

Impact of high speed solar wind streams on cosmic ray decreases

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Abstract. Galactic cosmic rays on their way to Earth through the heliosphere are affected by magnetic field in homogenities. The high-speed solar wind streams lasting for several days are observed by satellites and spacecraft. These streams produce geomagnetic disturbances and changes in the level of cosmic ray intensity. The influence of two types of high speed solar wind streams- coronal-hole and solar-flare-associated on cosmic ray intensity has been studied using the neutron monitor data of three stations. Cosmic ray intensity data together with solar wind plasma and field data were subjected to superposed epoch analysis with respect of high-speed solar wind streams. The cosmic ray depressions influenced by coronal hole streams are much smaller than the typically Forbush like depressions. During these events the interplanetary magnetic field strength (B) and solar wind speed observed to increase. However, a significant correlation has been observed between disturbance storm time index (Dst) with geomagnetic activity index (Ap) and plasma temperature with plasma density.

Keywords: Galactic cosmic ray, solar wind, interplanetary magnetic field

I. INTRODUCTION

Two types of high-speed solar wind streams namely flare generated streams (FGS) and corotating streams (CS) are found equally effective in producing cosmic ray intensity decreases. Iucci et al. [1] and Shukla et al. [2] have shown the close correspondence between the cosmic ray intensity decreases observed by high-speed streams produced by solar flares accompanied by Forbush decreases whose amplitudes are not directly correlated with the increase in solar wind speed. These latter decreases are usually large and are dependent on the location of the solar flares.

Yadav et al. [3] studied the effect of two types of HSSWS on cosmic ray intensity using the data of three neutron-monitoring stations. They reported that cosmic ray depressions associated with coronal hole streams are much smaller than the typically Forbush-

like depressions and no spectral difference is found in the Forbush-like decreases between the periods before and after the polarity changes.

The enhancement or subsidence of both high-speed solar wind streams and the galactic cosmic rays in the minimum or the maximum phase of the solar cycle are interpreted in a unified manner by the concept of geometrical evolution of the general magnetic field of corona-helio-magnetosphere system. The subsidence of HSSWS in the maximum phase is understood as a braking of the solar wind streams by the tightly closed and strong coronal field lines in the lower corona in the maximum phase.

The decrease of the galactic cosmic rays in the maximum phase (known as the Forbush's negative correlation between the galactic cosmic rays and solar activity or the Forbush solar-cycle modulation of the galactic cosmic rays) is interpreted as a braking of galactic cosmic rays by the closed magnetic field lines at the heliopause.

No doubt few work has already done in the past to study the modulation of cosmic ray intensity during high-speed solar wind streams. But this study doesn't extend earlier to high amplitude anisotropic wave trains. This leads us to study the modulation of galactic cosmic ray intensity during the passage of high amplitude anisotropic wave train events by two different types of solar wind streams originating from two different sources.

It is now well known that there are two types of solar wind streams, one associated with solar flares and the other associated with solar coronal holes occurring in exclusion with each other, i.e., the first occurring abundantly during maximum phase of sunspot activity, whereas the other, coronal holes associated streams, abundantly occurring during declining phase of the solar activity. Such a difference can be associated with the peculiar observations reported here, however, the mechanism is not yet fully understood.

II. DATA AND ANALYSIS

Using the long-term plots of the cosmic ray intensity data as well as the amplitude observed from the cosmic ray pressure corrected hourly neutron monitor data using harmonic analysis the High amplitude

wave train events have been selected on the basis of following criteria:

High amplitude wave train events of continuous days have been selected when the amplitude of diurnal anisotropy remains higher than 0.4% on each day of the event for at least five or more days.

In the selection of these types of events, special care has been taken, i.e. if there occurred any pre-Forbush decreases or post-Forbush decrease before or after the event or if the event is in recovery phase or declining phase are not considered.

On the basis of above selection criteria we have selected thirty-eight high amplitude wave train events during the period 1981-94. The hourly cosmic ray intensity data for Deep River, Goose Bay, Inuvik neutron monitoring station have been investigated in the present study..

III. RESULTS AND DISCUSSION

The occurrence of two types of HSSWS during high amplitude days for the period 1981-94 has been plotted in Fig 1. It is clearly seen from the Fig that number of corotating streams is greater than the number of flare-generated streams and also indicates the tendency for larger duration in corotating streams for HAE.

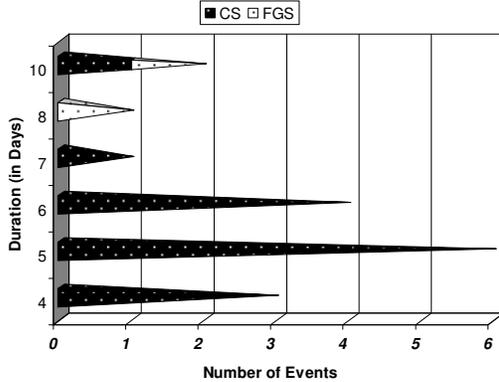


Fig 1: Frequency histogram of high-speed solar wind streams according to the duration of high-speed streams in days: Corotating and Flare-generated for HAE events during 1981-1994.

To study the effect of these streams on high amplitude days, we have adopted the Chree analysis of superposed epoch for days -5 to $+5$ and plotted (not shown here) as a percent deviation of cosmic ray intensity data along with statistical error bars (I) for the period 1981-94 during HAE. Deviation for each event is obtained from the overall average of 11 days. Epoch day (zero day) correspond to the starting days of high-speed solar wind streams. During corotating streams the decrease in cosmic ray intensity

starts from -4 day and reaches to minimum on -1 day i.e. before one day of the onset of HSSWS. It starts increasing from -1 day to $+1$ day and then decreases upto $+5$ day. However during flare-generated streams the intensity significantly increases -4 day and reaches to it's maximum on $+1$ day i.e. after one day of the onset of stream and then decreases up to $+5$ day. Thus we observed that significant deviations are observed in cosmic ray intensity during HAE events for both types of solar wind streams. Shrivastava and Jaiswal [11] and Shrivastava [12] reported almost equal influence of flare generated and coronal hole associated solar wind streams on cosmic ray transient decreases.

Badruddin [13] studied the two classes, coronal hole and solar flare associated streams alongwith the observed heliospheric plasma and field parameters of these streams such as speed, field strength and its variance in a systematic manner in order to see their effects in cosmic ray modulation. He found that flare associated streams are much more effective in modulation than streams from coronal holes. However, the possibility that solar wind structures during two types of streams might be different, the field variance appears to be the most critical parameter responsible for this difference in their effectiveness in modulation.

Sabbah [14] studied the behavior of cosmic rays observed by three stations during a time of high-speed solar-wind events. These stations cover the median rigidity range 16-164 GV. The influence of the interplanetary magnetic field associated with HSSW has also been studied. They reported that both the cosmic-ray intensity and geomagnetic activity are enhanced by coronal-mass-ejection events. They argued that IMF magnitude and fluctuation are responsible for the depression of cosmic-ray intensity during HSSW events and this depression is rigidity depend-ent. Low-energy cosmic rays suffer more intensity depression. The rigidity spectrum of the cos-mic-ray intensity decreases is dependent upon the phase of the solar cycle.

IV. CONCLUSIONS

We observed that: On the onset of both types of streams the cosmic ray intensity reaches to its minimum during high amplitude events and then increases statistically. The two types of solar wind streams (Corotating and Flare generated) produce significant deviations in cosmic ray intensity during high amplitude anisotropic wave train events

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