PROCEEDINGS OF SCIENCE

ELEVAN YEAR VARIATION IN THIRD HARMONICS OF DAILY VARIATION IN COSMIC RAY INTENSITY ON QUIET DAYS AT WORLDWIDE NETWORK OF NEUTRON MONITORING S

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The purpose of research work is establish eleven year variation in the amplitude of third harmonics of daily variation in Cosmic Ray Intensity on sixty quiet days after using neutron monitor data at different latitude Neutron Monitoring Station. It has been observed that in spite of abrupt variation in the amplitude and phase of third harmonic of Cosmic Ray Intensity, The amplitude of third harmonic is relatively larger during the declining phase of solar cycle twenty one as it is also absorbed during the declining phase of earlier solar cycle twenty. Therefore, this enhancement establish the eleven years variation in the amplitude of third harmonics of Cosmic Ray Intensity on quiet days at Equatorial Neutron Monitoring Stations. Further, the amplitude of third harmonics of Cosmic Ray Intensity on quiet days has been observed almost equal during the two consecutive solar maximum activity period of solar cycle twenty one and twenty two supporting eleven years variation in the third harmonics of daily variation at high latitude Neutron Monitoring Station

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1. Introduction

The anisotropic variation of galactic cosmic rays and their characteristics are studied through the diurnal, semi-diurnal, Tri-diurnal component of daily variation mainly and the level of the isotropic intensity collectively provides fingerprint for identifying the modulating process and the electromagnetic state of interplanetary space in the neighborhood of the Earth. Many workers have attempted to derive relationship between the mean daily variation and the level of solar and geomagnetic activity [1]. 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 the course of a day. The power Spectrum analysis as well as the Fourier analysis of the long term data of the 24-hour values of CR intensity observed by Earth based detectors have provided daily variation of extraterrestrial origin [2-4]. However, the amplitude of the fourth harmonics is still controversial [5-7]. Moreover, it has been observed that the amplitude and phase of tri diurnal anisotropy of CR intensity on quiet days vary considerably from one period to another. On the long term behaviour of the first three harmonics showed that high degree of year to year variability exists, a trend with solar activity was evident. The studies of the higher harmonics in the daily variation of cosmic ray intensity provided valuable information as to the nature of the cosmic ray modulation in the heliosphere. The amplitude and phase of all the three components (Diurnal, Semi-diurnal and tri-diurnal) usually shows 11 and 22 years variability

2. ANALYSIS OF THE DATA

Solar daily variation has been studied in terms of helio-magnetic activity. A new concept of data analysis has been introduced for studying the long/short term daily variation in CR intensity recorded with world wide network of neutron monitors. Fourier technique has been applied on different types of group of days chosen according to their different geomagnetic condition.

1. All days: This means all the 365/366 days in year. Thus, these days are termed as AD. Of course ignoring the days with abrupt changes.

Quiet days: Those days on which the transient magnetic variation are regular and smooth are said to be magnetically quiet or Q days. The criteria is based upon Ap and Kp values. There are two types of days.

2. 60 Quiet days: According to solar geophysical data (SGD) lowest mean order number are the five quietest days in a month. Thus, 60 Q days in a year; termed as 60 QD.

3. 120 Quiet days: First ten quiet days in a month. Thus, 120 Q Days in a year; termed as 120 Quiet days.

The pressure corrected hourly CR intensity data (corrected for meteorological effects) on geomagnetically five quietest days (QD) in every month for worldwide network of neutron monitoring stations for the period 1978-94, have been used in Fourier analysis given below:

