Study Of Higher Harmonics Of Cosmic Ray Intensity On Quiet Days At Tokyo Station

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ABSTRACT

The cosmic ray intensity data recorded with TOKYO Neutron Monitoring Station have been investigated on 60 Quiet Days (QD) in a year for studying the higher harmonics of daily variation during solar cycle 21 and 22. It has been observed that inspite of the abrupt change in the amplitude and the phase of the higher harmonics of daily variation in cosmic ray intensity, the amplitude of third harmonic of daily variation on QDs is larger by a factor of two during the period 1983 to 1986, i.e. the declining phase of solar cycle 21, similar to that observed 11-years ago i.e., declining phase of solar cycle 20, at Tokyo station. Thus, 11-year variation in the tri-diurnal anisotropy of cosmic ray intensity is clearly observed at the Tokyo neutron monitoring station. Further, the amplitude of the fourth harmonic of the daily variation on QD during 1987–90 shows an increasing trend continuously in association with phase of fourth harmonic shifting to earlier hours.

1. INTRODUCTION

Anisotropies of galactic cosmic rays and their characteristics are studied through the diurnal and semi diurnal components mainly and the level of the isotropic intensity collectively provides the finger prints for identifying the modulation process and electromagnetic state of the interplanetary space in the neighbourhood of the Earth. Many workers have attempted to derive relationship between the main daily variation and the level of solar and geomagnetic activity. The spatial anisotropy of the galactic cosmic ray intensity in the interplanetary space manifests itself as daily variation with a period of 24 hours (and its higher harmonics) due to the rotation of the earth in course of a day. The power spectrum analysis as well as the Fourier analysis of the long term data of 24-hour values of cosmic ray (CR) intensity observed by Earth based detectors have provided confirmatory existence alongwith the characteristics of the first three harmonics of daily variation of extra terrestrial origin. However, the amplitude of the fourth harmonic is still controversial [1–3 and 9–13]. Moreover it has been observed that the amplitude and the phase of tri diurnal variation of CR intensity on quiet days also vary considerably from one period to another.

pp. 3977–3980

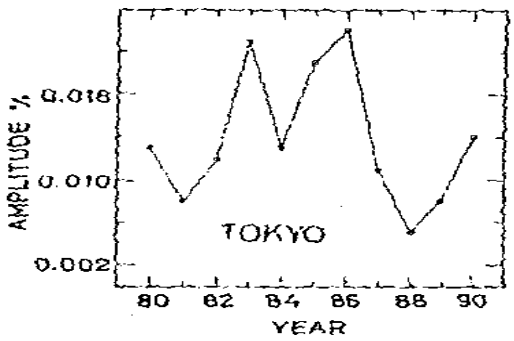

Fig. 1. Amplitude(%) of tri-diurnal anisotropy of CR intensity on QD during 1980–90.

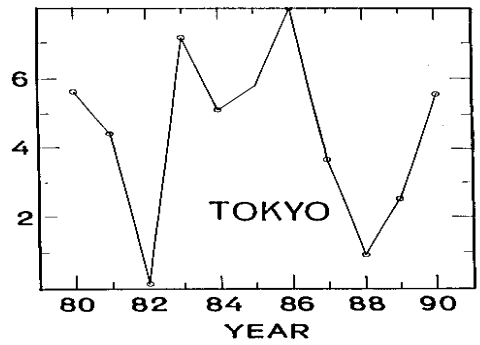

Fig. 2. Phase(Hrs in local time) of tri-diurnal anisotropy of CR intensity on QD during 1980–90.

2. ANALYSIS OF DATA

The CR intensity data (corrected for meteorological effects), on geomagnetically five quietest days (QD), for Tokyo neutron monitoring station during the period 1980–90, have been used in this analysis. The justification for the selection of only geomagnetically quiet days for the analysis purpose has been discussed elsewhere [12]. The long term effects have been removed by applying the trend corrections [14]. Such a set of data has been subjected to harmonic analysis for each day. The average values of the amplitude (%) and phase (hrs) in local time of the station for the third (tridiurnal) and fourth harmonic have been obtained. The days with abrupt changes in CR intensity have not been considered in deriving the average harmonics.

