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Correlation of the quiet day diurnal variations of cosmic rays to the interplanetary parameters

Rekha Agarwal Mishra[a] and Rajesh K. Mishra[b]
(a) Department of Physics, Govt. Model Science College (Autonomous), Jabalpur (M.P.) 482 001, India
(b) Computer and I.T. Section, Tropical Forest Research Institute, P.O.: RFRC, Mandla Road, Jabalpur (M.P.) 482 021, India
Presenter: Rekha Agarwal Mishra (rkm_30@yahoo.com), ind-mishra-RA-abs2-sh34-poster

We studied the cosmic ray data as well as interplanetary magnetic field data (Bz) and solar wind velocity data to examine the relation and correlation between quiet day diurnal variations during the time interval 1964-1995. The amplitude of cosmic ray diurnal anisotropy significantly correlates with the polarity of z component of IMF, Bz during quiet days. The amplitude and time of maximum of the quiet day diurnal variation of galactic cosmic rays is linearly correlated with: the z- component of interplanetary magnetic field (IMF) vector, Bz. The solar wind velocity found to remain low for negative Bz; whereas it remains high for positive Bz during quiet days. Our observations suggest that the direction of the anisotropy of quiet days contribute significantly to the long-term behaviour of the CR diurnal anisotropy.

1. Introduction

Numerous study have dealt with connection between long-term CR variations and variations of solar wind (SW) characteristics and the solar magnetic field [1-3 and references therein], where CR long-term variations have been calculated and their model description has been proposed. The CR variations observed near the Earth are an integral result of numerous solar and heliospheric phenomena, so it would be difficult to believe that any parameter alone can determine the behaviour of CR. A strong correlation between the CR modulation and the IMF module was established [3, 4]. The role of the solar wind velocity for cosmic ray modulation was established previously [5].

Sabbah [6] found that the values of the upper cut off rigidity (Rc) show a magnetic cycle variation with the lowest values occurs during years of solar activity minima of the positive state of solar cycle. Ahluwalia [7] correlated the values of Rc to the IMF magnitude (B) during the period 1966-1987. Sabbah [6] supported this conclusion by finding a good correlation between the later two parameters during the period 1968-1995. The cosmic ray intensity decreases as the interplanetary magnetic field (IMF) magnitude increases [8]. Cane et al. [9] obtained an inverse correlation between cosmic ray density and IMF magnitude. Sabbah and Duldig [10] have proved that the cosmic ray spectra are dependent on the magnetic state of the solar cycle. This is consistent with the predictions of the modulation drift model. Sabbah [11] found that the days characterized by high IMF magnitude are associated with higher diurnal variation amplitudes.

2. Experimental data and analysis

Pressure corrected data of Deep River neutron-monitoring (NM) station (cutoff rigidity 1.02 GV; latitude 46.1º N; longitude 282.5º E; altitude 145 M) has been Fourier analyzed after applying trend corrections to obtain the first harmonic at ground for the period 1964-95. According to solar geophysical data five quietest days are selected in a month; thus 60 quietest days in a year. These are called International Quiet Quiet days or QQ days. The study of diurnal variation has been performed on 60 QQ for the period 1964-95. The days

with extraordinarily large amplitude, if any, have not been taken into consideration. Also all those days are discarded having more than three continuous hourly data missing. The daily values of southward component of IMF (Bz) and solar wind velocity (km/sec.) for each corresponding quiet days have also studied in the present analysis.

3. Results and Discussion

Many researchers [12 and references therein] studied the dependence of the IMF sense on solar diurnal variation. Annual mean amplitudes of the diurnal anisotropy observed with Deep River NM for 'away' and 'towards' polarity of IMF for the period 1965-93, the amplitude for the 'away' group exceeds that for the 'toward' group for the period 1965-68 and from 1969-73, the amplitude for the 'toward group exceeds that for the away group [13]. At the most northerly viewing latitudes the amplitude of the solar diurnal variations for the toward polarity days is greater than that for the away polarity days (northward pointing gradient) while as the viewing latitudes become more southerly, there are greater and greater years in which the amplitude for the away polarity days is greater than that for the toward polarity days (a predominant southward gradient) [14]. Burlaga and Ness [15] argue that it is ultimately the strong magnetic field and their associated fluctuations that produce the modulation of cosmic rays. Cane et al. [4, 9] have found that the cosmic ray profile tracks rather well variations in the interplanetary magnetic field strength. The effect of interplanetary magnetic field B and its Bz component on cosmic ray intensity and geomagnetic field variations have been examined by Singh et. al. [16]. They observed that (1) B not less than 10 gamma (magnetic blobs) is a pre-requisite in producing cosmic ray intensity and geomagnetic field variations of varying magnitudes; (2) the longer existence of magnetic blobs on successive days produces larger decreases in cosmic ray intensity and geomagnetic field; (3) the southward component (Bz) of IMF generally gives rise to large Ap changes, though it is not effective in producing cosmic ray intensity decreases.

