UNUSUALLY LOW AMPLITUDE ANISOTROPIC WAVE TRAIN EVENTS OF COSMIC RAY INTENSITY DURING 1981–94

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Abstract

The investigation has been made for unusually low amplitude anisotropic wave train events (LAE) for cosmic ray intensity data of Deep River neutron monitoring station during the period 1981–94. It has been observed that the phase of diurnal anisotropy remains in the same co-rotational direction for most of the LAE cases while the phase shifted to early hours for some of the LAE cases in diurnal anisotropy. During minimum solar activity LAEs has been observed dominant. Solar wind plasma (SWP) parameters, Interplanetary magnetic field and various features at solar disk have also been studied. The amplitude remains low continuously for most of the days while the phase shifts to earlier hours.

1. Introduction

Solar diurnal variation of cosmic ray (CR) intensity shows a large day-to-day variability. This variability appears even in the case of high counting rate instruments like super neutron monitors and at least a part of this variability is a reflection of the conditions continually changing in the interplanetary space. The annual average diurnal variations are highly significant.

Apart from the above mentioned systematic and significant departures in amplitude and phase of diurnal anisotropy from average values are known to occur in association with strong geomagnetic activity[1]. The duration when these types of deviations occur during undisturbed solar conditions has particular significance.

The anisotropies occurred without accompanying geomagnetic disturbances or Forbush decrease indicating that they are not due to solar activity on the visible side of the Sun[2]. The average characteristics of cosmic ray diurnal variation are adequately explained by the co-rotational concept. This concept supports mean diurnal amplitude in space of 0.4N along the 18-Hr direction. However the observed day-to-day variation both in amplitude and phase and the abnormally low amplitude of consecutive days cannot be explained in co-rotation terms.

By selecting some low amplitude events (LAE), which were essentially respecting the quasi-permanent anomalous conditions in the interplanetary medium[3].

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Jadhav et al.[4] studied the behaviour of semi-diurnal anisotropy of LAE by comparing the average semi-diurnal amplitude for each event with 27-days annual average semi-diurnal amplitude. They observed that there is no significant difference between these two wave train events[4]. An attempt has been made in this paper to study the unusually low amplitude anisotropic wave train events in cosmic ray intensity over the period 1981–94.

2. Data Analysis

The pressure corrected data of Deep River Neutron monitor NM (cut off rigidity=1.02 GV, Latitude=46.1°N, Longitude=282.5°E, Altitude=145M) has been subjected to Fourier Analysis for the period 1981–94 after applying the trend correction to have the amplitude (%) and phase (Hr) of the diurnal and semi-diurnal anisotropies of cosmic ray intensity for unusually low amplitude events. The amplitude of the diurnal anisotropy on an annual average basis is found to be 0.4%, which has been taken as reference line in order to select low amplitude events.

The days having abnormally low amplitude for a successive number of five or more days have been selected as low amplitude anisotropic wave train events. The anisotropic wave train events are identified using the hourly plots of cosmic ray intensity recorded at ground based neutron monitoring station and selected twenty eight unusually low amplitude wave train events during the period 1981–94. The solar wind plasma (SWP) and interplanetary magnetic field (IMF) have also been investigated.

3. Results and Discussion

The amplitude and phase of LAEs has been plotted in Fig 1. It is quite apparent from Fig 1 that for most of the LAEs the phase of the diurnal anisotropy remains in the 18-Hr or co-rotational direction, whereas for some of the LAEs plotted in Fig 2 the phase has shifted to earlier hours. The amplitude and phase of the diurnal anisotropy for all the LAEs along with amplitude and phase of quiet day annual average have been plotted in Fig 3. It is quite clear form Fig 3 that phase of the diurnal anisotropy has shifted to earlier hours as compared to quiet days annual average values for majority of the LAEs. Further, the amplitude and phase of the semi-diurnal anisotropy have been plotted in Fig 4, which shows that amplitude of the semi-diurnal anaisotropy remains statistically the same for all LAEs, whereas the phase is shifted to later hours. Similar results have been found by Jadhav et al.[4] for the period 1966–73.

The amplitude and phase of the diurnal anisotropy for each LAE alongwith the variation in the associated value of the z-component of the interplanetary magnetic field i.e. Bz have been plotted if Fig 5. It is evident from fig that for

