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Some results of whistler and VHF scintillation observations at Agra

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Results of whistler observations for the period Dec. 1989-Mar. 1991 and VHF scintillation observations for the period Jan. 1991-Mar. 1991 at the low latitude ground station of Agra are presented. It is shown that whistler activity at this station is very rare and sporadic. Large whistler activities have been observed at two occasions only, during fourteen months of observations. Some new results include the observations of higher harmonics of tweeks, daytime whistlers and daytime discrete chorus emissions for the first time in a low latitude ground station in India. The VHF scintillations at 244.168 MHz from FLEETSAT are recorded both during night and daytimes and their temporal variation of occurrence number and association with spread-F and sporadic-E irregularities are discussed.

1 Introduction

In recent years effects of equatorial anomaly and ionospheric irregularities like sporadic-E and spread-F on whistler wave propagation at low latitudes have been examined in great detail. It has been shown that enhanced ionization along the field lines in the equatorial anomaly region may guide the daytime whistlers[1-3], and negative latitudinal gradients of ionization provided by the anomaly during magnetic storm periods may guide the nighttime whistlers to ground stations at low latitudes[4]. The sporadic-E layers have been found to cause lower and upper cut-off and banding in frequency-time spectrograms of low latitude whistlers[5]. Similarly, spread-F irregularities have been found to guide the whistler waves to ground stations at low latitudes in the absence of suitable ducts in the ionosphere[6]. However, these studies have been made independently and no attempt has been made to make a coordinated study of these irregularities vis-a-vis whistler propagation at low latitudes. Further, no attempt has been made to locate the exit points of whistlers in the low latitude ionosphere in the Indian meridional planes, which is only possible from a coordinated study of whistlers.

In this paper, results of whistler and scintillation observations at Agra (geogr. lat., 27.2°N; long., 78°E; geomagn. lat., 17.1°N) for the period 27 Dec. 1989-31 Mar. 1991 under all India Co-ordinated Projects on Ionospheric & Thermospheric Studies (AICPITS) are presented and discussed.

2 Observations and analysis of data

Whistler observations at Agra under AICPITS were started on 27 Dec. 1989 and are continued on a routine basis. The equipments employed for recording are similar to those used earlier at Gulmarg, Nanital and Agra ground stations[7] that include a T-type antenna, pre- and main-amplifiers and magnetic tape recorder. Initially, a spool-type of tape recorder was used, but was replaced later by a cassette-deck-type of recorder which is similar to those in use at other stations. The observations are taken during nighttime from 1800 to 0600 hrs LT with a break for one hour between 2000 and 2100 hrs LT and during daytime between 1000 and 1200 hrs LT, and between 1400 and 1600 hrs LT at Bichpuri which is located 10 km west of Agra city in rural area. The observations are stopped for 4 months from June to September in view of rainy season during which whistlers are active in opposite hemisphere. The whistler data on magnetic tapes are analyzed on digital sonagraph initially at Indian Statistical Institute (ISI), Calcutta, and later at Central Electronics Engineering Research Institute (CEERI), New Delhi.

Round-the-clock recording of amplitude scintillations of VHF signals at 244.168 MHz transmitted from FLEETSAT satellite was started at this centre on 12 Jan. 1991 and is continued. The equipments employed for recording include a high gain Yagi-Ude antenna, VHF receiver and converter, and a strip chart recorder. These equipments are similar to those being used at other stations, and are supplied by Indian Institute of Geomagnetism, Colaba, Bombay. The charts on which scintillations are recorded are calibrated as 1 cm = 2.5 dB, and are of z-fold type.

3 Results and discussion

3.1 Whistlers

Analysis of whistler data obtained from about 14

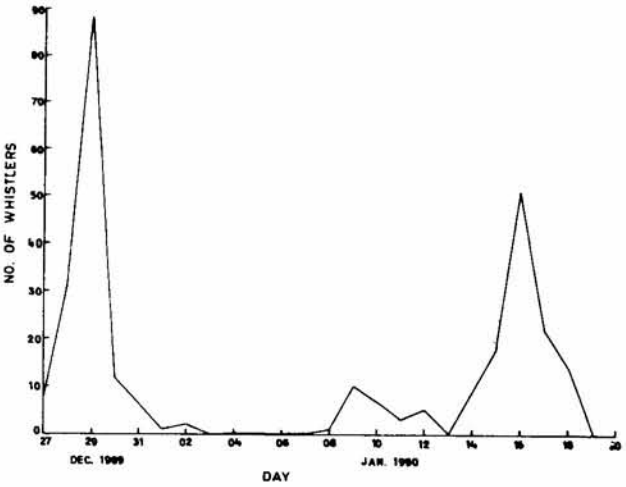

Fig. 1—Number of whistlers recorded on different days in the months of December 1989 and January 1990

