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COSMIC RAY INTENSITY VARIATION WITH THE AP INDEX AT HIGH AND LOW CUTOFF RIGIDITY STATIONS

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ABSTRACT*:*

Practically all the experimental studies of the solar daily variation of cosmic rays have been carried out with the earth-based detectors responding to the particles of varying energies. This is of particular significance for the meson component measured at low levels in the atmosphere and enables correction to be made for variations of atmospheric origin. In the present study the pressure corrected hourly data of neutron monitor at high latitude station 'Kiel' and low latitude station 'Haleakala' for different days of the year 2000 has been distributed into five group of Ap index. The average diurnal vector of cosmic ray intensity for these groups has been well represented in terms of percentage amplitude and phase in form of the harmonic dial representation.

KEYWORDS: *Ap Index; Average Diurnal Vector; Cosmic Ray; Neutron Monitor; Solar Cycle.*

1. INTRODUCTION

The cosmic rays which originate outside the solar system originate in the aftermath of exploding stars or supernovae are known as Galactic Cosmic Ray. These are being accelerated to nearly the speed of light by the shockwave, and are constantly bombarding the Earth's atmosphere from all directions. The cosmic ray intensity has been found to exhibit a daily variation of extraterrestrial origin [1], which composed of characteristic first three harmonics, a prominent diurnal component, a semi-diurnal component and also tri-diurnal component of lesser amplitudes [2, 3]. The semi-diurnal variations are produced by the diffusion and convection of cosmic rays in the interplanetary space [3]. Ahluwalia [4], studied on the long term behavior of the three harmonics of cosmic ray daily variation, showed that although a high degree of year to year variability exists, a trend with solar activity is evident. In the present study, an attempt has been made to look into the possible dependence of diurnal variation in cosmic ray intensity with solar variations and the results have been discussed in terms of the finding carried out by the other researchers. The energy spectrum of the primary cosmic ray particle intensity shows a decrease of flux with increasing energy. Sun plays a dominant role and the solar wind emanating from it effectively controls the propagation of the low energy part of the galactic cosmic rays. As such the intensity of the galactic cosmic rays is low during the year of high solar activity and vice-versa [4, 5]. The solar plasma cloud emitted during the solar flares is responsible for the geomagnetic storms. It also enhances the sweep out of the galactic cosmic rays causing sudden decreases in its intensity known as Forbush decreases. As such, time variation in the cosmic ray intensity give an effective tool to study the vast interplanetary phenomena containing variable solar plasma and field. The solar wind decelerates the incoming particles and blocks some of the particles with energies below about 1Gev. The amount of solar wind is not constant due to changes in solar activity. Thus, the level of the cosmic ray flux varies with solar activity. During solar flares sun also produces cosmic radiation of comparatively lower energies (<100Mev), but sometimes extending even to higher energies ($\geq$ 1Gev). The primary cosmic radiations which bombard our earth constantly from all directions in space contain ultra relativistic protons (~86%) with sprinkling of nuclei of heavier elements. The cosmic rays have been used as a tool for a long time in the studies related to many elementary particles such as muons, positrons, pions, kions and some hyperons. The interplanetary magnetic field (I.M.F.) also plays an important role for the time variation of galactic cosmic radiations. The Earth's magnetic field deflects some of the cosmic rays, giving rise to the observation that the flux is apparently dependent on latitude, longitude and azimuth angle. The magnetic field lines deflect the cosmic rays towards the poles, giving rise to the aurora.

2. METHODOLOGY

For good reliability, group of days (of similar nature) and /or for continuous days with similar type of observed variability (say continuously occurring low or high amplitude waves of the diurnal variation has been taken to derive their characteristic. As far as parameters of interplanetary medium are concerned, we use Ap index as proxy for solar wind speed, or may be to properly represent for the overall degree of the interplanetary disturbances. The study of cosmic ray variations with time scales $\leq$ 1 hour is almost entirely limited by the statistical fluctuation. On the other hand, studies of the time variation with time scalars > 1 day is limited mainly by the stability of the neutron monitor. The atmospheric effect on cosmic rays has extensively been reviewed by Bercovitch [6], who observed two leading correlations in the observed cosmic ray intensity. The first one deals with the pressure changes which is related to the total mass of the absorber in the atmosphere, whereas the second is related to the variations in the differential density in the upper atmosphere, or the change of the height of the production layer due to different changed in the temperature at different heights.

