Study of Long Term Cosmic Ray Daily Variation

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The average diurnal variation of cosmic rays at neutron monitor energies vary with a period of eleven and twenty two years. Moreover, the annual average comprises of days with significant departure from the observed average amplitude and time of maximum. Consecutive days with very low amplitudes as well as of very high amplitudes have been identified earlier also, for which many investigators have reported the characteristic properties of such waves. However, they are not consistent and no characteristic and no reliable interplanetary parameter could be associate with these waves. In order to understand the occurrence of these waves during solar cycle 22, the data from a number of neutron monitors have been analyzed and average characteristics for each event has been derived in a manner as was done in the past by us for the earlier solar cycle. We find that the first harmonic of high amplitude days usually have zero spectral exponent. Moreover the second harmonic of high amplitude days show "0" spectral exponent in contrast to "I" expected. A few specific events of longer duration support these statistical conclusions. However, from the available limited interplanetary data, no specific parameter is identifiable either for the low or high amplitude wave trains.

1. INTRODUCTION

The average daily variation of cosmic ray intensity generally consists of diurnal variation, semi-diurnal and tri-diurnal variation with significant amplitudes, the amplitude of the diurnal variation (1^{st} harmonic) at a high/middle latitude station has been found to be of the order of 0.3 to 0.4%, where as the amplitudes of two higher harmonics is found to be of the order of 0.8% and 0.02% respectively (Pomerantz *et al.*, 1958). The characteristics of all the three harmonics have been reported showing the variational spectral.

Exponent to be 0.0, 1.0 and 1.0 respectively. The average characteristics have also been found to very with the solar cycle, where the variation much larger at higher energies. However, the average spectral exponent has not shown any significant changes from one period to another. A number of investigators have selected continually occurring days of high amplitude and Low amplitudes of diurnal variation (Agrawal 1974, Tiwai 1994, Tiwari 1995). These results have pointed out significant departures in the time of maximum as well as their association with higher harmonics. We have selected large number of long duration

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event's and obtained the characteristics for the individual events and then have also selected some much larger events to obtain the spectral characteristic of all the three harmonics of the daily variation of cosmic rays.

2. METHOD OF ANALYSIS

To study the characteristic of low amplitude wave Train (LDW) and high amplitude wave Train events (HDW) during solar cycle 22, the LDW and HDW events were selected under strict selection criteria (Tiwari A.K. 1995) Each event and for each day the amplitude and phase of first three harmonics have been calculated by Harmonic analysis after removing the long term trend.

3. RESULTS & DISSUSSION

Correlation analysis between the amplitudes of the first second and third harmonics does not reveal any significant correlated changes between three harmonics. The distribution of phase, however, does show very significant departures for HDW and LDW's. The most probable value of the diurnal phase for HDW is 240^0–250^0, whereas, the most probable for LDW is around 180^0–190^0. The diurnal phase for the normal days is about 225^0–230^0. It is thus found that for the HDW, the phase shifts to later hours.

Such a result is significant as the high amplitude diurnal waves trains are not associated with high amplitudes of second and third harmonics. The distribution of phase shows very significant departures for the HDW and LDW's. The most probable value of the diurnal phase for HDW is 240^0–250^0, whereas, the most probable for LDW is around 180^0–190^0. The diurnal phase for the normal days is about 225^0–230^0. It is thus found that for the HDW, the phase shifts to later hours, where as for the LDW, the diurnal phase shifts to early hour's for the larger number of events.

The diurnal variation on an average basis shows energy independent variation i.e. spectral exponent of the power law spectra is ≈ 0.0 Similarly the spectral exponent for the second and third harmonic of daily variation is ≈ 1.0. For the most significant events of HDW (Seven) and LDW (Four), we have derived the spectral characteristics using a low latitude (Tokyo) neutron monitor and a high latitude (Deep River) neutron monitor station. The table very clearly reveal's the LDW is associated with positive spectral exponent even for diurnal variation. Similarly the second harmonic of HDW is associated with zero spectral exponent as compared to exponent "1", for the annual average values. Such a significant change in the characteristics of LDW and HDW is to be confirmed by adding another pair of station's and if confirmed the results reported would be of great releavence in the studies of daily variation of cosmic rays.

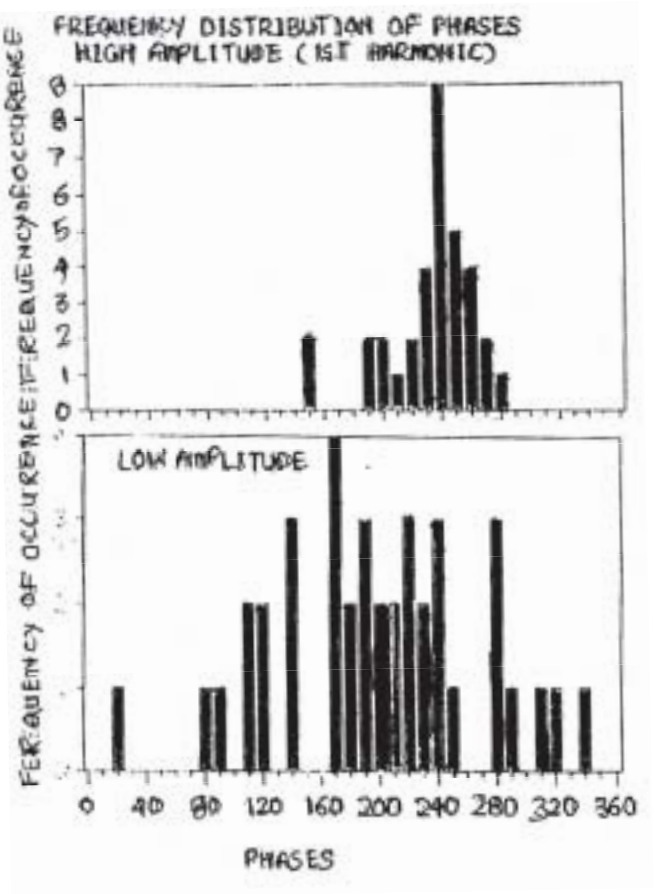

Fig. 1. **(a&b)**- Shows frequency distribution of the phases, of the first harmonic, for the HDW & LDW events, for 1979–1990 i.e. solar cycle 22.

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