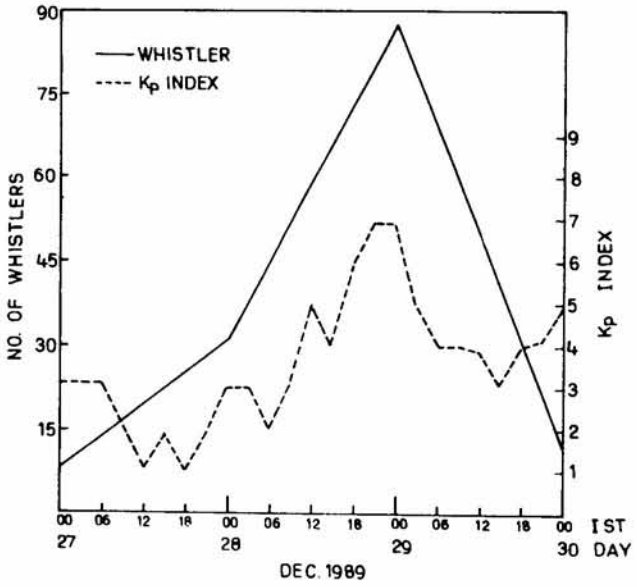

Fig. 2—Variation of whistler activity during the magnetic storm period of 27-30 Dec. 1989

months of regular observations reveals that whistler activity at this centre is very rare and sporadic. Only on two occasions, during the months of December 1989 and January 1990, large number of whistlers are recorded at this centre, while during rest of the period the activity is too low to be of any statistical importance. This is consistent with the result obtained by Singh *et al.*[7] earlier when large whistler activities were observed on 4 occasions only during seven months of regular observations. Figure 1 shows the number of whistlers recorded in the month of December 1989 and January 1990. It is clear from Fig. 1 that the enhanced whistler activities occurred on 29 Dec. 1989 and 16 Jan. 1990, when 88 and 55 whistlers were recorded, respectively. A noticeable feature is that the whistler activity on 29 Dec. 1989 showed positive correlation with the magnetic activity. This is shown in Fig. 2, where both the whistler activity and magnetic activity (3 hr K_p indices) are plotted for the period 27-30 Dec. 1989. This result is similar to that obtained earlier by Somayajulu and Tantry[8]. Although, they have interpreted this result in terms of additional duct formation in the low latitude ionosphere, Singh[4] has interpreted this result in terms of negative latitudinal gradients of ionization existing in the ionosphere around the equator (provided by the equatorial anomaly), which guides the whistler waves to low latitude ground stations. Large whistler activity during storm periods at low latitudes has been correlated with spread-F phenomena also[6]. However, the result shown in Fig.2 could not be ascertained as due to spread-F because of nonavailability of the ionospheric data.

Some new results obtained from the current wake of observations are: (i) observation of third harmonics of tweeks, (ii) whistlers during daytime, and (iii) discrete chorus emissions during daytime. These results have been obtained, for the first time, at a low latitude ground station in the country. Some selected spectrograms of these events are shown in Fig. 3. As shown in the top panel of Fig. 3, tweeks occurred at frequencies 2, 4 and 6 kHz, the latter two being the second and third harmonics of the fundamental frequency of 2 kHz which, after being generated from the lightning stroke, travelled to our receiver through earth-ionosphere waveguide, a part of the path lying in the ionosphere. Thus far, only second harmonics of the tweeks have been reported by VLF atmospheric groups in the country[9]. It is interesting to note that whistler group at Varanasi has also observed similar tweeks as shown in Fig. 3 during their current observations under AICPITS. The middle panel of Fig. 3 shows a spectrogram of daytime whistler which was recorded at our centre on 15 May 1990 at 1335 hrs LT. This is a low dispersion (~ 5.5 $s^{1/2}$) whistler which follows Eckersley law and is believed to have propagated through the ionospheric region and received at this ground station. This is similar to the ionospheric whistlers observed by K-95-26 rocket at low latitudes by Hayakawa *et al.*[10]. These whistlers have followed hybrid paths in reaching the ground station of Agra, i.e. they propagated first in waveguide mode, penetrated the ionosphere in whistler mode and propagated to other hemisphere along the geomagnetic lines of force corresponding not to the observing station but to lower latitudes, and again propagated in waveguide mode to reach the observing station as suggested by Japanese workers[11,12] for similar whistlers

observed at Kakiokao (geomagn. lat., 26°N) and Tohkatta (geomagn. lat., 28°) ground stations. The bottom panel of Fig. 3 shows one of the many discrete chorus emissions observed by us currently during daytime. Discrete chorus emissions have been observed earlier also at this station but during nighttime[13].

