Research Paper Physics

Forbush Decreases in Relation with Solar and Solar Wind Plasma Parameters During the Period of Decline Phase of Solar Cycle 23rd

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ABSTRACT

Coronal mass ejections(CMEs} are a key aspect of coronal and interplanetary dynamics .They can eject large amounts of mass and magnetic field into the heliosphere ,a key source of interplanetary shocks, disturbances in solar wind plasma parameters and asymmetric cosmic ray intensity decreases (Fds). We have studied decreases (Fds) (magnitude ≥ 7.0%) observed at Oulu super neutron monitor, during the period of decline phase of solar cycle 23rd with coronal mass ejections, interplanetary shocks, X-ray solar flares and disturbances in solar wind plasma temperature and velocity .We have found that all Forbush decreases are associated with halo and partial halo coronal mass ejections (CMEs) and X-Class ,M-Class X-ray solar flares .Positive correlation with correlation coefficient 0.74 have been found between magnitude of Forbush decreases and speed of associated CMEs. All the Forbush decreases (Fds) have also been found to be related with interplanetary shocks and the related shocks are forward shocks. From the further study it is observed that Forbush decreases are strongly related to the disturbances in solar wind plasma temperature and velocity. Positive co-relation with correlation coefficient 0.40 has been found between magnitudes of Forbush decreases and magnitude of jump in solar wind plasma temperature and 0 .36 between magnitude of Forbush decreases and peak value of solar wind plasma temperature. Positive co-relation with correlation coefficient 0.27 has also been found between magnitude of Forbush decreases and magnitude of jump in solar wind plasma velocity and 0.33 between magnitude of Forbush decreases and peak value of solar wind plasma velocity.

Keywords : Coronal Mass Ejections, Solar wind plasma parameters and Asymmetric cosmic ray intensity variations (Fds)

1-Introduction

Forbush decreases are transient depressions in the galactic cosmic ray intensity which are characterized by a sudden onset, reaching a minimum within about a day, followed by a more gradual recovery phase typically lasting several days. These decreases are most likely produced by perturbations in the interplanetary magnetic field and particle flow which propagate away from the Sun [Morrison, 1956; Parker, 1963] and are strongly related to coronal mass ejections and their interplanetary counter parts [Cane et al, 1996; 2000; Badruddin ,1997; 2000; 2002; 2003; Subhrmanayam et al, 2005] .Cane et al have studied 30 years of neutron monitor data and found 86% of cosmic ray decreases to be attributable to coronal mass ejections and interplanetary shocks that they generate .These decreases are generally of lesser magnitude when only the forward shock is present [Cane et al., 1996]. Cane et al (1997) have associated CME ejecta with short-term particle decreases observed by Helios 1 and 2. The observed depth of a Forbush event is found to depend on one's trajectory through the interplanetary coronal mass ejection. They have also found that the depth of a Forbush decrease is dependent on the heliolongitude of the active region which ejected the associated coronal mass ejections. The depth is largest when the associated coronal mass ejection originates near solar meridian and the vast majority of Forbush events are caused by coronal mass ejections originating within 50 degrees of 0 degrees heliolongitude. Robert F. Penna et a l [2005] have investigate the relation between Forbush cosmic ray decrease recovery time and coronal mass ejection transit time between the Sun and Earth.Ifedili S.O [2004] has studied two-step asymmetric cosmic ray intensity decreases (Fds) with coronal mass ejections magnetic clouds, interplanetary shocks and interplanetary disturbances, interplanetary magnetic field (magnitude and direction). Interplanetary coronal mass ejection (ICME) impacting on slow solar wind, there is a sheath upstream of the ICME led by a fast forward shock and the large IMF variations in this sheath, which sustained the Forbush decreases (FDs) in the cosmic ray intensity. P Subhrmanayam et al [2005] have studied asymmetric short term cosmic ray intensity decreases (Fds) with coronal mass ejections and inferred that these decreases (Fds) are associated with front side coronal mass ejections. The The Forbush decreases in cosmic ray intensity have also been studied by several scientists [Badruddin 1997,2000,2002,] and have inferred that the measure cause of these decreases (Fds) are coronal mass ejections and their interplanetary manifestations. Chuchkov et al [2009] have analyzed the modulation structures of quasi-symmetric ("bays") short-term Forbush decreases. It is concluded that these Forbush decreases were recorded due to the stations flying through coronal mass-ejection regions.

