LOW/HIGH AMPLITUDE ANISOTROPIC WAVE TRAIN EVENTS IN COSMIC RAY INTENSITY AS AN EFFECT OF INTERPLANATERY TURBULANCES

Rajesh K. Mishra[1] and Rekha Agarwal Mishra[2]
(1) Tropical Forest Research Institute, Jabalpur (M.P.) 482 001, India
(2) Govt. Autonomous Model Science College, Jabalpur (M.P.) 482 001, India

Abstract

Using the ground based neutron monitor data of Deep River we have studied the low and high amplitude anisotropic wave train events (LAE/HAE) in cosmic ray intensity for different latitudes. The investigation has been made for both LAE and HAE during the period 1981–94. It has been observed that the phase of diurnal anisotropy for majority of HAE/LAE cases remains in the same co-rotational direction while phase of diurnal anisotropy shifted to later hours for some of the HAE cases, whereas shifted to early hours for some of the LAE cases. Further, for majority of HAE/LAE cases the amplitude of semi-diurnal anisotropy remains statistically the same, while phase of semi-diurnal anisotropy for all HAE cases shifted to later hours. The HAE appears dominant during the declining phase of solar activity whereas LAE appears dominant during minimum solar activity.

1. Introduction

The average characteristics of cosmic ray diurnal anisotropy are adequately explained by the co-rotational concept. However the observed day-to-day variation both in amplitude and time of maximum and the abnormally large amplitudes or abnormally low amplitudes of consecutive days cannot be explained in co-rotational term. The average diurnal anisotropy of cosmic radiation has generally been explained in terms of azimuthal co-rotation[1]. Mavromichalaki[2] have reported the existence of the consecutive days having abnormally high diurnal amplitude. The enhanced diurnal variation of high amplitude events exhibits a maximum intensity in space around the anti-garden hose direction and a minimum intensity around the garden hose direction[3].

The diurnal variation might be influenced by the polarity of the magnetic field[4]. The largest diurnal variation is observed during the period when the daily average magnetic field is directed away from the Sun. the variation in the amplitude and phase of the high speed solar wind stream (HSSWS) have been observed coming from coronal holes[5,6]. An analysis by Agarwal[7] shows that for high amplitude semi-diurnal wave for the days with HSSWS, which suggests that, the solar

pp. 3999–4004

polar coronal holes may influence the semi-diurnal variation of galactic cosmic ray intensity.

By selecting some low amplitude anisotropic wave train events, which were essentially representing the quasi-permanent anomalous conditions in the interplanetary medium[8]. Jadhav et al.[9] studied the behaviour of semi-diurnal anisotropy of LAEs by comparing the average semi-diurnal amplitude. They observed that there is no significant difference between these two wave train events[9]. An attempt has been made in this paper to investigate interplanetary turbulence effects causing unusually high/low amplitude anisotropic wave train events for 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 high/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 high/low amplitude for a successive number of five or more days have been selected as high/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 thirty eight unusually high amplitude wave train events and 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. Result and Discussion

The amplitude (%) and phase (Hr) of each HAE has been plotted in Fig 1. It is quite apparent from Fig 1 that the phase of diurnal anisotropy has shifted to earlier hours in some of the events. However for majority of HAEs plotted in Fig 2 the phase of diurnal anisotropy remains in the co-rotational direction. Further amplitude (%) and phase (Hr) of semi-diurnal anisotropy for HAEs is plotted in Fig 3. It is quite clear from Fig 3 that the amplitude of the semi-diurnal anisotropy for each HAE remains statistically the same whereas the phase has shifted to later hours.

