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Characteristics of Pi2 pulsations at an equatorial station and its occurrence association with the phase of the Moon

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Abstract. Diurnal variations of occurrence hours and the period of Pi2 pulsations at Choutuppal (India) for nearly half a solar cycle are presented. Maximum occurrence is noticed to be around local midnight in all the seasons. Shorter periods are observed in the late afternoon hours in E- and J-seasons. Lunar influence on the occurrence of Pi2 pulsations at this station is inferred with the occurrence due to this influence peaking in the vicinity of the lunar phase 4.

Keywords. Pulsations; equatorial station; lunar influence; diurnal variations.

1. Introduction

The irregular pulsations, Pi2, are shortlived fluctuations of the geomagnetic field ranging from 40–150 sec (Jacobs 1970). Pi2 are generally observed, simultaneous with the onset of substorms, over a wide range of latitudes on the ground and in the magnetosphere (Saito 1969; Gupta *et al* 1971; Gupta 1981). The characteristics of Pi2 have been studied earlier, especially in the auroral and high latitudes. However, such studies for low latitudes and equatorial regions are sparse. For a thorough understanding of the wave characteristics responsible for these Pi2s, a comprehensive morphological study at all latitudes will be useful.

In the present paper, the occurrence frequency and the diurnal variations of the period of Pi2s from an equatorial station, Choutuppal (Hyderabad) (Geomag. Lat. 7.5° N), a permanent pulsation recording station in the Indian region, are reported. These morphological characteristics at the equatorial station are compared with those obtained at middle and high latitudes by other investigators. It is shown that the occurrence frequency of Pi2s peaks at more or less the same local hours at different latitudes. Considering that Pi2s observed at all latitudes originate in the geomagnetic tail, which itself extends well beyond the lunar orbit, an attempt is made to investigate lunar influence on this class of pulsations.

2. Data analysis

The basic data for the study are extracted from the magnetic and telluric pulsations records for the period 1 January 1968 to 31 December 1972. These have been published by the National Geophysical Research Institute, Hyderabad. The method for decodin the pulsation data is the same as that adopted by Rao (1978) for Pc5 data. By a similar procedure, Pi2 activity reported for each day is decoded for 24 consecutive hours. The hourly interval is considered to have pulsational activity irrespective of the duration of activity. The data are sub-divided into three seasonal groups, summer (J, May to August); winter (D, November to February) and equinoxes (E, March, April, September and October). Diurnal variations of the occurrence of Pi2 as a function of local time (LT) for seasons and for the entire period considered (Y) are shown in figure 1. Also, median, 25th and 75th percentiles of the Pi2 periods for each of the hours are calculated and are shown in figure 2.

3. Results and discussion

3.1 *Diurnal variation of occurrence hours*

It is apparent from figure 1 that Pi2 activity is predominantly observed during local night at Choutuppal. The maximum occurrence is around local midnight in all the seasons. Similar results have been reported by Sanker Narayan and Sarma (1975) for the same station and by Channon and Orr (1970) for another equatorial station. At middle and high latitudes also, the maximum occurrence of Pi2 is near midnight (Yanagihara 1960; Smith 1973; Gupta 1981). No obvious seasonal variation is observed in the peak occurrence time of Pi2 at Choutuppal which is found to be between 00–01 LT.

