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Optical Auroral Forms over Maitri during Antarctic Winter 1994 and Their Relationship with Simultaneous Geomagnetic Variations

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Abstract

During the Antarctic winter of 1994 (Apr-Oct), the Indian Institute of Geomagnetism carried out one man campaign of auroral photography over the Indian stations MAITRI(MAI) and DAKSHIN GANGOTRI(DG). The idea was to study the direction in which the phenomenon of "aurora australis" originated and moved with respect to MAI and DG, and the changes which occurred in its colour, form and structure. Since all-sky cameras and Video/TV cameras were not available, the photographs were taken outdoors on a stand mounted ZENITH ET camera using 400 ASA Kodak film and exposure times of 8 to 15 sec.

The other investigation was to see how the changes in aurora corresponded with simultaneous variations in the Y, X and Z components of the geomagnetic field, using both Daily Variation (DV) and electronically filtered Micropulsation (MP) magnetograms.

Two events, namely a Harang Discontinuity which occurred over DG on 29 Apr 1994, and a fluted band auroral display over MAI on 20 Aug 1994, are selected for this study. Clear correlations seen between variations in the auroral forms and geomagnetic components are discussed, and periodicities observed in geomagnetic pulsations are brought out.

Introduction

The correlation of visual auroral forms with simultaneous geomagnetic variations has been a technique for understanding high latitude physics for several decades [Mc Pherron *et al.* 1968; Kisabeth and Rostokar 1973; Subbarao and Whalen 1973; Pike and Whalen 1974 and more recently Aikio and Kaila 1996; Bosinger *et al.* 1996]. The ideas of yester years that the two phenomena, geomagnetic and optical, originate from a common cause have crystallised into clear realisation that the high-latitude ionosphere behaves almost like a TV screen, mirroring optical, electric and magnetic phenomena which originate in the deep distant magnetosphere (Rajaram, 1994). With this feature in mind during the Antarctic Winter of 1994, IIG carried out a one man

campaign of photographing in close time sequences, as many auroral events as possible from MAITRI (70°46'S, 11^0 45'E geog) and DAKSHIN GANGOTRI(70°05'S, 12° E geog). Since all-sky cameras and Video/TV cameras were not available, the photography was carried out with a stand mounted ZENITH ET camera, using 400 ASA Kodak film and exposure times of 8 to 15 sec. Given the temperatures of -35C and wind speeds of 30-80 km/hr, it was not exactly an easy task to record the 53 auroral displays between Apr - Oct 1994. Table 1 is a list of the 53 auroral events which were observed between Apr' 94 and Oct' 94(Photographs could be taken for 23 events). IIG also operates a 3-component fluxgate magnetometer round-the-year at MAITRI, recording both Daily Variations (DV) and Micropulsations (MP) in the geomagnetic field. Hence a correlative study between the two was feasible, and two events, namely those on 29 Apr 1994, and 20 Aug 1994 are discussed in detail in this work.

Maitri (MAI) and Dakshin Gangotri (DG) are located just equatorward of the auroral zone.

Experimental Details

During 1994 Antartcic winter (Apr to Oct) the visible aurora at Maitri has been photographed on all possible clear weather days namely for 23 events. Table 1 gives days of 1994 and the time in UT at which observations were made. Micropulsations in X, Y, Z components of the geomagnetic field at MAI are selected for comparison with the optical observations. These pulsations include all variations with time periods between 30 sec and 3000 sec (i.e. frequencies between 33 mHz and 0.33 mHz). The precise times at which the photographs taken are indicated on the magnetograms in Figs 2 and 3 as P1,P2, etc. Below the magnetograms are shown circles containing the shape and form of the auroral structures as viewed from MAI or DG (as the case may be); the station is located at the centre of the circles. The variations in Y, X, Z geomagnetic components which simultaneously accompany the changes observed in the form, intensity and structure of the aurora are discussed.

Finally a brief study is made of the frequencies of prominent magnetic pulsations observed on the magnetograms during the auroral events considered.

Observations

THE EVENTS SELECTED - 29 April 1994 and 20 August 1994

Figs 1(a) and 1(b) show the daily variation magnetograms for DG on 29 April 1994 and at Maitri on 20-21 August 1994. Only the hours considered for

Table 1: Auroral events observed between 1 Mar.1994 and 20 Oct.1994

Event No.	Day and Time of Observations			
	From		To	
01	06.04.94	1920 UT	06.04.94	2340 UT
02	07.04.94	2215 UT	07.04.94	2315 UT
03	08.04.94	2150 UT	09.04.94	0118UT
04	14.04.94	2310 UT	15.04.94	0355 UT
05	15.04.94	2315 UT	16.04.94	0130 UT
06	16.04.94	2025 UT	17.04.94	OOIOUT
07	18.04.94	0010 UT	18.04.94	0130 UT
08	29.04.94	2203 UT	29.04.94	2245 UT
09	01.05.94	1915 UT	01.05.94	2100 UT
10	02.05.94	2350 UT	03.05.94	0304 UT
11	05.05.94	0015 UT	05.05.94	0305 UT
12	06.05.94	2225 UT	07.05.94	0227 UT
13	09.05.94	2205 UT	10.05.94	0114 UT
14	10.05.94	2008 UT	10.05.94	2312 UT
15	11.05.94	2125 UT	11.05.94	2305 UT
16	18.05.94	0010 UT	18.05.94	0210 UT
17	18.05.94	2125 UT	18.05.94	2137 UT
18	29.05.94	2145 UT	29.05.94	2235 UT
19	30.05.94	0036 UT	30.05.94	0525 UT
20	30.05.94	2025 UT	30.05.94	2230 UT
21	03.06.94	2130 UT	04.06.94	0125 UT
22	04.06.94	2045 UT	04.06.94	2245 UT
23	05.06.94	2045 UT	06.06.94	0255 UT
24	08.06.94	0000 UT	08.06.94	0200 UT
25	13.06.94	2305 UT	13.06.94	2330 UT
26	26.06.94	2115 UT	26.06.94	2310 UT
27	28.06.94	2200 UT	29.06.94	0030 UT
28	06.07.94	0045 UT	06.07.94	0100 UT
29	06.07.94	2225 UT	06.07.94	2325 UT

(Contd.)