3.2 VHF scintillations

Recording of amplitude scintillations of VHF signals at 244.168 MHz from FLEETSAT was started on 12 Jan. 1991. We have analyzed data for the months of January, February and March and the results are presented here. This period corresponds to diminished phase of sunspot cycle. We find that the scintillations are, in general, of three types, viz. fast, slow and weak. Examples of each type of scintillation are presented in Fig. 4. In Fig. 5(a) we show the temporal variation of occurrence number of scintillations at Agra. From Fig. 5(a) it may be seen that scintillations occurred mostly during midnight hours in January and during pre- and post-midnight hours in the other two months. Further, scintillations occurred during daytime in February and March, whereas no such scintillations were observed in January. Figure 5(b) shows the temporal variation of occurrence number of individual types of scintillations during the three months. It may be seen from Fig. 5(b) that fast and slow fades dominate the pre- and post-midnight hours, whereas weak

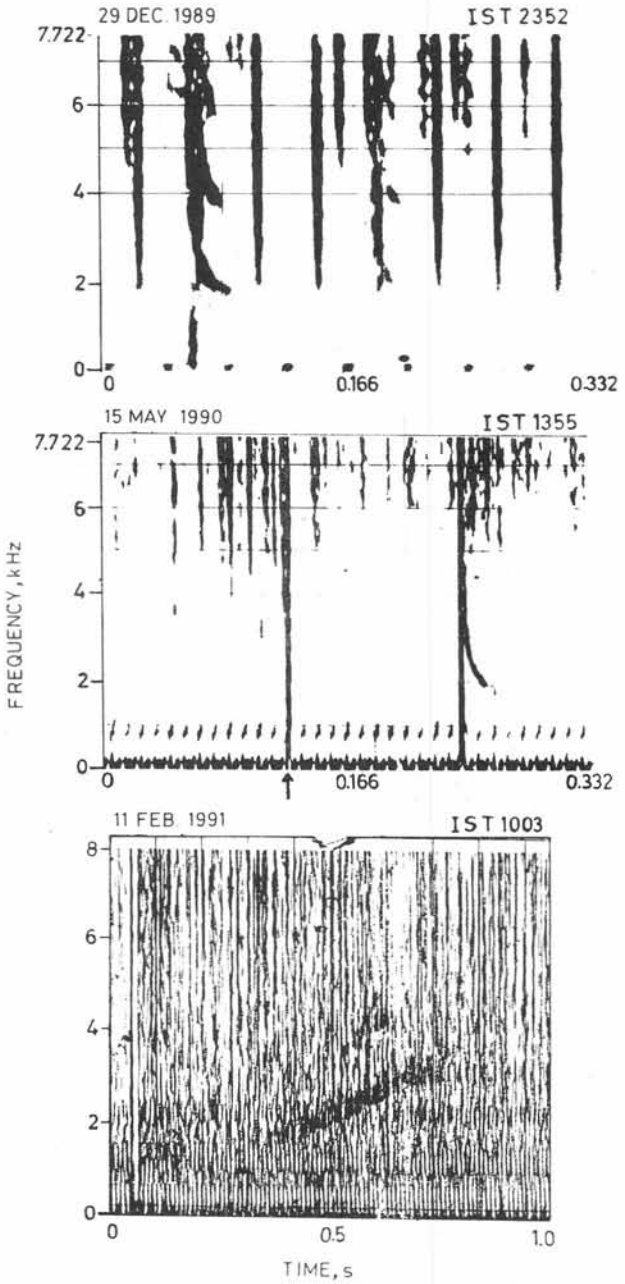

Fig. 3—Some unusual observations at Agra; tweeks and their harmonics (top), a daytime low dispersion whistler (middle), and a daytime discrete chorus emission (bottom)