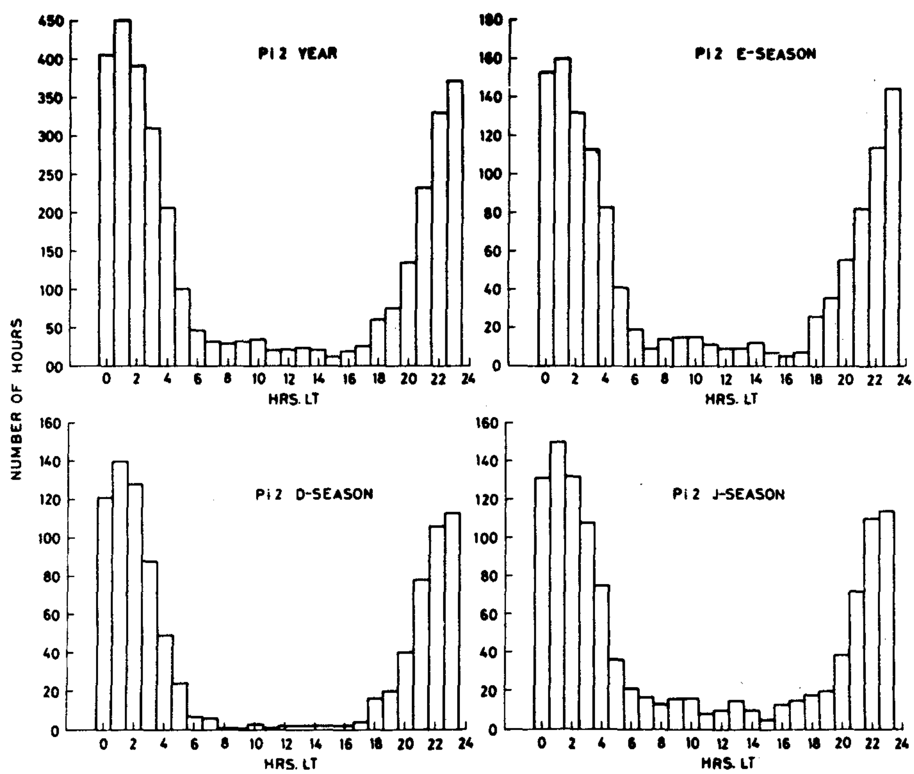

Figure 1. Diurnal variation of occurrence hours of Pi2 pulsations at Choutuppal for J, E and D seasons as well as for the entire period, designated as Y.

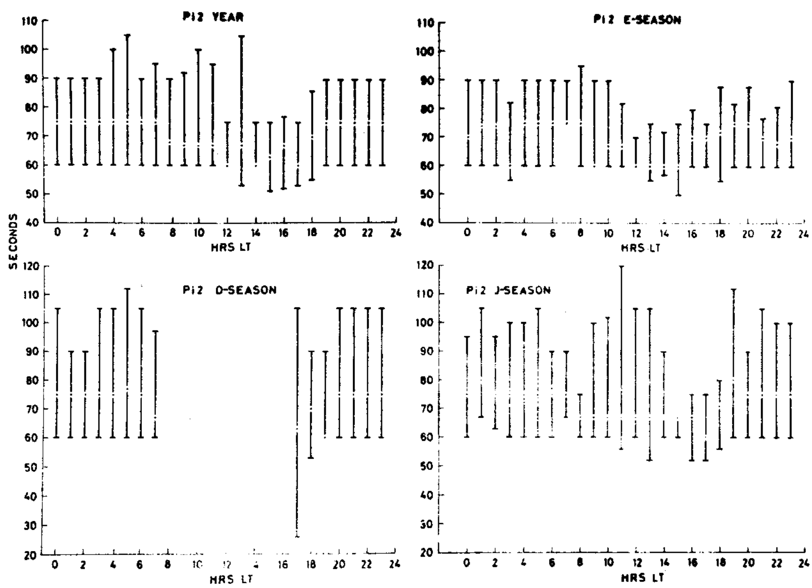

Figure 2. Diurnal variation of median periods of Pi2 at Choutuppal for J, E and D seasons as well as Y. 75th (upper line) and 25th (lower line) percentiles are also shown at each of the median periods.

Gupta (1981) has shown that at mid-latitude station, Ottawa (geomag. Lat. 57° N), the largest number of Pi2s occurred between 00–01 LT in D and E seasons and an hour earlier in J season. At higher latitudes also these pulsations have shown a clear seasonal variation. However, the peak occurrence of Pi2s in the vicinity of local midnight seems to be common at all latitudes.

3.2 *Diurnal variation of Pi2 periods*

It can be noticed from figure 2 that the Pi2 periods are generally larger during local night hours than during day-light hours. There is no definite progression of periods with the time of the day. However, shorter periods are observed in the late afternoon hours in the E and J seasons (around 14 LT). Gupta (1981) investigated the diurnal variation in the periods of Pi2 pulsations at four stations in the latitude range of 45 to 75° N. He found that there is a significant difference between diurnal variations of periods observed at high latitudes and that observed at the mid-latitude station, Ottawa. At Ottawa, the trend was reasonably well-defined with broad minimum in the early morning hours and a broad maximum in the afternoon.

From a comparison of the results it seems that the minimum of periods shifts from morning at mid-latitude to afternoon in the equatorial regions.

3.3 *Lunar influence*

Having established in the earlier section that the diurnal variations of occurrence of Pi2s at high and low latitudes are almost similar, it is apparent that the source of the instability can be identified in the same magnetotail region. According to Kikuchi *et al* (1978), the horizontal electric fields, such as those due to magnetospheric convection, are impressed on the high latitude ionosphere. From there they can propagate to the equator within the ionosphere in the guided mode as zero order transverse (TM) waves. Based on the analysis of over 10 years of Pc5 data from Choutuppal and comparing their characteristics with those at high latitude stations, Sarma *et al* (1981) have concluded that amplitudes of TM waves suffer significant attenuation in ionospheric transmission but the signals appearing in the equatorial region would still bear considerable resemblance to those at high latitudes. In the equatorial zone, all types of micropulsations propagate in the same direction (Prince and Bostick 1964; Field and Greifinger 1966); as such the Pi2s at Choutuppal are assumed to have the source in the magnetotail region and the waves propagate to the equatorial region in the same way as those of Pc5.