Table 1: Contd.

Event No.	Day and Time of Observations			
	From		To	
30	15.07.94	2250 UT	15.07.94	2350 UT
31	17.07.94	0400 UT	17.07.94	0530 UT
32	24.07.94	2250 UT	24.07.94	2300 UT
33	25.07.94	0000 UT	25.07.94	0030 UT
34	28.07.94	2230 UT	28.07.94	2300 UT
35	29.07.94	2230 UT	29.07.94	2240 UT
36	20.08.94	2210 UT	20.08.94	2330 UT
37	31.08.94	2330 UT	01.08.94	0120 UT
38	01.09.94	2250 UT	02.09.94	0015 UT
39	03.09.94	2345 UT	04.09.94	0020 UT
40	07.09.94	0300 UT	07.09.94	0400 UT
41	07.09.94	1930 UT	08.09.94	0030 UT
42	09.09.94	2315 UT	09.09.94	2325 UT
43	10.09.94	0130 UT	10.09.94	0130 UT
44	10.09.94	2305 UT	11.09.94	0013 UT
45	11.09.94	2315 UT	12.09.94	0032 UT
46	13.09.94	2100 UT	14.09.94	0100 UT
47	18.09.94	2250 UT	18.09.94	2315 UT
48	25.09.94	2000 UT	26.09.94	0015 UT
49	26.09.94	2225 UT	27.09.94	0030 UT
50	29.09.94	2255 UT	29.09.94	2300 UT
51	30.09.94	2250 UT	30.09.94	2350 UT
52	06.10.94	2110UT	07.10.94	0010 UT
53	19.10.94	2300 UT	19.10.94	2345 UT

the studies is shown here. Perusal of the entire managnetogram for Fig 1 (a) shows that it was a fairly quiet day at DG with kp=10, and almost undisturbed traces over the whole day. The event seen between 2200 and 2400 hours suggests a temporary increase in the electromagnetic activity state of geospace (the kp value for this interval 2200 to 2400 hr was 3-). Hence DG has shifted into the auroral oval and sees the pre-midnight auroral feature known as Harang Discontinuity (HD). The HD seen in the auroral ionosphere indicates an

electrical discontinuity between the eastward electrojet of the dusk hours and the westward electrojet of dawn hours. This electrical discontinuity has many manifestations such as change in auroral forms, change in plasma convection patterns and change in geomagnetic signatures. The details of the auroral forms seen during this HD event at DG are discussed in section 3.2.

Fig 1(b) on the other hand for 20-21 August 1994, shows a moderately disturbed day with kp=14- and moderate disturbance during the event considered (2200 and 2400 hrs), with kp=20 preceding it and kp=2 following it. The mild disturbance over a prolonged period of 10 to 12 hours gave rise to band-like auroral structure. Details of the auroral structure seen are discussed in section 3.3.

Geomagnetic Signatures and Auroral Displays Associated with a Harang Discontinuity (HD) over Dakshin Gangotri, 29 April 1994

The daily variation magnetogram at DG [Fig 1(a)] showed for a brief while around 2200 to 2245 UT, the signatures of a typical auroral disturbance known as Harang Discontinuity (HD). The HD occurs around midnight hours when the location experiences magnetically disturbed conditions and hence is a rather localised phenomenon [Harang 1946]. The variations in the Y,X and Z components confirm that DG has moved from EAE current region to a WAE current

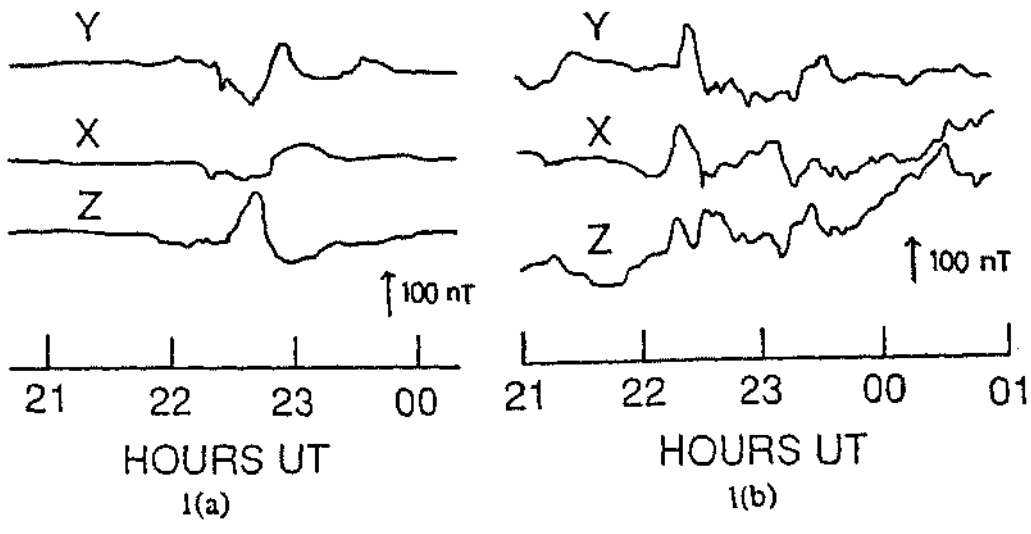

Fig. 1(a) & 1(b): Daily Variation(DV) magnetograms for the events 29 April 1994 and 20-21 August 1994