To analysis the vectorial changes from one year to another it is always instructive to plot the value in vector form. This can be easily done by depicting them either by the vector addition format or in form of harmonic dial representation.

3. Experimental Data and Analysis

The temperature and pressure corrected hourly data of cosmic ray intensity from the Kiel and Haleakala neutron monitors have been used to obtain the amplitude and phase of the harmonic component for each day for five groups (Ap→ ≤8, 9-16, 17-26, 27-53 & >53) by Fourier techniques, where the long term change from the data has been removed by the method of 24 hour moving average. Moving average is slide average technique which shows the long-term profile of data set. In this way we can exclude the short term fluctuation of noise in the data set. The days of For bush decreases have been removed from the analysis to avoid associated superposed variation in cosmic rays. The harmonics of every day during the period 2000 has been calculated using the Matlab programming.

4. Result And Discussion

The average daily vector of the daily variation of cosmic rays have been derived for the years and for all the five groups of Ap index (these days are discrete and are not expected to occur continuously) for both the stations [Kiel (Cut-off rigidity 2.29 GV) and Haleakala (Cut-off rigidity 12.9 GV) stations]. The yearly average values for different groups so calculated are plotted in fig.1 and fig.2 for Kiel and Haleakala stations respectively for the first harmonic vectors. Similar type variations are seen in almost for the whole years for the two stations particularly so for the periods where the relationship with increasing value of Ap group and the diurnal phase is quite different. This gives confidence in reporting the variability with different level of disturbance. In general, we notice that the last group five always shows much larger amplitude of the diurnal variation. This group of high value of Ap days is expected to be associated with higher value of solar wind speed and more disturbed condition of the interplanetary medium. Infact, the higher the value of Ap, the higher should be the solar wind speed and hence enhanced convection, thereby increasing the diurnal amplitude accompanied with the shifting of the diurnal phase to earlier hours. Hence rotation of diurnal vector from higher phase to lower phase (clockwise) from group 1 to 5 is what is expected logically. This is what is observed (Fig. 1 & 2) for the whole year.

Minute observation of the average diurnal amplitude (represented by black colour) we observe that the average diurnal amplitude is significantly substantially high during the period of solar maxima of solar activity cycle 23, for both the stations. Similar set of results have been reported by many other investigators for earlier solar cycles showing smaller amplitudes during minimum sunspot activity and substantially larger diurnal amplitude during high sunspot activity periods [5, 6, 7, 8]. The implication is that the diurnal phase for high Ap days has shifted by large values to early hours as compared to low Ap days. Since the very beginning the average diurnal anisotropy of cosmic radiation has generally been explained in terms of azimuthal co-rotation [9, 10, 11, 12].