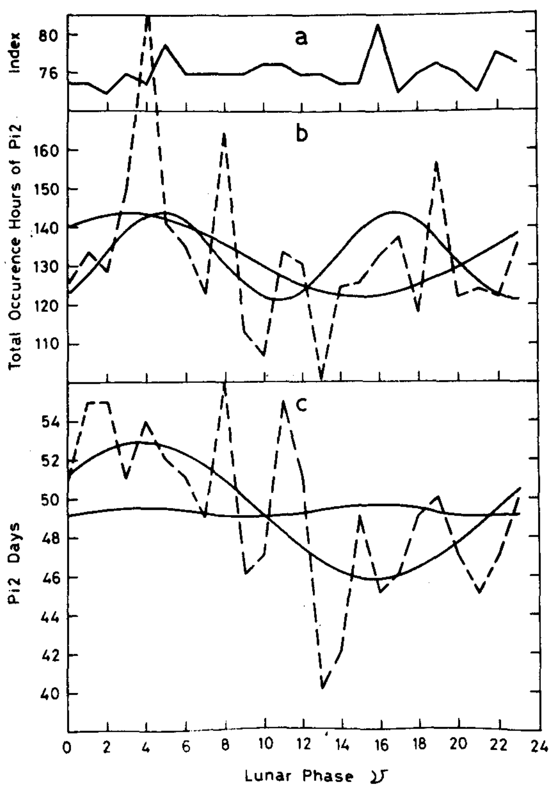

Figure 3. (**a**) Number of times the same lunar phase is reckoned against each of the lunar phases. (**b**) Total occurrence hours of Pi2s (broken line) *vs* the lunar phase numbers. The two smoothed curves are variations from the 1st and 2nd harmonic components. (**c**) Total number of days of Pi2 occurrences (broken line) *vs* the lunar phase numbers. The two smoothed curves are variations from the 1st and 2nd harmonic components.

Table 1. Results of harmonic analysis of Pi2 activity grouped according to lunar phases.

Harmonic Number	Total number of hours of Pi2 activity			Number of days of Pi2 activity		
	Amplitude (hr)	Lunar phase of 1st maximum	Percentage accounted in the total distribution	Amplitude (Days)	Lunar phase of 1st maximum	Percentage accounted in the total distribution
1	10.8	3.0	15.4	3.6	3.8	38.9
2	11.4	4.8	17.1	0.2	3.6	0.2
3	4.9	3.4	3.2	2.0	1.9	11.8
4	4.2	4.1	2.3	1.1	5.9	3.6

It is well-known that the average lunar orbit is at 60 earth radii and during the first quarter of lunation, the moon is in the antisolar direction in the magnetotail region. The aim here is to delineate the effect, if it exists, on the observed Pi2 pulsations when the moon, in its orbit, crosses the tail region of the magnetosphere. For this, the occurrence hours per day of Pi2 during 1 January 1968 to 31 December 1972 are grouped according to the lunar phase of that day. In a lunation, the lunar phases vary from 0 at new moon to 24 for the next. During the interval, the number of times the same lunar phase has been reckoned is shown as 'index' in figure 3a and the total occurrences of the Pi2s corresponding to each of the phases are shown in figure 3b. Treating the variations of Pi2 occurrences from phases 0 to 23 as fundamental period, harmonic analysis is carried out to derive the amplitudes and phase angles of the first four harmonics. The individual curves of the 1st and 2nd harmonics are also shown in figure 3b. The number of hours per day of Pi2s is felt to some extent subjective and a little over emphasised index of activity. For this, grouping is redone according to the lunar phase, assigning '1' for the day which had Pi2 activity and '0' otherwise. The total number of days of Pi2 activity and the first two harmonics obtained from them are plotted against each of the lunar phases in figure 3c. Amplitudes, lunar phases of the 1st maximum derived from the phase angles and the percentage accounted by each of the harmonics in the entire distribution for the above two groups are given in table 1.

There seems to be no undue biasing in the frequency of occurrence of the lunar phases in the interval which may have reflected in the pulsational activity. Any lunar phases association, either between the total occurrence hours per day or the number of days on which pulsations occurred, is not readily apparent from figures 3b or 3c. There is, however, a suggestion of lunar semi-monthly (2nd harmonic) association when the total number of hours are considered. The amplitudes of the lunar monthly (1st harmonic) and semi-monthly (2nd harmonic) variations of the total occurrence hours have nearly the same magnitude and they together account for 33% of the total distribution. On the other hand, though the variation of number of days of pulsational activity is not smooth in figure 3c, the lunar monthly harmonic (1st) is the dominant one and accounts for nearly 39% of the distribution. The most interesting aspect to note is that, systematically the variations of the lunar monthly and semi-monthly harmonics in both the cases reach their maximum amplitudes in the vicinity of lunar phase 4 ± 1. Thus, it appears that there is a suggestion of lunar influence on the occurrence of Pi2 pulsations at Choutuppal with occurrence due to this influence peaking at the lunar phase around 4.

It suggests that the passage of the moon through the geomagnetic tail may contribute to its dynamics in some way to influence the instability that results in Pi2 activity. The large scatter, which is not accounted for by the harmonics, is evidently due to the stronger influences of the electric and magnetic fields above the ionospheric levels responsible for the generation of Pi2s other than the moon.

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