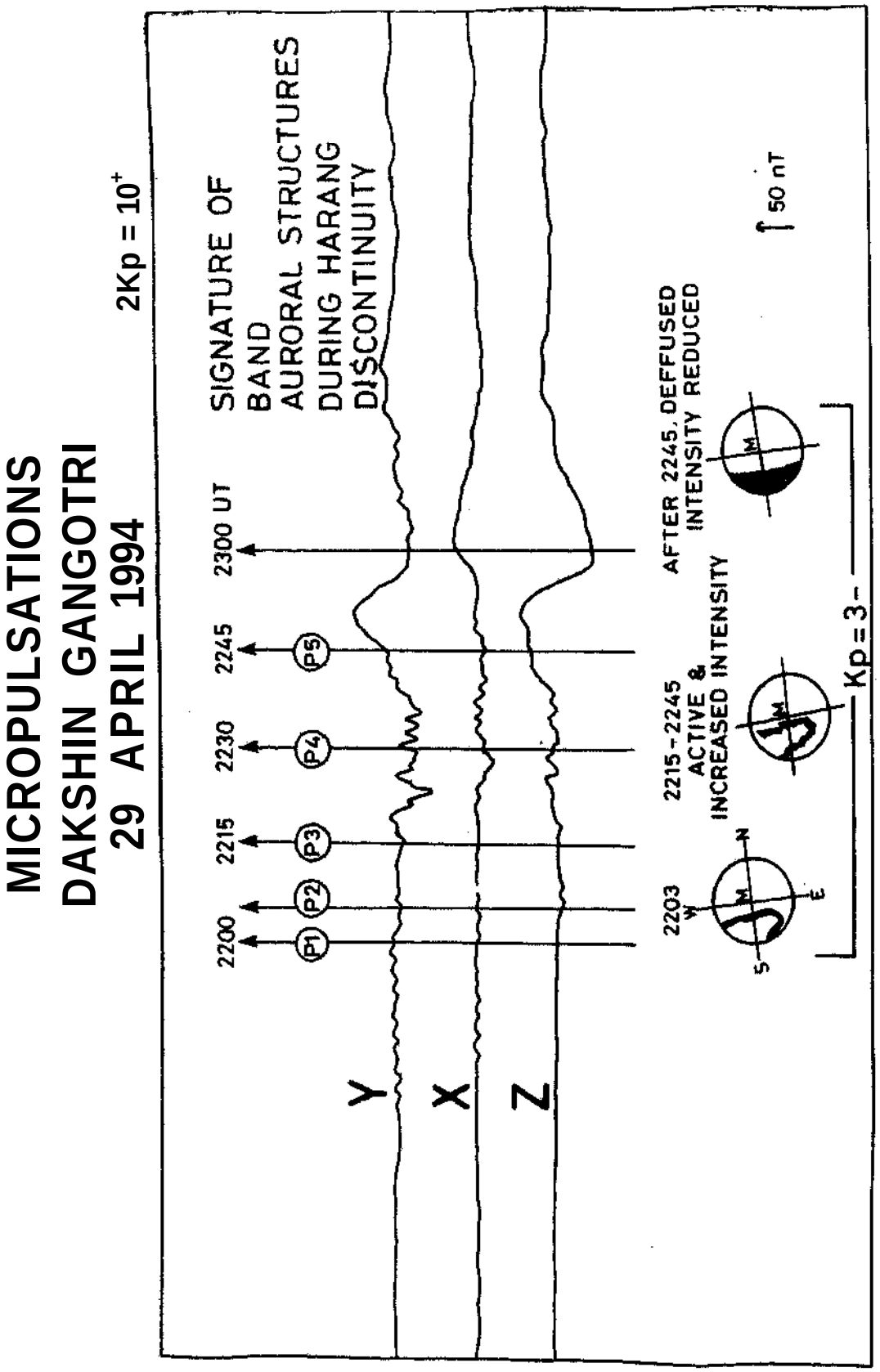

Fig.2: Magnetogram showing the filtered pulsations between the frequencies 33 mHz and .33 mHz for the event on 29 April 1994