The amplitude (%) and phases (Hr) of diurnal anisotropies for quiet days with the variations in the associated values of z-component of interplanetary magnetic field B, i.e. Bz have been plotted in Figure 1 during the period 1964-95. It is evident from the plot that the diurnal amplitude during quiet days remains statistically constant for different values of Bz during the entire period. It is noteworthy that diurnal time of maximum significantly shifts towards earlier hours as compared to the 18-Hr/co-rotational values for both positive and negative polarity of Bz; or, it remains in the corotational direction

The z component of IMF, Bz is found to remain positive i.e. away from the Sun for the majority of the period. It is quite apparent from the plot that the magnitude and polarity of southward component of IMF (Bz) do not play any significant role for the amplitude and time of maximum of cosmic ray diurnal anisotropy during quiet days for the entire period of investigation. As depicted in Figure the solar wind velocity also found to remain constant during the entire period of investigation. We observe that for positive polarity of Bz component of IMF the solar wind velocity found to remain high; whereas for negative polarity of IMF, Bz it remains low. The solar wind velocity lies in the interval 350-400 km/s i.e. being nearly average for different values of Bz during quite days.

Sabbah [17] also observed that the days characterized by high IMF magnitude are associated with higher diurnal variation amplitudes as well as higher solar plasma parameters. The Bz component of IMF does not usually contribute to the solar modulation of cosmic rays since the long-term average of this component near the Earth is ~0. However, Swinson [18] and Swinson et al. [19] have demonstrated that on occasions it can contribute to a field dependent anisotropy especially to the extended trains of enhanced solar diurnal variation observed in 1974.

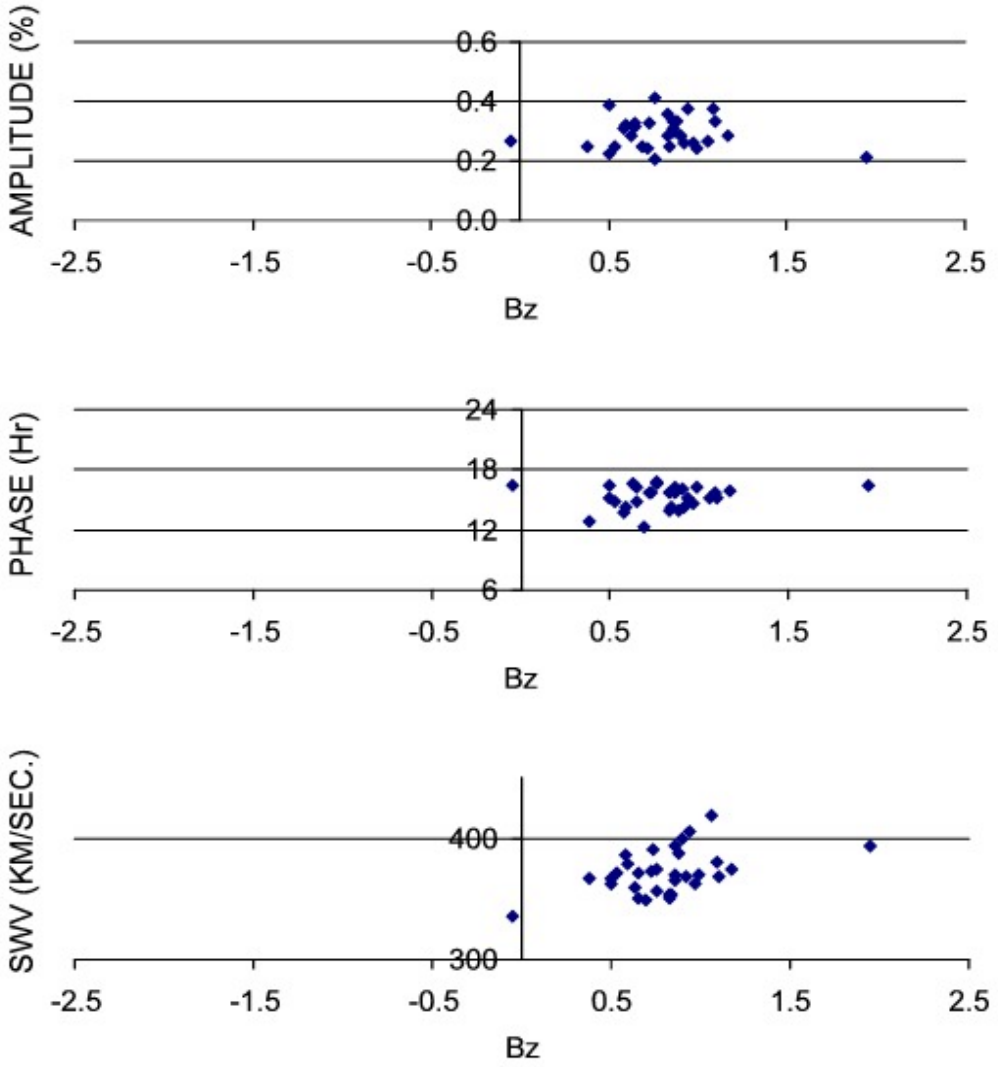

Figure 1: The amplitude(%) and phase (Hr) of the cosmic ray diurnal anisotropy and solar wind velocity for all the quiet days with the variation in associated values of southward component of IMF (Bz) during 1964-1995.

4. Conclusion

On the basis of present investigations the following conclusions have emerged:

1. The magnitude as well as the polarity of southward component of IMF does not play any significant role for the variation of amplitude and time of maximum of cosmic ray diurnal anisotropy.
2. The solar wind velocity remains low for negative polarity of IMF, Bz; whereas it remains high for positive polarity of IMF, Bz during quiet days.
3. The amplitude/phase of cosmic ray diurnal anisotropy and solar wind velocity during quiet days are positively correlated with southward component of IMF Bz.

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