2-Data Reduction and Analysis

In this investigation Forbush decreases observed at Oulu neutron monitor for decline phase of solar cycle 23rd have been analyzed with coronal mass ejections and their interplanetary counterparts such as, solar flares, ,interplanetary shocks,disturbanceces in solar wind parameters. For this work the data of different types of coronal mass ejections have been taken from SOHO – large angle spectrometric, coronagraph (SOHO / LASCO) and extreme ultraviolet imaging telescope (SOHO/EIT) data. The data of interplanetary shocks are taken from shocks arrival derived by WIND group from WIND observations, ACE list of transient and disturbances. To determine disturbances in solar wind plasma parameters and geomagnetic field, hourly data of solar wind plasma velocity temperature has been used and these data has been taken from omni web data (http;//omniweb.gsfc.nasa.gov/form/dxi.html). The data of X ray solar flares data,

solar geophysical data report U.S. Department of commerce, NOAA monthly issue and solar STP data (http://www.ngdc.noaa.gov/stp/solar/solardataservices.html.) have been used.

3-Data Analysis and Results

The total number of Forbush decreases (Fds) magnitude ≥7.0% observed during the period of decline phase of solar cycle 23rd are found 11.Out of these observed Forbush decreases (Fds) all are found to be associated with coronal mass ejection (CMEs).The association rates of halo and partial halo coronal mass ejections have been found 91% and 9% respectively.. For further analysis we have plotted scatter diagram between magnitude of Forbush decreases and speed of associated CMEs .The resulting diagram is shown in Fig 1 and Figure shows positive correlation between these two events .Statistically calculated co-relation co-efficient 0.74 have been found between magnitude of Forbush decreases (Fds) and speed of associated coronal mass ejections.

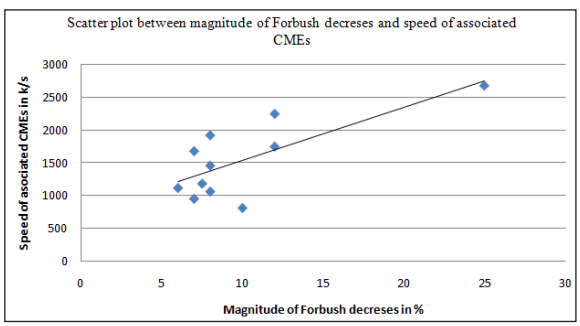

Fig-1 Scatter plot between magnitude of Forbush decreases and speed of associated CMEs showing positive correlation with correlation coefficient 0.74.

Forbush decreases with X-ray solar flares and interplanetary shocks

From the data analysis of Forbush decreases, X-ray solar flares and interplanetary shocks, it is observed that all the Forbush decreases are associated with X-Class and M-Class solar flares. The association rates of X-class and M-class solar flares have been found 45.45% and 54.54% respectively. All the Forbush decreases have also been found to be associated with interplanetary shocks and related shocks are forward shocks. The occurrences of Forbush decreases have been found in ± time lag between onset time of Forbush decreases and arrival time of interplanetary shocks. The occurrences of majority of the Forbush decreases (54.54%) have been found before the arrival of interplanetary shocks where as occurrences of minority of the Forbush decreases (45.45%) have been found after the arrival of interplanetary shocks.