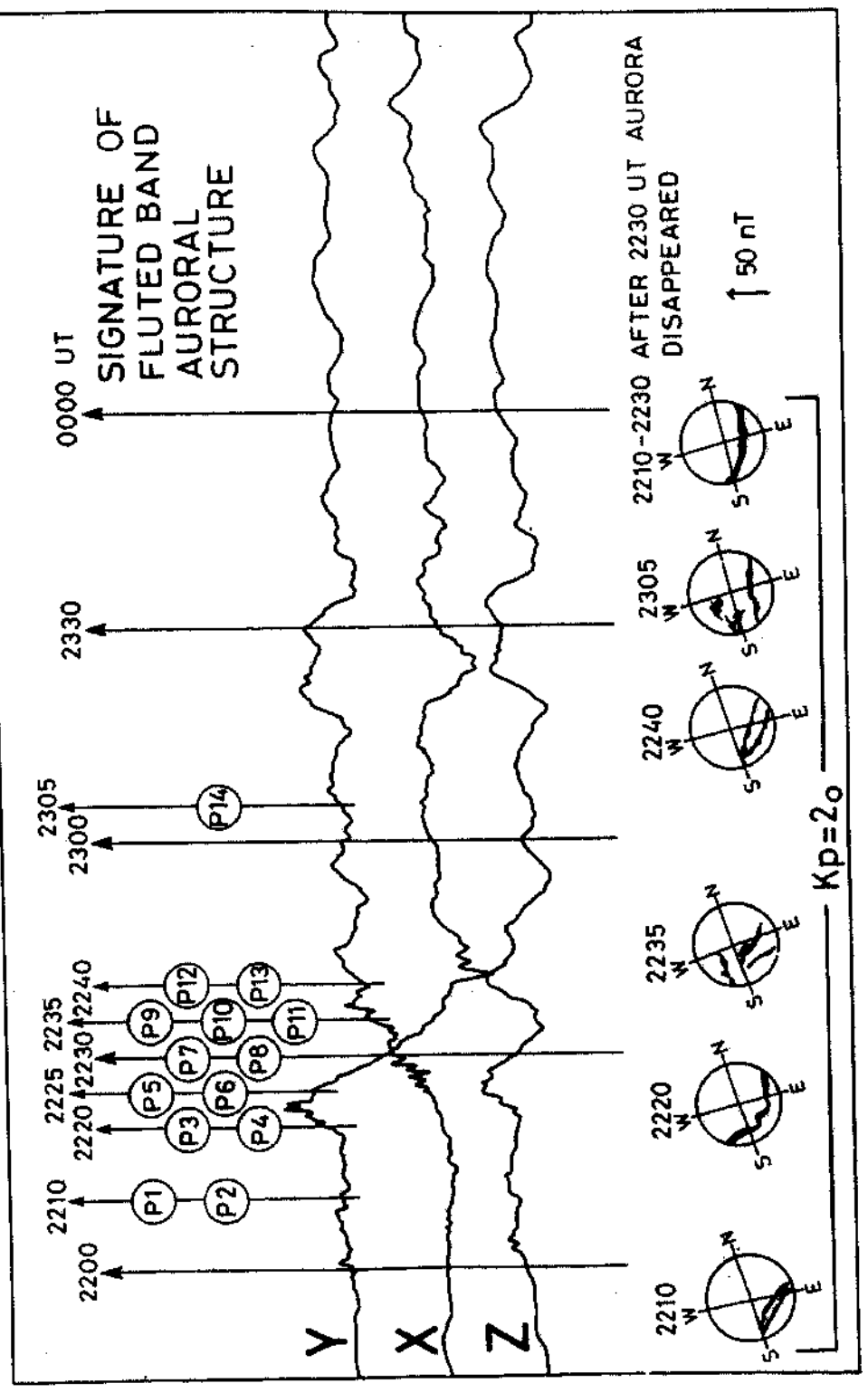

Fig.3: Magnetogram showing the filtered pulsations between the frequencies 33 mHz and .33 mHzfor the event on 20-21 August 1994

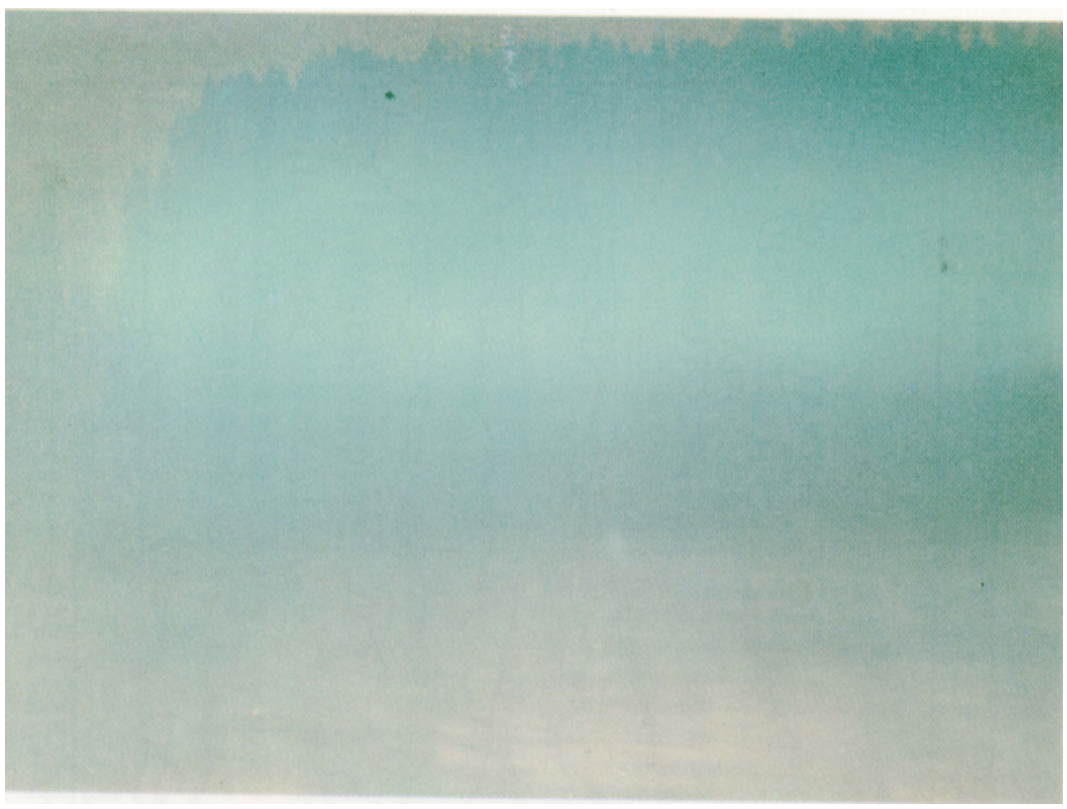

Fig.4 (a)