Name of Neutron Monitoring	Latitude	Longitude	Cut-off rigidity	Altitude

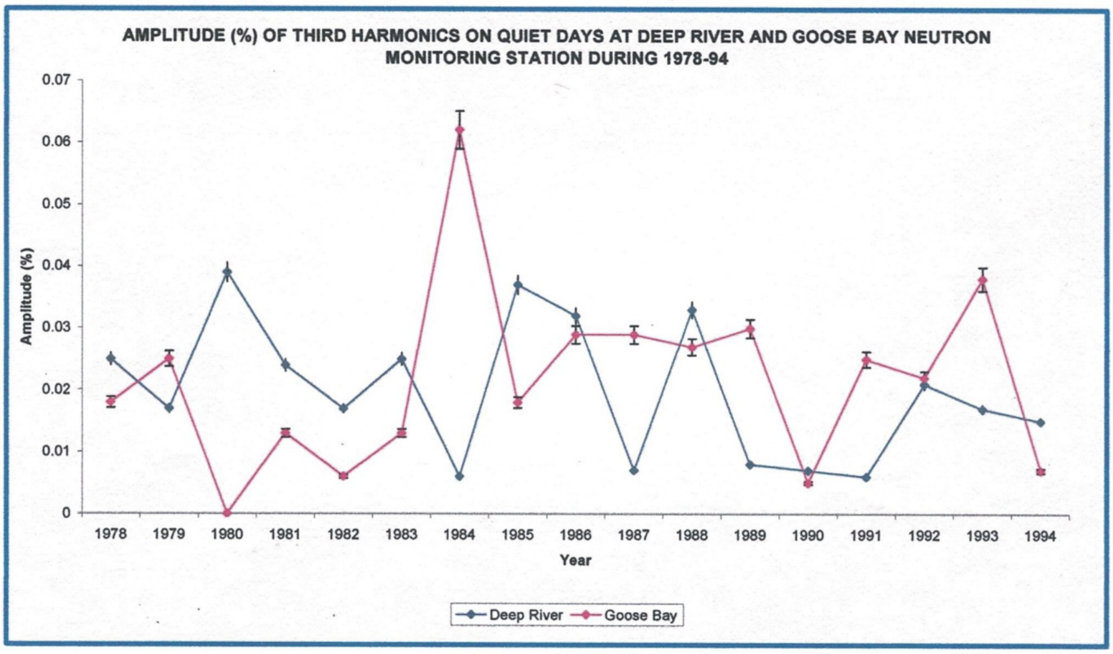
Station				
Deep River	46.06°N	282.5° E	1.02 GV	145m
Goose Bay	53.33°N	229.58° E	0.52 GV	46m
Tokyo	35.75°N	139.72° E	11.61 GV	20m
Mount Nourikura	36.12°N	137.56° E	11.39 GV	27.7m
Inuvik	68.35°N	226.27° E	0.18 GV	21 m

After applying the trend corrections, such a set of data have been subjected to Harmonic analysis for each day [8]. The average values of the amplitude and phase (local time of the station) of the third (tri diurnal) harmonics on yearly basis have been obtained. According to solar geophysical data five quietest days are selected in a month; thus 60 quietest days are obtained in a year. These days are called international quiet days (QD). The days with extra ordinary large amplitude, if any, have not been considered. Further, the variation in the tri-diurnal anisotropy with the reversal of polarity of solar magnetic field (PSMF) on 60 QD has been also investigated. Also all those days are discarded having more than three continuous hourly data missing.

3. RESULTS AN DISCUSSION

The yearly average amplitude of the third harmonics of daily variation for Deep River, Goose Bay, Tokyo, Mount Nourikura and Inuvik Neutron Monitoring Stations have been plotted in Fig. 1 during the period 1978-94 on QD. It is quite apparent from Fig. 1 at Deep River Neutron Monitoring Station, the amplitude of third harmonics of daily variation has quite abruptly increased during the years 1980 and 1985. The likely one of the cause for such type of variation could be the changing of geomagnetic threshold cut off rigidly from 1.02 GV to 1.15 GV in 1980 and from 1.02 GV to 1.12 GV in 1985 respectively [9-11] as it has been discussed in the case of change of diurnal anisotropy of cosmic ray intensity on QD [12]. Therefore, these type of variation in the amplitude of the tri-diurnal anisotropy on QD may be also attributed to the change in the rigidity spectrum. The amplitude of tri-diurnal anisotropy on QD has shown as exceptionally small value during 1987 and 1994, which is a period of minimum solar activity [13]. The amplitude of third harmonics of daily variation on QD is observed to be significantly low during 1981 as well as in 1990, which coincides with phase reversal of the solar poloidal magnetic field. Further, during the year 1985 and 1986, the year of minimum solar activity, the amplitude of third harmonics on QD significantly high, which support the earlier finding [13]. The amplitude of third harmonics found to remain low showing dips during the year 1984, 1987, 1989, 1990, 1991 and remain high during the year 1980, 1985, 1986 to 1988 at Deep River neutron monitoring stations.