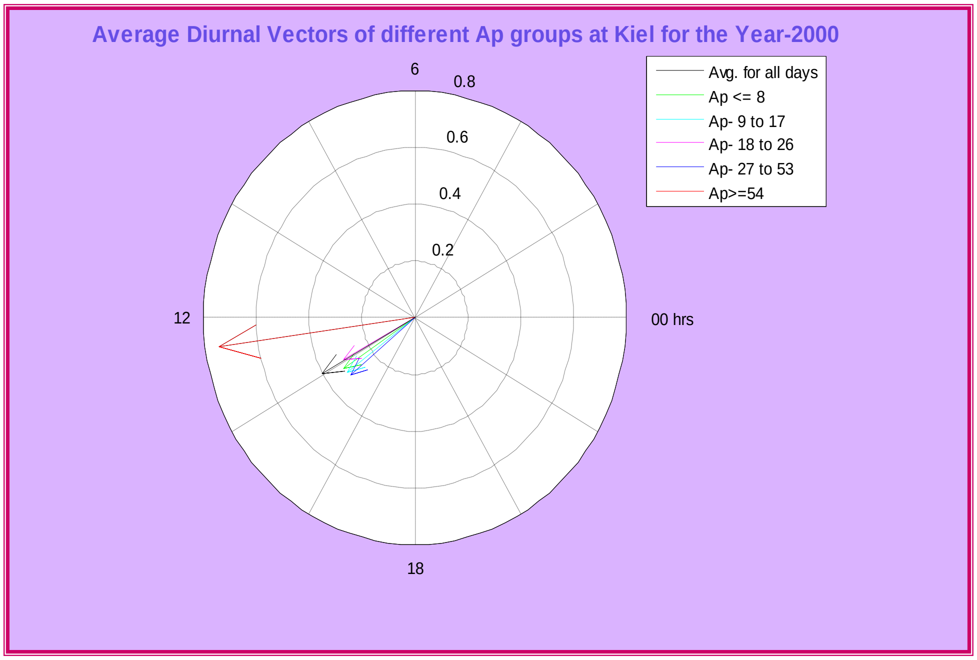

Fig.1 Shows the harmonic dial representation of average diurnal vector for different Ap group at Kiel (Low cutoff rigidity) for the year 2000.

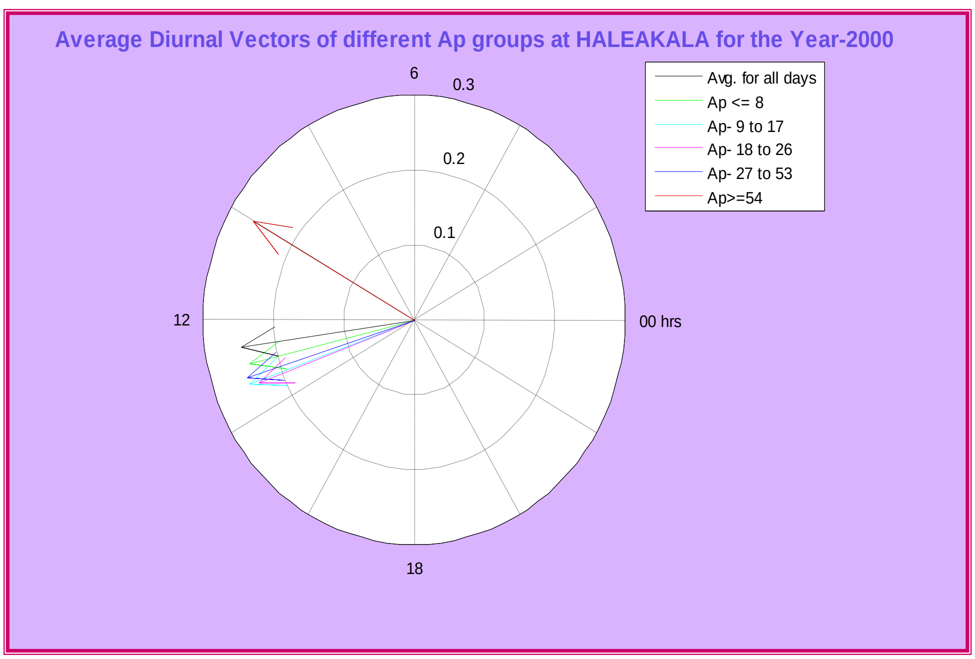

Fig.2 Shows the harmonic dial representation of average diurnal vector of different Ap group at Haleakala (High cutoff rigidity) for the year 2000.

5. Conclusion

The statistical analysis of the research work carried out confers the following conclusions:-

1. The amplitude of the diurnal variation vector of the cosmic ray variation has been found to be recovered during the high solar activity period (i.e. maximum Ap index).
2. The amplitudes of the diurnal variation vector of the cosmic ray variation are much larger for high latitude station as compared to the low latitude station for all the five Ap groups.
3. The phase of the diurnal variation vector of the cosmic ray variation has been found to be shifted to the later hours for low latitude station.

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