Fig. 4 (b)

Fig. 4 (c)

Fig. 4 (d)

Fig. 4 (e)

Figs 4(a) to 4(e): Auroral pictures on 29 April 1994 showing the changes in the form, intensity and direction at different times indicated as P1.P2,.P5 in Fig.2

region and is simultaneously passing under strong FAC; these are the typical signatures of the HD. Fig 2 shows the filtered magnetograms i.e. the pulsations at DG in the Y,X and Z components during the period 2200-2300 UT on 29 April 1994 when an intense auroral band structure occurred over DG. The kp magnetic index for this interval was 3 showing it to be slightly disturbed. Figs 4(a), 4(b), 4(c), 4(d), 4(e) were taken at times P1,P2,P3,P4,P5 which are indicated on Fig 2. We will first discuss the circles shown in the lower part of Fig 2 which depict the dielectrical perspective of the aurora as seen from the centre of the circle i.e. DG. The directions N,S,E and W indicate the normal points of the compass with respect to DG. At 2203 UT the whole aurora appeared as a curved diffuse band lying to the south of DG; by 2215 UT the aurora became active increasing in intensity and subsequently took up a clear band structure moving overhead towards DG. The third circle at 2245 UT indicates that the band structure degenerated into bright patches of aurora lying south of DG. The corresponding geomagnetic variations show that mild pulsation activity preceding 2215 develops into clear large variations in all three components Y,X and Z. Between 2240 and 2300 UT there are clear variations of 28 nT in the Y and Z components. The enhanced positive in the Y component shows the presence of FAC over DG and the change-over in Z from positive to negative indicates that the station has moved from a region of EAE to one of

WAE between 2240 - 2300 UT. By about 2320 UT quiet conditions are seen on magnetogram in Fig 1(a).

We now discuss the auroral photographs in Fig 4(a), 4(b),... in relation to the times PI, P2, P3, etc. marked on Fig 2. Fig 4(b) (P2 at 2303 UT on Fig 2) indicates that the entire diffuse band has lifted off the horizon. At the time P3 (2215 UT) the aurora has broken into discrete patches of bright light. In Fig 4(d) (P4 at 2230 UT) the intense auroral structure is directly over DG. The last picture Fig 4(e) (P5 at a few minutes before 2245 UT) shows that bright band structure still persists over MAI. Clear pulsation activity is seen in Y and X components with frequency 60 sec. and 120 sec. Another phase of pulsation activity takes place in Y and X at 2235 UT with periodicity of 2.5 sec.

Optical and Geomagnetic Signature of Fluted Band Auroral Structure on 20 August 1994 at Maitri

Fig.3 shows the electronically filtered micropulsation in Y,X and Z components (frequencies between 0.33 mHz and 33 mHz) between 2200 and 2400 UT on 20 August 1994. This interval is relatively quiet with 3-hourly kp value of 20, but the field is experiencing the after effects of the moderate electromagnetic disturbance of earlier hours. The circles in the lower part of Fig 3 as in Fig 2, show the direction perspective of the aurora with respect to the centre of the circle (MAI). At 2210 UT, circle 1 shows an elongated band stretching out all the way from the east direction to the south direction and this spreads westward in circle 2 at 2220 UT. In circle 3, at 2235 UT, the band structure has broken up into segments lying east and west of MAI. Circle 4 at 2240 UT shows two parallel bands lying south-east of Maitri; circle 5 at 2305 UT shows bqth to have joined to become one band stretching from north-east to south-east. Circle 6 at 2310 UT shows a broad quiet auroral band stretching from south-east to south-west.

We now describe the auroral photographs taken during this event; these are shown as Figs.5(a) to 5(n). The pictures 5(a) and 5(b) clicked soon after 2210 UT show in two parts the long diffuse band which stretched from the east to the west direction in the sky south of Maitri (seen in the foreground of picture 5(b.) are the permanent structures north east of Maitri). The pictures 5(c) and 5(d) clicked in quick succession at 2220 UT indicate how diffuse band breaks up into two bands of corrogated appearance with ray structure, 5(e) and 5(f) are shot in succession at 2225 UT and show two portions of the same auroral band stretching from the east to the south. (Seen in the foreground of 5(f) are the huts with washroom facilities lying north-east of Maitri). Note that this fluted band ray structure in the aurora accompanies long period wave variations in the Y,X and Z components seen in Fig 3. 5(g), 5(h) and 5(i) shot in quick succession at

