Cosmic ray modulation at low/high cut off rigidity

REKHA AGARWAL 1, RAJESH K. MISHRA 2
1 Department of Physics, Govt. Model Science College (Autonomous), Jabalpur (M.P.) 482 001, India
2 Computer and IT Section, Tropical Forest Research Institute, P.O. RFRC, Mandla Road, Jabalpur (M.P.) 482 021, India
contact. rm_jbp@yahoo.co.in, rkm_30@yahoo.com

Abstract: The various observed harmonics of the cosmic ray variation may be understood on a unified basis if the free space cosmic ray anisotropy is non-sinusoidal in form. The major objective of this paper is to study the first three harmonics of cosmic ray intensity on geo-magnetically quiet days over the period 1965-1990 for Deep River, Goose Bay and Tokyo neutron monitoring stations. The amplitude of first harmonic remains high for Deep River having low cutoff rigidity as compared to Tokyo neutron monitor having high cutoff rigidity on quiet days. The diurnal amplitude significantly decreases in 1987 at Deep River and in 1986 at Tokyo during solar activity minimum years. The diurnal time of maximum significantly shifts to an earlier time as compared to the corotational direction at both the stations having different cutoff rigidities. The time of maximum for first harmonic significantly shifts towards later hours and for second harmonic it shifts towards earlier hours at low cutoff rigidity station i.e. Deep River as compared to the high cut off rigidity station i.e. Tokyo on quiet days. The amplitude of second/third harmonics shows a good positive correlation with solar wind velocity, while the others (i.e. amplitude and phase) have no significant correlation on quiet days. The solar wind velocity significantly remains in the range 350 to 425 km/s i.e. being nearly average on quiet days. The amplitude and direction of the anisotropy on quiet days are weakly dependent on high-speed solar wind streams for these neutron monitoring stations of low and high cutoff rigidity threshold.

Keywords: cosmic ray, cut off rigidity, quiet days, harmonics.

1 Introduction

Researchers have attempted to derive relationship between the mean daily variation and the level of solar and geomagnetic activity [1]. Yearly average values of the first harmonic of solar daily variation experience strong changes from year to year and with the cycle of solar activity. Amplitude and phase of diurnal anisotropy are changes with the solar activity cycles [2, 3, 4]. Lockwood and Webber [5] found a close relationship between the magnitude and frequency of Forbush decreases and the eleven-year cosmic ray variation. They concluded that the effect of Forbush and other transient decreases is a dominant factor in the long-term intensity modulation. Forbush [6] showed that annual means of the CR diurnal anisotropy resulted from the addition of two distinct components. One, W has its maximum in the asymptotic direction of 128° E of the Sun and is well approximated by a wave W with a period of two solar cycles and the other component V has its maximum in the asymptotic direction 90° E of the Sun. Ahluwalia [7] has reported that diurnal anisotropy is unidirectional during 1957-70 with direction along 1800 Hr LT (East-West) and during 1971-79 it consists of two components; one is in the East-West direction and the other is the radial component with direction along 1200 Hr LT. Sabbah [8] characterized the diurnal anisotropy by two components. Only one anisotropy is dominant during each magnetic state of the solar cycle. The direction of the dominant anisotropy vector points towards the 1800 Hr LT direction during the negative state of the solar cycle and toward earlier hours during the positive state. Ballif et al. [9] correlated Kp and Ap with the mean fluctuations in amplitude of IMF, which in turn is related to diffusive component of convection-diffusion theory. Ap is also found to related with solar wind velocity, which is related to the convective component of convection-diffusion theory. Agrawal [10] and Bieber and Evenson [11] have preferred to investigate the daily variation in cosmic ray intensity on long/short term basis performing the analysis for all days in a year; whereas, Kumar et al. [12, 13] have studied long/short term daily variation on geomagnetically 60 quiet days (QD).

We present a study of the short-term evolution of coronal mass ejections observed by the Large Angle and Spectrometric Coronograph (LASCO) on board SOHO during 2005 and their association with the modulation of galac-
tic cosmic ray (GCR) intensity observed at 1 AU by the Moscow neutron monitor and IMP-8 spacecraft. We compare the short-term GCR modulation with the CME occurrence rate at all, low, and high latitudes, as well as the observed CME parameters.

2 Data Analysis

The pressure corrected data of Deep River (Vertical cutoff rigidity = 1.02 GV, Geog. Latitude = 46.1° N, Geog. Longitude = 282.5° E), Goose Bay (Latitude: 53.27N, Longitude: -60.40W, Altitude: 46 m, Rigidity 0.64 GV) and Tokyo (Vertical cutoff rigidity = 11.61 GV, Geog. Latitude = 35.75° N, Geog. Longitude = 139.72° E) Neutron Monitor (NM) station has been subjected to Fourier analysis for the period 1980-90 after applying the trend correction. While performing the analysis of the data all those days are discarded having more than three continuous hourly data missing.

3 Results and Discussion

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 has 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 cosmic ray diurnal/semi-diurnal/tri-diurnal anisotropy alongwith the variation in associated value of north south component of IMF (Bz), the product (V x Bz) and calculated the correlation coefficient between them on quiet days for Deep River, Goose Bay and Tokyo stations. We observed that the semi-diurnal amplitude A2 have a significant anti-correlation with Bz (r = -0.71) and the product V x B (r = -0.59) at Deep River and Goose Bay. The tri-diurnal amplitude A3 have a good anti-correlation with Bz (r = -0.49) and the product V x Bz (r = -0.39) at Deep River and Goose Bay. The time of maximum of first harmonic also shows a good anti-correlation with both Bz (r = -0.46) and V x Bz (r = -0.47) at Deep River and Goose Bay. The other components (amplitude and phase) does not have a significant correlation with Bz and V X Bz.

4 Conclusion

The diurnal time of maximum significantly shift to an earlier time as compared to the corotational/1800 Hr direction at all these stations of different cutoff rigidity. The semi-diurnal amplitude has a significant anti-correlation, whereas the amplitude of third harmonic and direction of first harmonic has a good anti-correlation with IMF Bz and the product V x Bz on quiet days at Deep River and Goose Bay station. However, the direction of first harmonic has a significant anti-correlation and the direction of second harmonic has a good anti-correlation with IMF Bz and the product V x Bz on quiet days at Tokyo station.

5 References