The amplitude and phase of the diurnal anisotropy along with quiet days annual average values has been plotted in Fig 4. It has been found from Fig 4 that

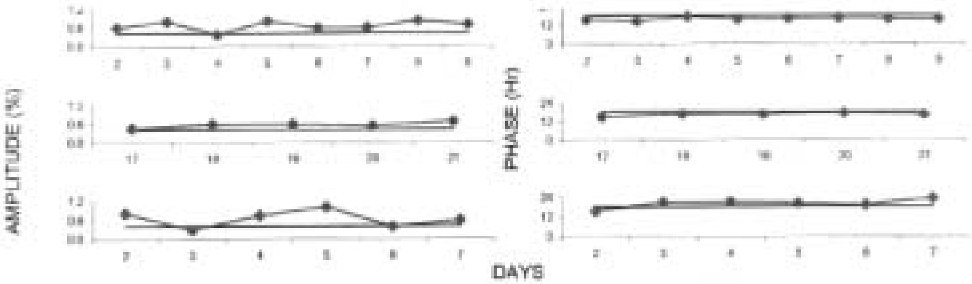

Fig 1: Amplitude and phase of the diurnal anisotropy for HAE of 2-9 Sept. 1981, 17-21 Jul. 1983 and 2-7 Oct.1992

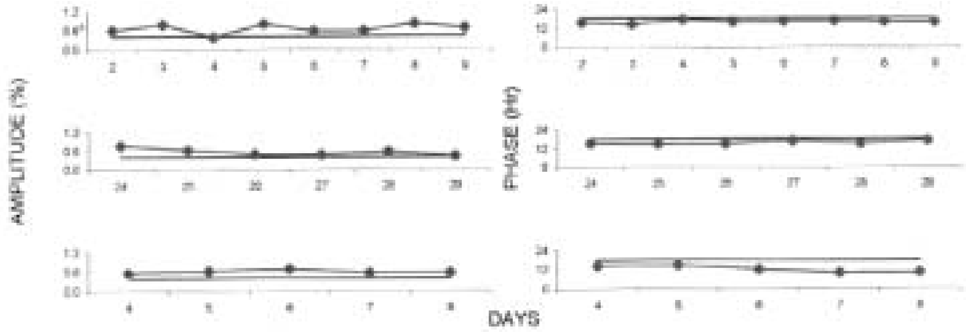

Fig 2: Amplitude and phase of the diurnal anisotropy for HAE of 2-9 Sept. 1981, 24-29 Sept. 1983 and 4-8 Feb. 1993

Fig 3: Amplitude and phase of the semi-diurnal anisotropy for HAE of 24-29 Sept. 1983 and 20-27 March 1994

the amplitude of the diurnal anisotropy for each HAE is significantly large than the quite day annual average amplitude throughout the period and the phase of the diurnal anisotropy has shifted to earlier hours for majority of the HAEs as compared to the quiet day annual average values.

The amplitude and phase of LAEs has been plotted in Fig 5. It is quite apparent from Fig 5 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 6 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 7. It is quite clear form Fig 7 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 8, 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

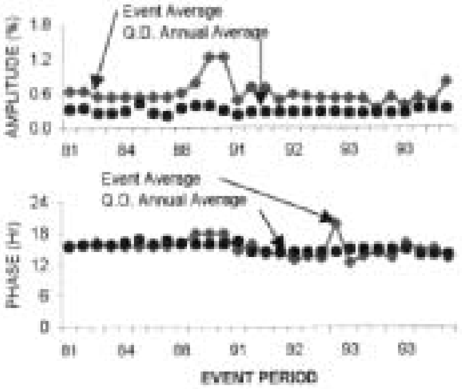

Fig 4: Amplitude and phase of the diurnal anisotropy for each HAE alongwith quiet day annual average values

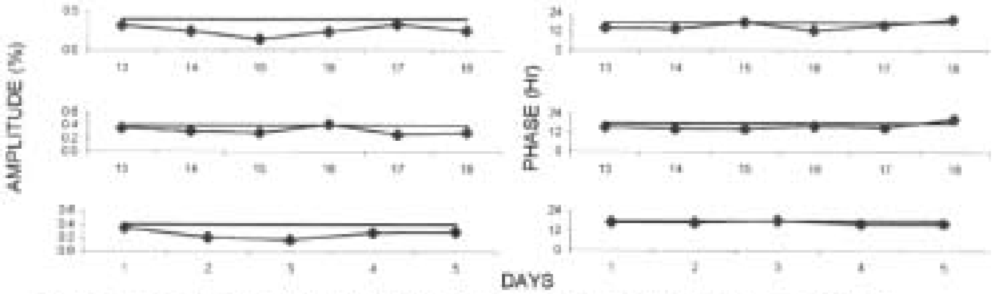

FIG-5: Amplitude and phase of the diurnal anisotropy of LAE for the events 13-18 June, 1986, 13-18 Jan 1991and 1-5 May 1991