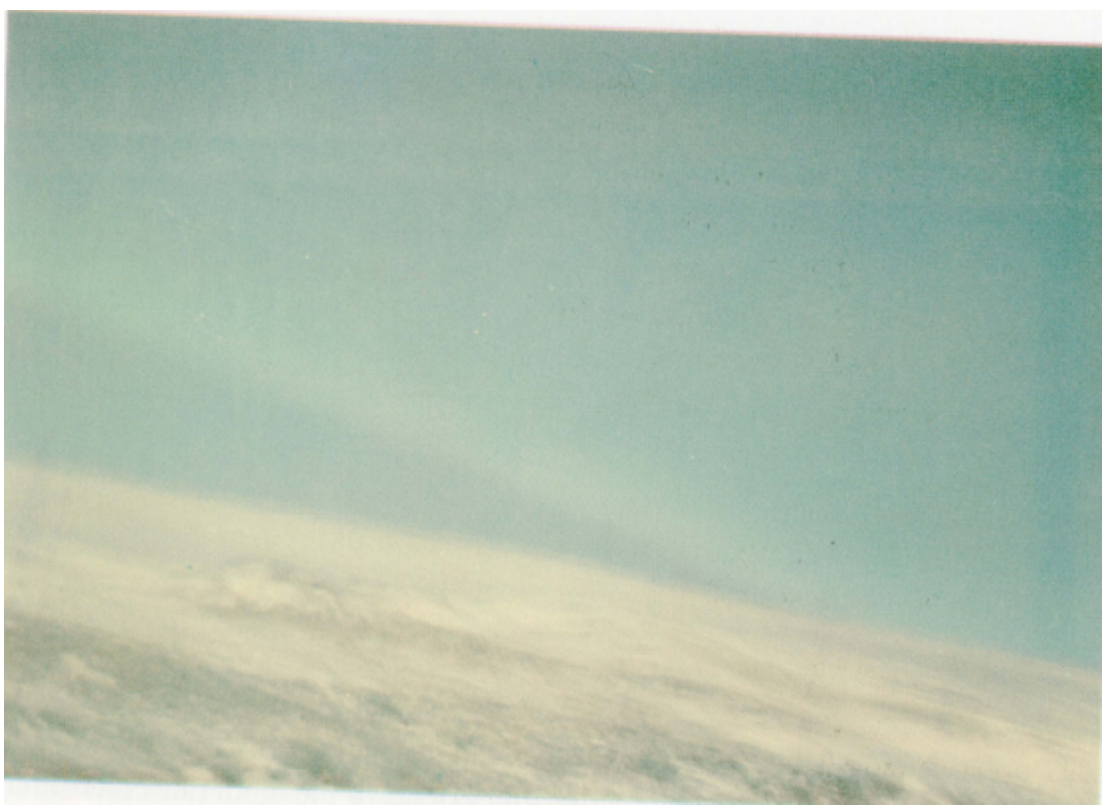

Fig. 5 (a)

Fig.5(b)

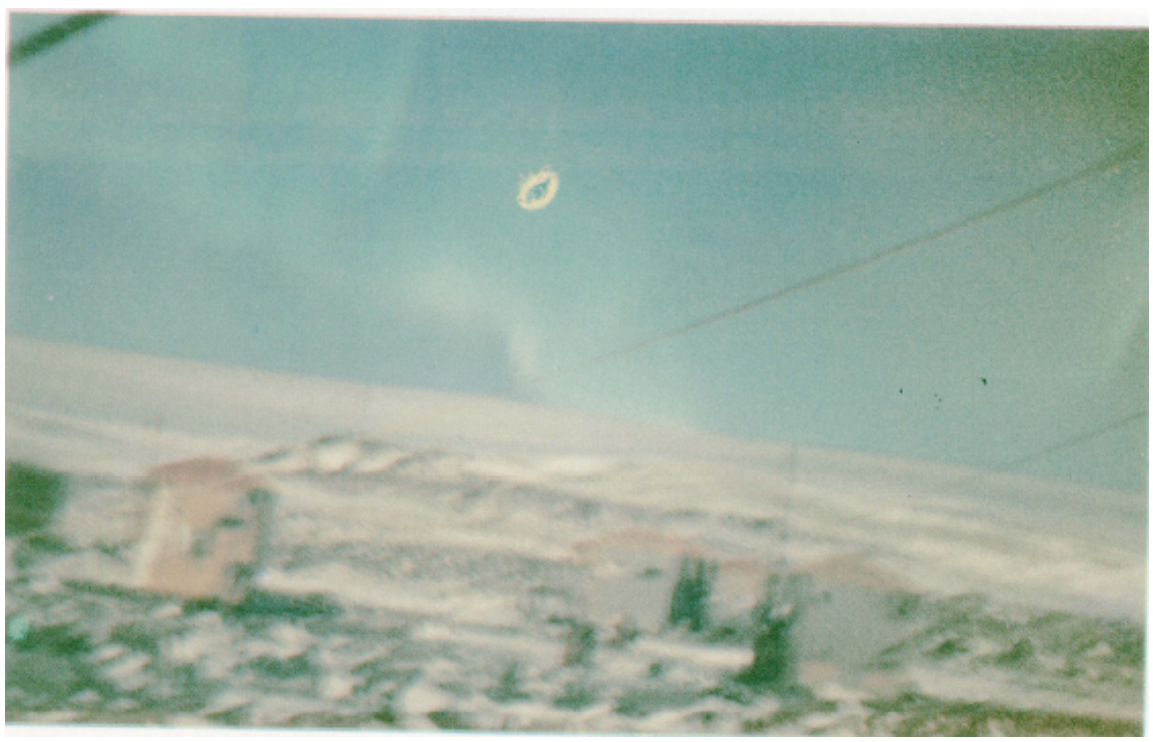

Fig. 5 (c)

