOYA *et al.*, 1994). Figure 1 shows the analysis procedure for the present auroral conjugate study using this system. The procedure and characteristics of the system are as follows: (1) Auroral pictures in video format are digitized by ARSAD: Automatic Retrieval System for Auroral Data (ONO, 1993). (2) Simultaneous digital images observed at several stations are composed to one image, which is converted to video format as shown in Fig. 2. (3) The composite pictures of spatially extended fields of view in both hemispheres makes it easy to understand the conjugacy of auroral features such as position, shape, motion and intensity variation in both hemispheres. (4) In order to carry out quantitative analysis, auroral features are picked up from the digital data, and analyzed using techniques such as transformation from the all-sky image to rectangular geomagnetic coordinate images, and the autocorrelation analysis developed by ONO *et al.* (1987).

We applied this method to periodic pulsating auroral events obtained by SIT-TV cameras at nearly geomagnetic conjugate stations, Husafell in Iceland and Syowa and Asuka stations in Antarctica, during the period from 2254 to 2256 UT on September 9, 1991. The locations of the conjugate stations are listed in Table 1. The IGRF'90 model

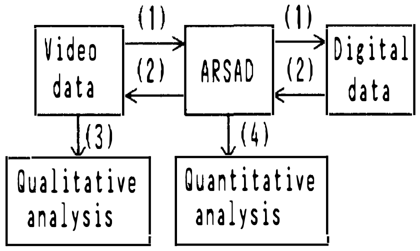

Fig. 1. Procedures for the systematic analysis of auroral image data for the auroral conjugate study.

Fig. 2. An example of composite all-sky picture of Husafell (upper side), Syowa (lower right side) and Asuka (lower left side) at 2255 UT. Up and right sides of each all-sky picture are oriented to high latitude and east, respectively.

indicates that Husafell and Syowa have almost geomagnetic conjugate relations, while Asuka is located near the same latitude but about 670 km west of them. These stations are close enough to each other for their observational areas to overlap at auroral altitude (100 km), giving a wider field of view for investigation.

According to the composite pictures, two kinds of periodic pulsating auroras were seen. One is a pulsating aurora of the expansion type (YAMAMOTO, 1988) along the eastern edge of a large scale torch structure within Husafell and Syowa's fields of view. The other is that of the patchy type (YAMAMOTO, 1988) within the field of view of Asuka. MINATOYA *et al.* (1994) have already shown that large scale torch structures, which passed in the time interval of about 2220-2300 UT, indicated good correlation of shape and motion between Husafell and Syowa's fields of view, while there was poor correlation between Husafell and Asuka's fields of view. The location of the torch structure and type of pulsating auroras as mentioned above suggest that Husafell and Asuka are not in a conjugate relation to each

Table 1. Location of conjugate-pair stations in Iceland and Antarctica. Geomagnetic latitude, longitude and L-value are calculated with IGRF'90 model for 00 UT on January 1, 1991.

Station	Geographic		Geomagnetic		L-value
	latitude	longitude	latitude	longitude	
Husafell	64.47°	338.97°	65.97°	68.88°	6.03
Syowa	−69.00°	39.58°	66.54°	71.79°	6.31
Asuka	−71.53°	24.14°	65.41°	58.53°	5.77

other, while Husafell might be conjugate with Syowa.

A more detailed investigation was carried out to compare the data from Husafell and Syowa, using an autocorrelation analysis to derive the pulsating spatial pattern, intensity variations, periodicity and period, both spatially and temporally. The TV image data were digitized at a sampling rate of 0.2 s in order to analyze pulsating auroras with a period of 4–10 s. The autocorrelation analysis was applied to the intensity of each image pixel of the Husafell and Syowa data for the time interval 2254:40–2255:50 UT. The results are shown in Fig. 3. The panels (a–d) for Husafell represent (a) mean intensity, which is time-averaged intensity of each image pixel over the analysis interval, (b) deviation, which is the relative standard deviation of intensity variation measured from the mean intensity, (c) periodicity and (d) period, *i.e.* the maximum coefficient and the time lag for the autocorrelation function, respectively. The panels (a′–d′) for Syowa are of the same format as the panels (a–d).