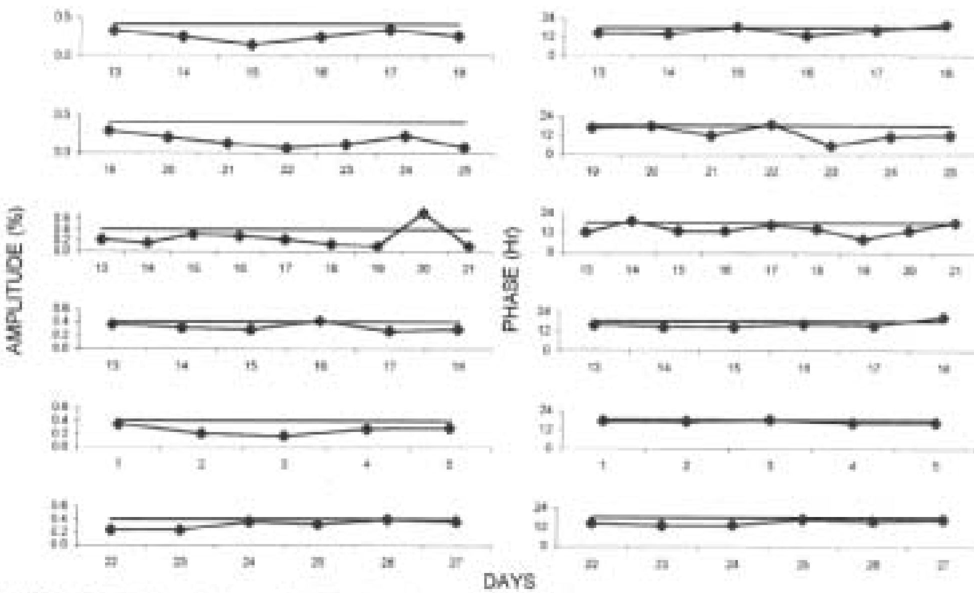

FIG-1: Amplitude and phase of the diurnal anisotropy of LAE for the events 13-18 June 1985, 19-25 Jan. 1987, 13-21 Apr. 1988, 13-1 8 Jan 1991, 1-5 May 1991 and 22-27 March 1992

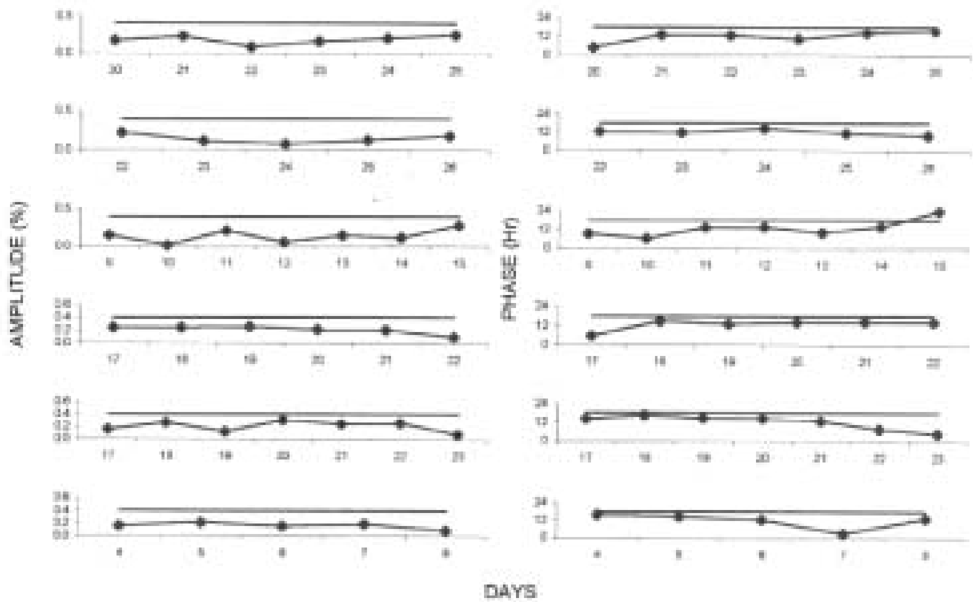

FIG 2: Amplitude and phase of the diurnal anisotropy of LAE for the events 20-25 Apr. 1981, 22-26 Nov. 1984, 9-15 March 1987, 17-22 Sep. 1991,17-23 Oct. 1992 and 4-8 Oct. 1994.

majority of the days of LAEs the Bz is +ve, i.e. away from the Sun. However, Bz remains −ve i.e. towards the Sun for some of the days of LAEs, which shows that LAESs occurred dominantly during the positively directed IMF polarity. It is found by Kananen et al.[5] that for positive Bz or away-polarity of IMF, the

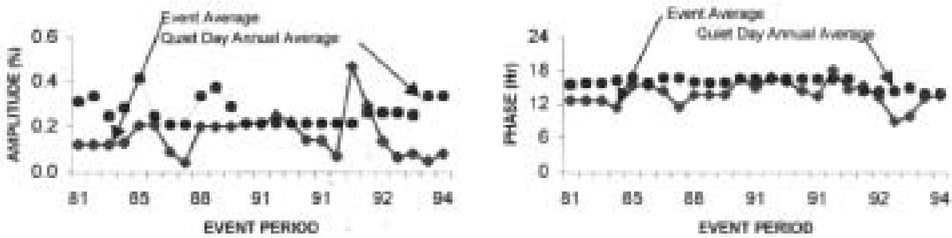

Fig3: Amplitude and Phase of diurnal anisotropy for LAE alongwith quiet day annual average values