Forbush decreases and solar wind plasma temperature

We have associated different phase and characteristics of Forbush decreases (Fds) with jump in solar wind plasma temperature. From the data analysis of these two events, we have found that all the Forbush decreases (Fds) are closely related to disturbances in solar wind plasma temperature and all the Forbush decreases are found to be associated with jump in solar wind plasma temperature (JSWT) events. To sees how the magnitude of Forbush decreases (Fds) are correlated with JSWT events. We have plotted a scatter diagram between the magnitude of Forbush decreases (Fds) and magnitude of jump in solar wind plasma temperature (JSWT) events in Fig.2 .From the Fig it is clear that, most of Forbush decreases (Fds) which have large magnitude are associated with such JSWT events which have relatively large magnitude, but the magnitude of these two events do not have any fixed proportion. We have found some Forbush decreases (Fds) which have large magnitude but they are associated with such JSWT events which have relatively small magnitude. Positive co-relation has been found between magnitudes of Forbush decreases (Fds) and magnitude of Jump in temperature of associated JSWT events. Statistically calculated co-relation co-efficient is .40 between these two events.

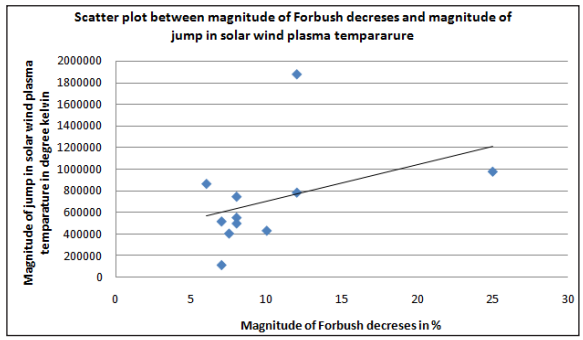

Fig-2-Scatter plot between magnitude of Forbush decreases and magnitude of jump in solar wind plasma temperature showing positive correlation with correlation coefficient 0.40.

To see how the magnitude of Forbush decreases (Fds) is correlated with maximum jump value of JSWT events. We have plotted a scatter diagram between the magnitude of Forbush decreases (Fds) and maximum jump in JSWT events in Fig.3. From the Fig it is clear that, most of the Forbush decreases (Fds) which have large magnitude are associated with such JSWT events which have relatively higher maximum jump values, but these two events do not have any fixed proportion, we have found some Forbush decreases (Fds) which have large magnitude but they are associated with such JSWT events which have lower jump values . Positive co-relation has been found between magnitudes of Forbush decreases (Fds) and maximum jump values of associated SWT events . Statistically calculated co-relation co-efficient is .36 between these two events.

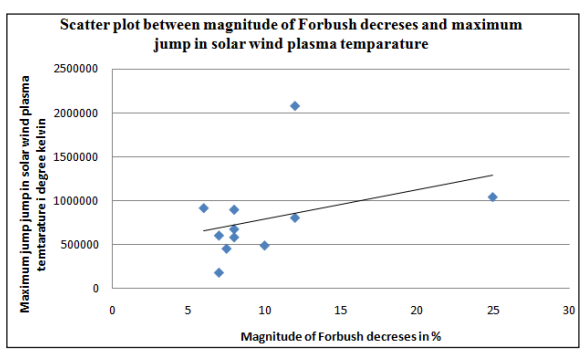

Fig 3-Scatter plot between magnitude of Forbush decreases and maximum jump in solar wind plasma temperature showing positive correlation with correlation coefficient 0.36.

Forbush decreases and disturbances in solar wind plasma velocity

From the data analysis of Forbush decreases and disturbances in solar wind plasma velocity it is observed that all the Forbush decreases are associated with jump in solar wind plasma velocity. To see how the magnitude of Forbush decreases (Fds) are correlated with the magnitude of associated JSWV events, we have plotted a scatter diagram between the magnitude of Forbush decreases (Fds) and magnitude of associated JSWV events in Fig.4. From the Figure it is clear that maximum Forbush decreases (Fds) which have large magnitude are associated with such JSWV events which have relatively large magnitude but magnitude of these two events do not have any quantitative relation. We have found some Forbush decreases (Fds) which have large magnitude but they are associated with such JSWV events which have small magnitude .Positive co-relation has been found between magnitude of Forbush decreases (Fds) and magnitude of associated JSWV events. Statistically calculated co-rela-

tion co-efficient is 0. 27 between these two events.