3. RESULT AND DISCUSSION

The amplitude (%) and phase (hrs) of the tri-diurnal and quart-diurnal anisotropy of CR intensity on QD for Tokyo neutron monitoring station (35.75N, 11.5GV) during the period 1980–90 have been investigated.

The yearly average amplitude and the phase of the third harmonics of daily variation for Tokyo Neutron Monitoring Station during the period 1980–90 have been plotted in Fig.1 and 2 on quiet days. It is quite apparent form Fig. 1 that there is no systematic change in the amplitude of third harmonics on QDs. Nevertheless, the amplitude of third harmonics on QD remain relatively large during declining phase of solar cycle 21 as compared with the declining phase of earlier solar cycle 20 [6 and 11]. The enhancement explicitly point out the 11 year periodicity [4]. Further, the amplitude of third harmonics of daily variation on QD is observed to be significantly low during the year 1981, which coincides with phase reversals of the solar poloidal magnetic field [5 and 8]. Furthermore, amplitude of third harmonics on QD has low values during minimum solar activity

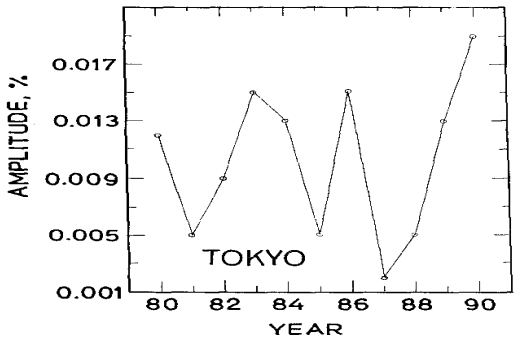

Fig. 3. Amplitude(%) of tri-diurnal anisotropy of CR intensity on QD during 1980–90.

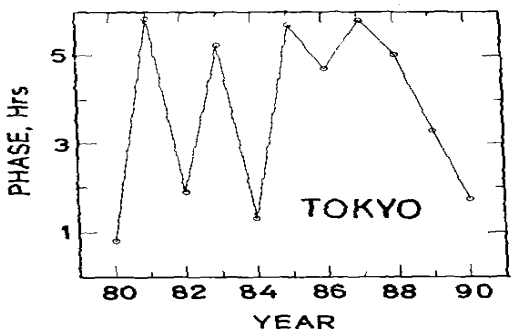

Fig. 4. Phase(Hrs in local time) of tri-diurnal anisotropy of CR intensity on QD during 1980–90.

period.

It is observed from Fig. 2 that there is no systematic change in the phase of third harmonic of daily variation of cosmic ray intensity. However, a significant change is observed, when the solar polar magnetic field reversed its polarity during 1980 and 1990. In the year 1980, the phase on QD shifted to early hours, when the polarity of solar magnetic field in the southern hemisphere has changed from negative to positive. Further, in the year 1990, reverse process occurred in comparison to 1980, in the phase on QD shifted to later hours, when the polarity of solar magnetic field in northern hemisphere has changed from negative to positive [7].

The annual average amplitude (%) and phase (hrs) in local time of quart-diurnal anisotropy of daily variation on QD has been plotted in Fig. 3 and Fig. 4, during the years 1980–90.

It is quite apparent from the Fig. 3 and Fig. 4 that there is no systematic change in the amplitude and phase of fourth harmonic of daily variation on QDs. Further, the amplitude of fourth harmonic of daily variation on QD during 1987–90 shows an increasing trend continuously in association with phase of fourth harmonic; shifting to earlier hours, as it is apparent from these figures.

Thus, it has become quite clear that the tridiurnal anisotropy in cosmic ray intensity on quiet days is statistically significant and the variations in it are of extraterrestrial in nature. Further, the variational characteristics are also consistent with the solar modulation of cosmic ray particles through the interplanetary magnetic field and solar wind plasma, Furthermore, the observed characteristics of tridiurnal anisotropy on quit days are now well defined for the period upto 1990. In future, for knowing the detailed characteristics of tridiurnal anisotropy on quiet days and also the mechanism of its production, the analysis of the data may be extended to a wider range of rigidity of cosmic ray detectors.

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