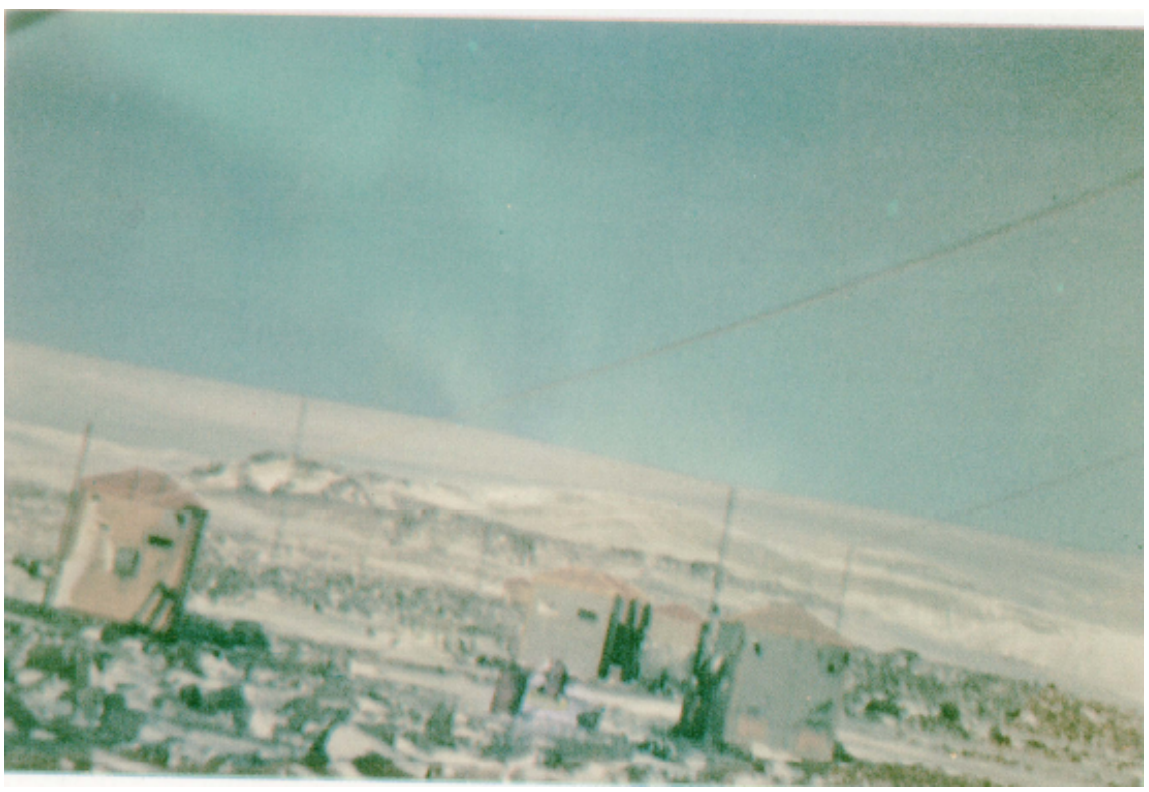

Fig. 5 (d)

Fig. 5 (e)

Fig.5 (f)

Fig. 5 (g)

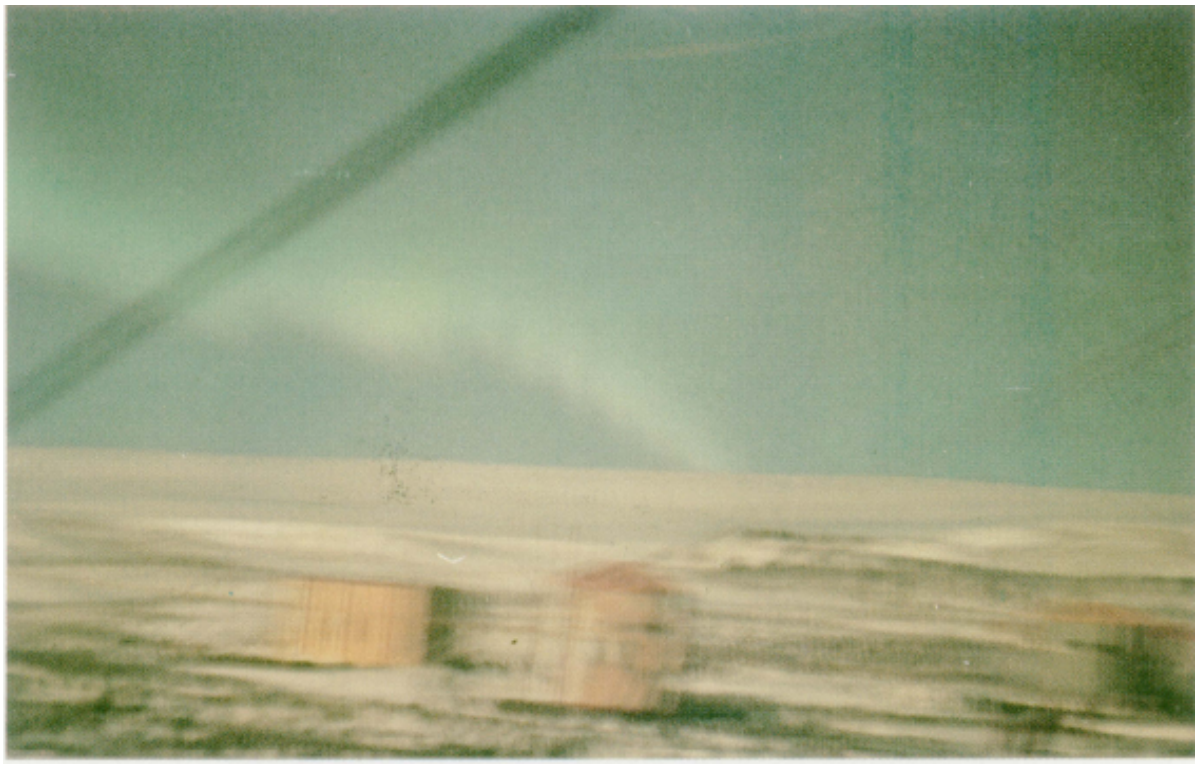

Fig. 5 (h)