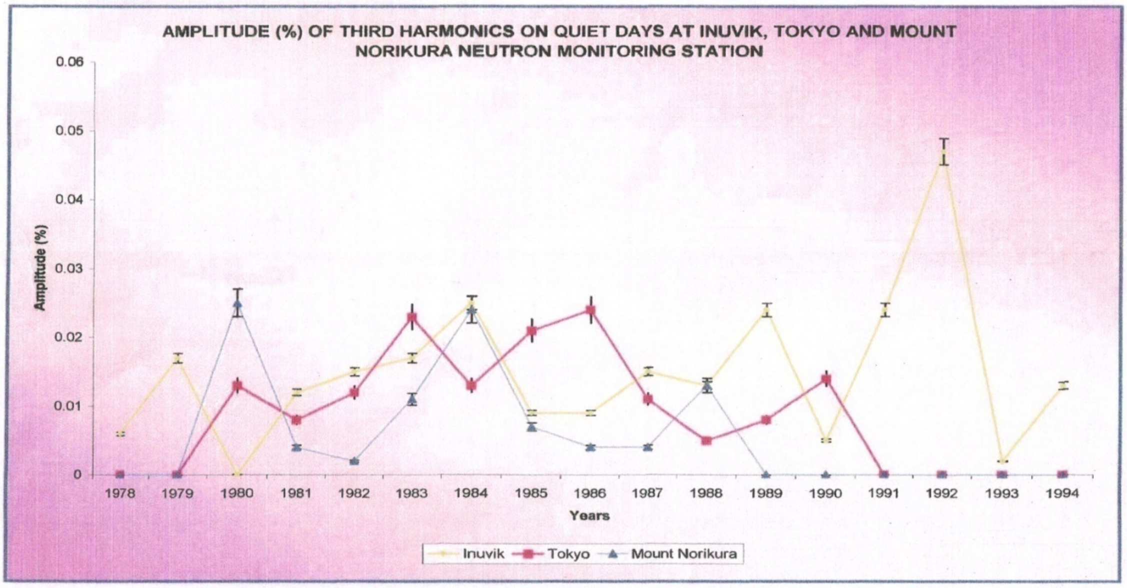
Fig. 1



It is also apparent from Fig.1 that there is some of the significant observations are observed in the amplitude of the third harmonics of daily variation at Goose Bay Neutron Monitoring Stations such as the amplitude is decreased during the year 1990, which coincides with phase reversal of the solar poloidal field [14]. It is observed that the amplitude is statistically nearly constant high value during the years 1986-88. The amplitude of the Tri-diurnal anisotropy of CR intensity has been observed almost equal during the two consecutive solar maximum activity periods i.e., (year 1979 and 1991) of solar cycles — 21 and 22 supporting 11-year variation in the Tri-diurnal anisotropy of CR intensity on QD. Further, the amplitude of third harmonics during the years, 1982 and 1994 (Difference at 11 year) having the same value, which is again confirm the 11 year type variation in third harmonics of daily variation [15]. The amplitude of third harmonics found to remain low showing dips during the years 1982, 1990, 1994 and remain high during the years 1986 to 1988 and 1993 at Goose Bay Neutron Monitoring Station.

The yearly average amplitude of the third harmonics of daily variation for Inuvik Neutron Monitoring Station during the period 1978-94 and Tokyo, Mount Nourikura Neutron Monitoring Stations during the period 1980-90 have been plotted in Fig. 2 on QD. It is quite apparent from Fig. 2 that there is no systematic change in the amplitude of third harmonics on QDs. Nevertheless, the amplitude of third harmonics on QD remain relatively larger during the declining phase of solar cycle 21 and 22 as compared with the declining phase of the earlier solar cycle 20 at equatorial stations. This enhancement explicitly point out 11 year periodicity [16]. The amplitude of the 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 and amplitude of the third harmonics on QD has low values during minimum solar activity period. Further, the amplitude of third harmonics of daily variation in the year 1980 has quite abruptly increased at Mount Nourikura Neutron monitoring station. The likely one of the cause of such type of variation could be changing threshold cut off rigidity from 1.02GV to 1.15 GV [9-11]. The amplitude of third harmonics found to remain low showing dips during the years 1981, 1988 and high during the years 1983 and 1986 at Tokyo Neutron Monitoring Station. The amplitude of third harmonics found to remain low showing dips during the years 1982, 1986, 1987 and high during the years 1980 and 1984 at Mount Nourikura Neutron Monitoring Station.

Fig.2



Furthermore, it is quite apparent from Fig. 2, that there is no systematic change in the amplitude of third harmonics on QDs. The amplitude of third harmonics of daily variation on QD is observed to be significantly low during the year 1981 as well as in 1990, which coincides with phase reversal of the solar poloidal magnetic filed at Inuvik neutron monitoring station. Further, the amplitude of third harmonics on QD is low during 1985 and 1986, the year of minimum solar activity. The cause of such changes may be the increase of interplanetary magnetic field irregularities (IMF). The amplitude of third harmonics of daily variation on QD during the year 1978 and 1990 (Maximum Solar activity period of solar cycle 21 and 22) having same values. A clear 11 year type variation is established at high latitude neutron monitoring station [15]. The amplitude of third harmonics found to remain low during the years 1978, 1990 and high during the years 1984, 1989 at Inuvik Neutron Monitoring Stations.

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