The structure H in panel (a) and S in panel (a′) indicate the large scale torch structures. Three small scale wavy structures, A, B and C, are found around H, near a vertical line bisecting the field of view along longitude ~70 deg. A similar structure D is also found around S, at the center of the image (longitude ~72 deg. and latitude ~66 deg.). Pulsations were seen in each of these structures. If the field of view from Husafell covers

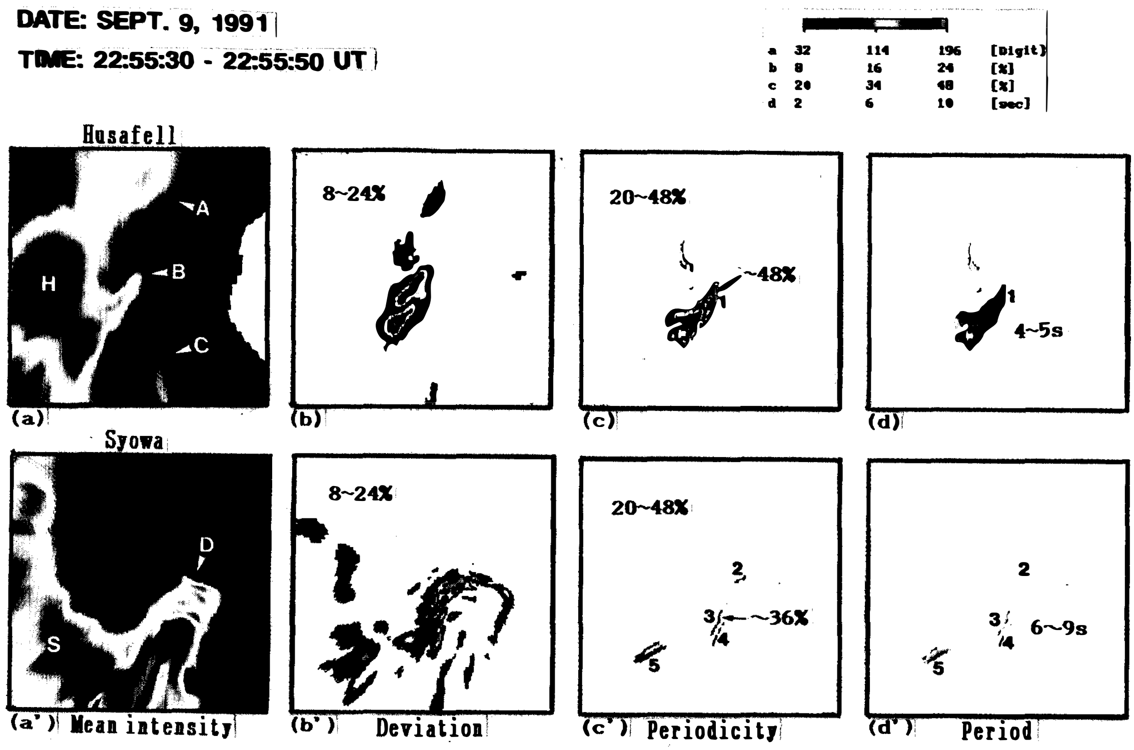

Fig. 3. Results of an autocorrelation analysis for the periodic pulsating aurora observed at Husafell and Syowa during the interval of 2255:30–2255:50 UT. The results were projected onto rectangular geomagnetic coordinates. Projection are is 64–68° in geomagnetic latitude (~520 km at 100 km) for the vertical axis and 64–76° in geomagnetic longitude (~600 km at 100 km) for the horizontal axis in both hemispheres. (a) Mean intensity, (b) deviation, (c) periodicity, (d) period.

the conjugate area of Syowa, similar characteristics of pulsating auroras might be expected at both stations.

Regular periodic pulsations with large amplitude are seen in structures B and D. The panels (b-d) show rather large size pulsating regions along structure B at Husafell. Region 1 has large intensity variation (8-24%) and high periodicity (20-48%) with a period of 4-5 s. The panels (b′-d′) show regions of large intensity variation (8-24%), relatively lower periodicity (20-36%) with periods of 6-9 s. It is notable that the pulsating regions 2-5 in structure D are very small. It is thus suggested that the pulsating auroras in structures B and D are similar in intensity variation but dissimilar in spatial pattern, size and period. We conclude that there is no correlation between structures B and D. Another event in the time interval 2254:40-2255:00 UT also indicates the same tendency as the above results.

The non-conjugate characteristics mentioned above may suggest that lack of conjugacies in periodic pulsating auroras between Husafell and Syowa were caused by asymmetrical generation mechanisms of auroral particles in both hemispheres. Repeated analysis of this type will throw further light on auroral conjugate study.

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