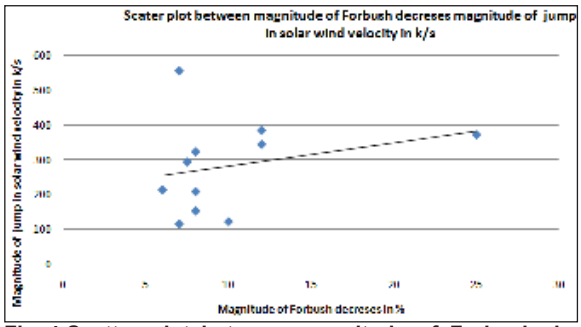

Fig 4-Scatter plot between magnitude of Forbush decreases and magnitude of jump in solar wind plasma velocity showing positive correlation with correlation coefficient 0.27.

To see how the magnitude of Forbush decreases (Fds) is correlated with maximum jump value of associated JSWV events. We have plotted a scatter diagram between the magnitude of Forbush decreases (Fds) and maximum jump in JSWV events in Fig.5. From the Fig It is clear that, most of the Forbush decreases (Fds) which have large magnitude are associated with such JSWV events which have relatively higher maximum jump values, but these two events do not have any fixed proportion, we have found some Forbush decreases (Fds) which have large magnitude but they are associated with such JSWV events which have lower jump values. Positive co-relation has been found between magnitudes of Forbush decreases (Fds) maximum jump values of JSWV events. Statistically calculated co-relation co-efficient is 0 .33 between these two events.

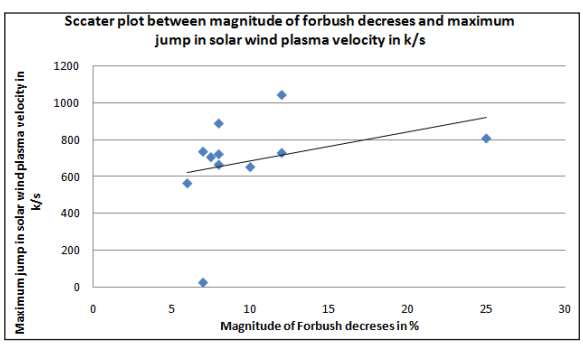

Fig-5 Scatter plot between magnitude of Forbush decreases and maximum value of jump in solar wind plasma velocity showing positive correlation with correlation coefficient 0.33.

IV. Conclusion

From our study all the Forbush decreases have been found to be associated with halo and partial halo coronal mass ejections. Positive co-relation with co-relation co-efficient .46 have been found between magnitude of asymmetric cosmic ray intensity decreases (Fds) and speed of associated coronal mass ejections. All the Forbush decreases have been found to be associated with X-class and M-class X-ray solar flares. The association rates of X-class and M-class solar flares have been found 45.45% and 54.54% respectively. All the Forbush decreases have been found associated with interplanetary shocks. All the Forbush decreases have been found to be associated with disturbances in solar wind plasma temperature and velocity. Positive correlation with correlation coefficient 0.40 have been found between magnitude of Forbush decreases and magnitude of jump in solar wind plasma temperature and 0.36 between magnitude of Forbush decreases and maximum jump value of solar wind plasma temperature. Positive correlation with correlation coefficient 0.27have was found between magnitude of Forbush decreases and magnitude of jump in solar wind plasma velocity and 0.33 between magnitude of Forbush decreases and maximum jump value of solar wind plasma velocity. From the above it is concluded that Forbush decreases are caused by coronal mass ejections and their interplanetary manifestations .It is also concluded that disturbances in solar wind temperature and velocity are closely related to Forbush decreases.

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