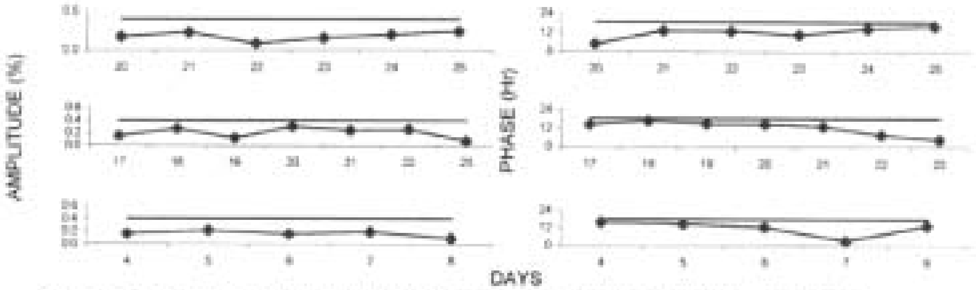

FIG 6: Amplitude and phase of the diurnal anisotropy of LAE for the events 20-25 Apr. 1981,17-23 Oct. 1992 and 4-8 Oct. 1994.

found by Jadhav et al.[9] for the period 1966–73.

For each HAE/LAE cases the interplanetary magnetic field (IMF) and solar wind parameter (SWP) have also investigated. The amplitude and phase of the diurnal anisotropy for each HAE/LAE alongwith the variation in the associate values of the z-component of the interplanetary magnetic field, i.e. Bz have been plotted in Fig 9 and Fig 10. It is apparent from these figures that for majority of the HAEs/LAEs the Bz is +ve i.e. away from the Sun. However Bz remains −ve i.e. towards the Sun for some of the HAEs/LAEs, which shows that HAEs/LAEs

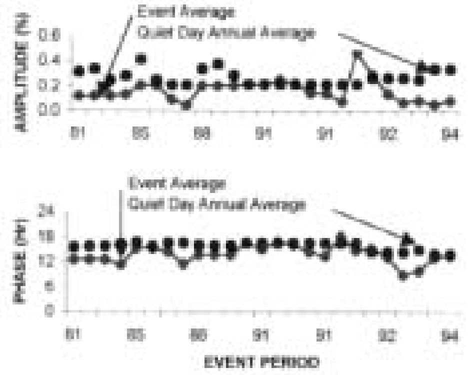

Fig 7: Amplitude and Phase of diurnal anisotropy for LAE alongwith quiet day annual average values

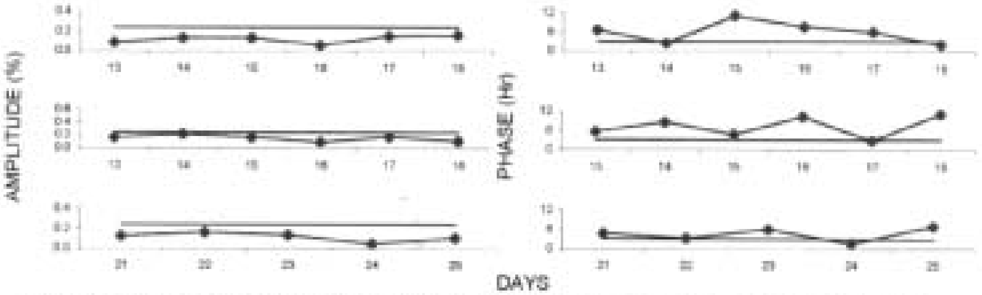

FIG 8: Amplitude and phase of the semi-diurnal anisotropy of LAE for the events 13-18 June 1985,13-18 Jan 1991and 21-25 Dec. 1993