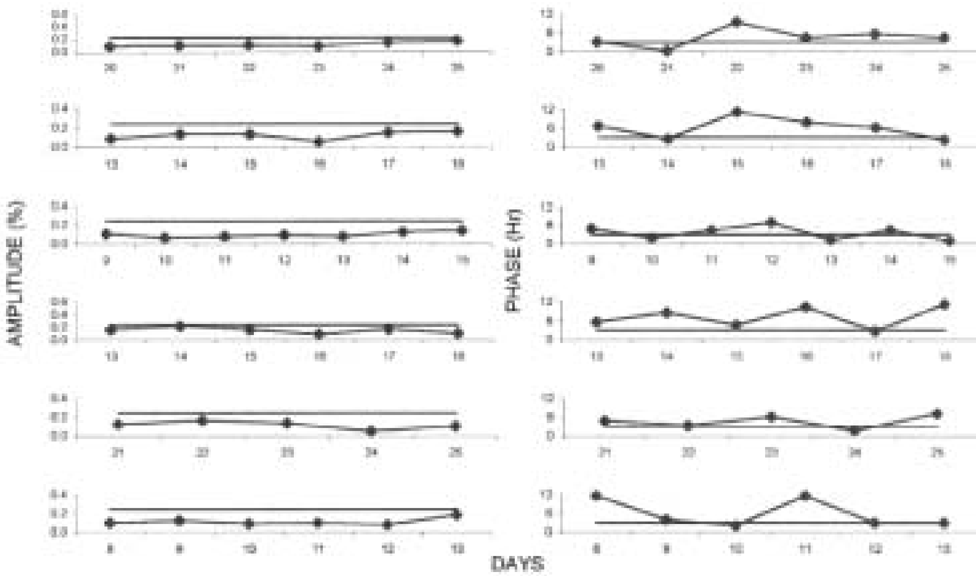

FIG 4: Amplitude and phase of the semi-diurnal anisotropy of LAE for the events 20-25 Apr.1981, 13-18 June 1985, 9-15 March 1987, 13-18 Jan 1991, 21-25 Dec. 1993 and 8-13 Sep 1994

amplitude is higher and phase shifts to early hours whereas for negative Bz or towards polarity of IMF the amplitude is lower and phase shifts to early hours as compared co-rotational values for the period 1967–68.

The frequency histogram of solar wind velocity for LAEs has been plotted in Fig 6. It is observed that the majority of the LAEs have occurred when the solar wind velocity becoming average. It is apparent from Fig 6 that the distribution of LAEs is quite broader between low to near-high solar wind velocity. So we can infer that polar coronal holes which are the major sources for high-speed solar wind velocity (HSSWS) do not play an important role in causing the LAEs. It is further noted that trains of days of LAES are not associated with either geomagnetic storm or any Forbush decrease. Thus the observed geomagnetic disturbances during these days of LAEs, the Earth has not encountered any interplanetary turbulence effect caused by solar sources.

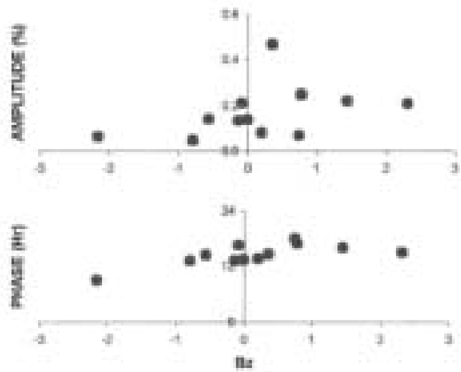

Fig 5: Amplitude and phase of the diurnal anisotropy for each LAE alongwith the variation in associated value of Bz

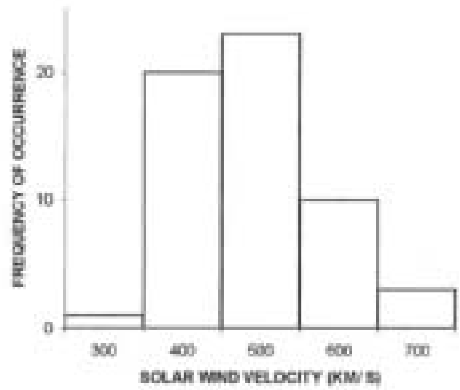

Fig 6: Frequency histogram of solar wind velocity for all LAEs

4. Conclusion

On the basis of above findings the following conclusions may be drawn:

- The phase of the diurnal anisotropy continually remains in the co-rotational direction for majority of the LAEs.
- The phase of the diurnal anisotropy for some of the LAEs shifted to earlier hours.
- The amplitude of semi-diurnal anisotropy for majority of LAEs remains same, while phase is shifted to later hours.
- Majority of the LAEs occurred when solar wind velocity is being average.
- The occurrence of LAE is dominant during positively directed IMF polarity.

5. Reference

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