Fig.5(i)

Fig.5(j)

Fig. 5 (k)

Fig. 5 (l)

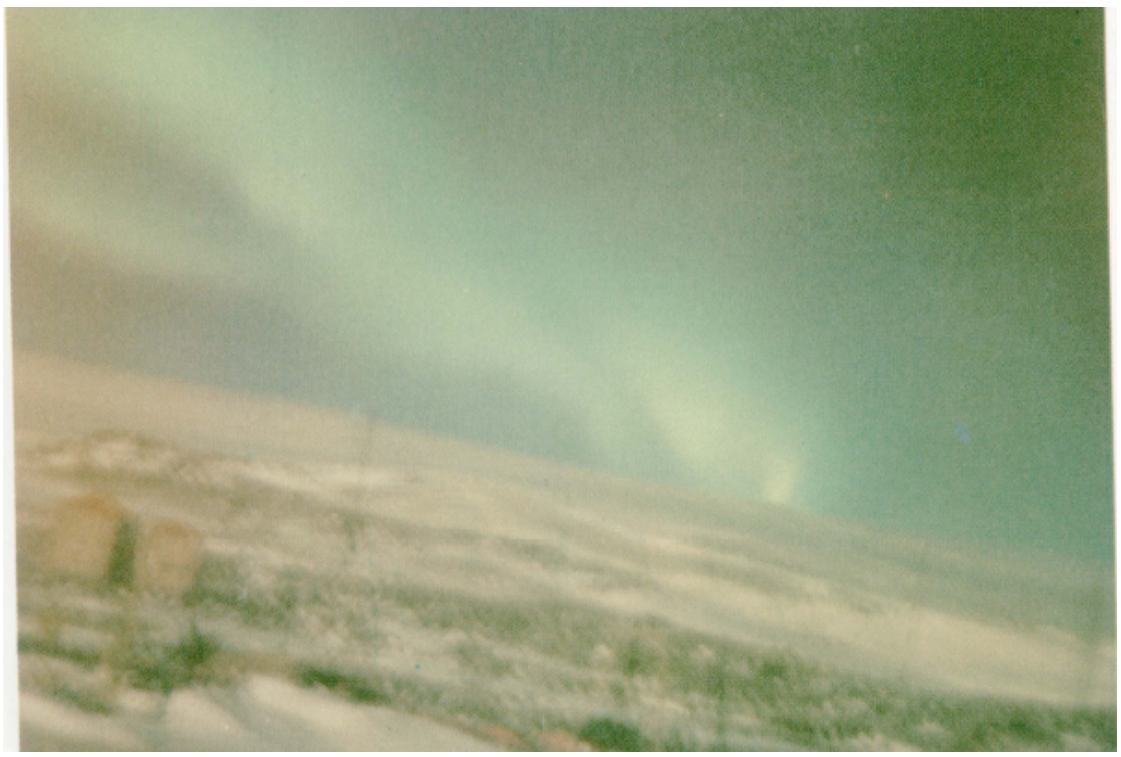

Fig. 5 (g)

Fig. 5 (n)

Fig 5(a) to 5(n) : Auroral pictures on 20-21August 1994 Shoiwng the changes in the from intensity and direction at different times indicated as P1,P2,....P14 in Fig.3

2330 UT show an intensification of the fluted ray structure and then dimmingcit down 5(j) taken at 2235 UT show the whole aurorol structure changed into a plain band. 5(m) is view of the extention of the same auroral band in 5(j). In 5(1) and 5(m) at 2240 UT7 the auroral band suddenly intensifies and breaks into a 3 parallel band structure directly over MAI. 5(n) at 2305 UT still show the parallel band structure.

Ihemagnetogramsin Fig.3 forthisentireperiodfrom2200UTtobeyond 0000 UT show clear wave-like variations in all three components (with Smaller frequency variations riding on them). The long wave forms have periods of 600 sec ion the Y X and Z components while the higher over-riding frequencies have time periods of roughly 60 sec. The large variation in Y shoes the presence of strong FAC in the vivinity of MAI, while the X and Z variations show localised changes in the east-west auroral electrojet currents.

Discussion and Conclusions

From the two events discussed above, namely the Harang Discontinity and a fluted band aurora it is clear that the change in the form, intensity, structure and directional location of the optical aurora at Indian Antarctic stations MAI and DG are accompanied by clear changes in the Y,X and Z components of the geomagnetic field. Often short-period pulsations ride on top of long-period wave forms in Y,X and Z.

Large change in the components can indicate the presence of large FAC over MAI, or the presence of intense north- south directed ionospheric currents. Large changes in the X component usually indicate indicate intensification or weakening of the norma sector and WAE current in the dawn sector. Sharp changes in Z copmonent normally indicate marked changes in the position of WAE and EAE either in an equatorward direction or poleward direction.

Table 2

Date	Time in UT		Component	Periodicity
	From	To		
29.04.94	2140	2205	Y	180 Sec.
			X	180 Sec.
			Z	——
29.04.94	2230	2235	Y	120 Sec.
			X	120 Sec.
			Z	——
20.08.94	2220	2225	Y	45 sec.
			X	60 sec.
			Z	60 sec.

There is clear wave like activity seen in the filtered magnetograms(containing variations with time periods between 30 and 3000 secs). Often long period waves are seen with shorter period micropulsations overriding this. In Table 2 are listed the periodicities of pulsations observed in the two events discussed here. The digital 2 sec values of the geomagnetic data for these events is available; it is currently under study, with the idea of obtaining quantitative ideas on the type of wave activity associated with auroral events.

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