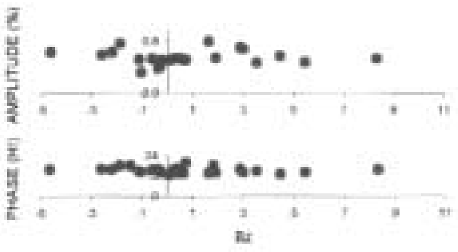

Fig 9: Amplitude and phase of the diurnal anisotropy for each HAE with the variation in associated values of Bz

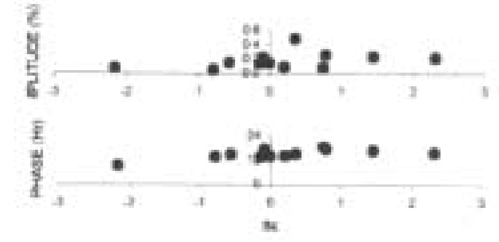

Fig 10: Amplitude and phase of the diurnal anisotropy for each LAE alongwith the variation in associated value of Bz

occurred dominantly during the positively directed IMF polarity. It is found by Kanaen et al.[10] that for positive Bz or away polarity of IMF, 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 to co-rotational values for the period 1967–68.

The frequency histogram of solar wind velocity for each HAE/LAE has been plotted if Fig 11 and Fig 12. It is observed that the majority of the HAEs/LAEs have occurred when solar wind velocity becoming average. Usually the velocity of HSSWS is 600–700 km/s[6]. So it is apparent from these figures

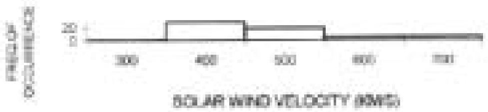

Fig 11: Frequency histogram of solar wind velocity for HAE

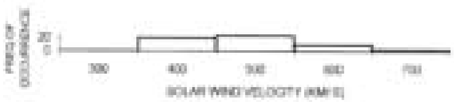

Fig 12: Frequency histogram of solar wind velocity for all LAEs

that HAEs/LAEs are not caused during the period of occurrence of HSSWS. So we can infer that polar coronal holes which are the major sources of HSSWs do not serve a significant role in causing the HAEs/LAEs. It is further noted that these trains of the days of HAEs/LAEs are not associated with either geomagnetic storms or any Forbush decrease.

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 HAE/LAE. However it shifts to earlier hours for some of the HAE/LAE cases
- The amplitude of semi-diurnal anisotropy for majority of HAE/LAE remains statically invariant, while phase has shifted to later hours for some of the HAE/LAE.
- Majority of the HAE/LAE occurred when solar wind velocity is being average.
- The occurrence of HAE/LAE is dominant during positively directed IMF polarity.

5. Reference

1. Rao U.R. 1972, *Space Sci. Rev.* 12, 719
2. Mavromichalaki H. 1980, Astrophys. & Space Sci. 68, 137
3. Rao U.R., Ananth A.G., Agrawal S.P. 1972, Planet. & Space Sci. 20, 1799
4. Parker E.N. 1991, 22nd Int. Cosmic Ray Conf., Dublin 5, 35
5. Iucci N., Parissi M., Storini M., Villoressi G. 1981, 17th Int. Cosmic Ray Conf., Paris 10, 190
6. Munakata Y., Mori S., Ryu J.Y. Agrawal S.P., Venkatesan D. 1987, 20th Int. Cosmic Ray Conf., Moscow 4, 39
7. Agrawal S.P. 1981, J. Geophys. Res. 86, 10115
8. Ananth A.G., Agrawal S.P., Rao U.R. 1971, 12th Int. Cosmic Ray Conf., Hobart 2, 651
9. Jadhav D.K., Shrivastava M., Tiwari A.K., Shrivastava P.K. 1983, 18th Int. Cosmic Ray Conf., Bangalore 3, 337
10. Kanaen H., Komori H., Tanskanen P., Okama, J. 1981, 17th Int. Cosmic Ray Conf., Paris 10, 190