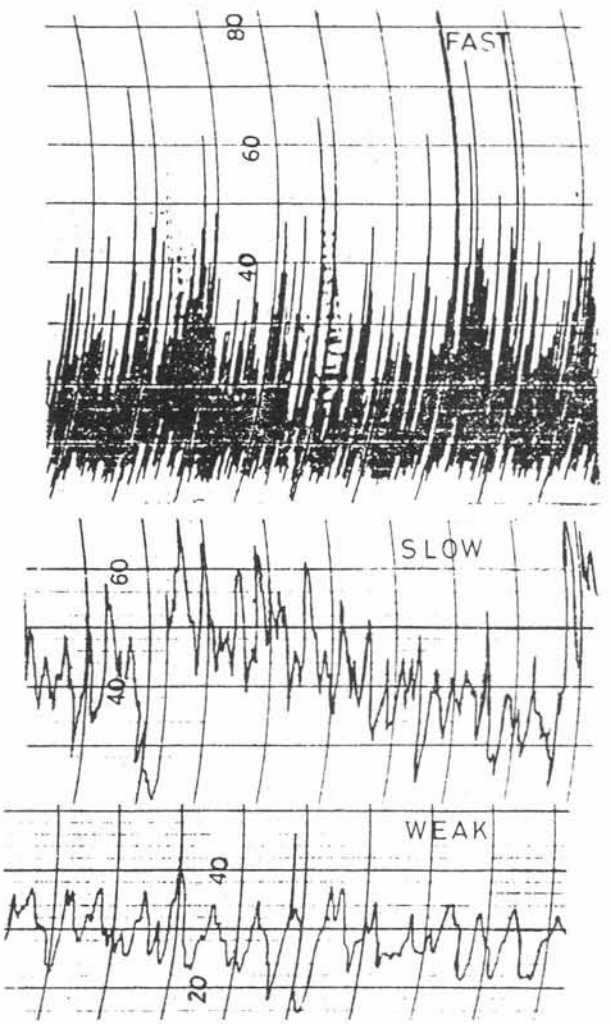

Fig. 4—Examples of fast (top), slow (middle) and weak (bottom) scintillations observed at Agra

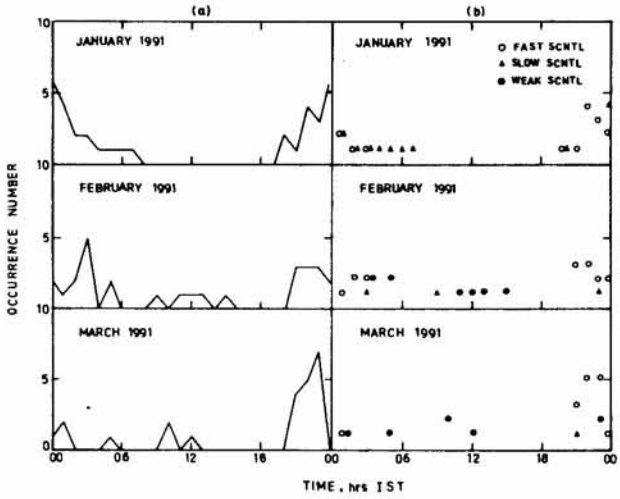

Fig. 5—(a) Temporal variation of occurrence number of all types of scintillations during three months of observations at Agra; and (b) Temporal variation of individual type of scintillations (○ fast scintillations; Δ slow scintillations; and ● weak scintillations)

scintillations dominate the day hours. It has been shown that fast fading type of scintillations occur over a wide range of frequencies extending up to UHF (perhaps even up to GHz range), unlike the slow type which are confined mainly to VHF range[14]. In our case, the two types of scintillations occur one after the other during both the pre- and post-midnight hours. This may be attributed to the presence of both the small and large size irregularities during pre- and post-midnight hours which are responsible for the two types of scintillations, respectively.

4 Summary

From the results of routine observations of whistlers at Agra ground station, it is seen that whistler occurrence at this station is very rare and sporadic. Some new results include the observations of third harmonics of tweeks, daytime whistlers and daytime discrete chorus emissions. Results of VHF scintillation observations at 244.168 MHz show that fast and slow types of scintillations dominate the pre- and post-midnight hours and weak scintillations dominate the day hours. These results indicate the necessity of intensive observations of whistlers and scintillations at this centre for prolonged periods.

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References

1 Hasegawa M & Hayakawa M, *Planet & Space sci (GB)*, 28 (1979) 17.
2 Tanaka Y & Cairo L, *Ann Geophys (France)*, 36 (1980) 555.
3 Jain S K, Prakash R & Singh B, *Curr Sci (India)*, 49 1980) 415.
4 Singh B, *J Geophys Res (USA)*, 81 (1976) 2429.
5 Singh H & Singh B, *Indian J Radio & Space Phys*, 9 (1980) 24.
6 Singh B & Jain S K, *J Geophys Res (USA)*, 91 (1986) 4567.
7 Singh H, Prakash R & Singh B, *Indian J Radio & Space Phys*, 9 (1980) 130.
8 Somayajulu V V & Tantry B A P, *J Geomagn & Geoelectr (Japan)*, 20 (1968) 21.
9 Lalmani, *Private Communication*, March 1991.
10 Hayakawa M, Ohtsu J & Iwai A, *J Atmos & Terr Phys (GB)*, 35 (1973) 1677.
11 Tsuruda K, Kokubun S, Oguli T & Nagata T, *Rep Ionos & Space Res Jpn (Japan)*, 18 (1964) 438.
12 Araki T & Kamiyama H, *Rep Ionos & Space Res Jpn (Japan)*, 23 (1969) 141.
13 Singh B, Prakash R & Singh H, *Nature (GB)*, 290 (1981) 37.
14 Raghav Reddi C, Krishnamurthy K & Krishnamurthy B V, *Radio Sci (USA)*, 15 (1980) 1001.