Coronal Mass Ejections and Disturbances in Solar Wind Plasma Parameters in Relation With Short Term Asymmetric Cosmic Ray Intensity Decreases

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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 asymmetric cosmic ray intensity decreases (Fds) (magnitude≥ 3.0%)observed at Oulu super neutron monitor, during the period of 1986-2006 with coronal mass ejections, interplanetary shocks and disturbances in solar wind plasma parameters (solar wind temperature, velocity, density). We have found that 88.46% are associated with halo and partial halo coronal mass ejections (CMEs). The association rate between halo and partial halo coronal mass ejections are found 89.13% and 10.87% respectively. Most of the asymmetric cosmic ray intensity decreases (Fds) are related to interplanetary shocks (76.00%) and the related shocks are forward shocks. We have also found positive co-relation with co-relation co-efficient .46 between magnitude of asymmetric cosmic ray intensity decreases (Fds) and speed of associated coronal mass ejections. From the further study it is concluded that asymmetric cosmic ray variations are strongly related to the disturbances in solar wind plasma parameters. Positive co-relation has been found between magnitudes of asymmetric cosmic ray intensity decreases (Fds) and magnitude of jump in temperature of associated JSWT events with co-relation co-efficient is .25 between these two events. Positive co-relation has also been found between magnitude of asymmetric cosmic ray intensity decreases (Fds) and maximum velocity associated JSWV events with co-relation co-efficient .37 between these two events.

1. Introduction

The galactic cosmic ray intensity remains constant in time and space outside the heliosphere, within the heliosphere, due to various dynamical processes occurring on the sun and extending into interplanetary space, the long term and short term variation in cosmic ray intensity takes place. There are mainly two specific types of cosmic ray intensity depressions, namely corotating and asymmetric short term (Fds) decreases [7, 10, 13,] Forbush decreases, characterized by a fast decrease within ~1 day followed by a more gradual nearly exponential recovery over a few days, have been observed continuously with neutron monitors since the 1950's. Recurrent modulations of galactic cosmic rays, characterized by a slow decrease and a gradual recovery within a period of ~27 days, comparatively, are less impressive changes in cosmic ray intensity.

It has now been proved by the recent studies that short term cosmic ray variations are strongly related to the coronal mass ejections. Cane H.V.[7]have studied cosmic ray intensity variations with coronal mass ejections and concluded that CMEs are large-scale phenomena that change the configuration of the interplanetary magnetic field (IMF) and clearly modulate the cosmic-ray intensity on short-term (few day) timescales .Forbush decreases which falls under the category of asymmetric short term cosmic ray variations are strongly associated with coronal mass ejections and the interplanetary shocks, Badruddin [4] has reported that abrupt onset of decrease in intensity starts upon the arrival of certain shocks and decreases continue till the passage of post shock turbulent sheath. He has further determined that turbulent shocks are much more effective in producing Asymmetric cosmic ray intensity deceases (Fds) than non-turbulent shocks. Cane et al [5,6] have inferred that the short-term cosmic ray decreases are strongly associated with ejecta and shocks. They have reported that 88% short term cosmic ray decreases are associated with ejecta and 70% of these are associated with shocks. Robert F. Penna et a l [11] have investigate the relation between Forbush cosmic ray decrease recovery time and coronal mass ejection transit time between the Sun and EarthIfedili S.O [9] 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 [12] have studied asymmetric short term cosmic ray intensity decreases (Fds) with coronal mass ejections and inferred that theses decreases (Fds) are associated with front side coronal mass ejections.

E. A. Chuchkov et al [8] 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. The short term variation of cosmic ray intensity recorded with ground based monitors have been studied by several scientists [1,2,3,9] and have inferred that the measure cause of asymmetric cosmic ray decreases (Fds) are coronal mass ejections and their interplanetary manifestations.

2. Experimental data

In this work hourly data of oulu super neutron monitor are used to determine asymmetric cosmic ray intensity decreases in cosmic ray intensity .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, hourly data of solar wind plasma velocity density temperature has been used and these data has also been taken from omni web data also.

Table -1 Association of Asymmetric Cosmic Ray intensity Decreases with Coronal Mass Ejections and Disturbances in Solar Wind Plasma Parameters

Asymmetric cosmic ray intensity decreases (Fds)				Temperature		Velocity		CMEs		
date	Onset set timedd (hh)	mag%	shocks	Start time dd(hh)	Magnitude of Jump in Deg k	Start time dd(hh)	Magnitude of Jumpkm /s	Date time dd(hh)	Type H/ P	SpeedK/s
06.02.86	06(12)	12	06(13)	06(03)	138008	06(04)	84	nd	nd	nd
04.11.86	04(00)	5.5	03(24)	nd	nd	nd	nd	nd	nd	nd
10.04.87	10(12)	5	na	nj	nj	nj	nj	nd	nd	nd
25.08.88	25(06)	6	25(10)	nd	nd	nj	nj	nd	nd	nd
10.10.88	10(00)	5	10(03)	09(02)	521861	09(01)	58	nd	nd	nd
04.01.89	04(18)	5	4(23)	04(14)	18666	04(11)	32	nd	nd	nd
13.02.89	13(00)	4	na	nj	nj	nd	nd	nd	nn	nd
16.02.89	16(08)	3.5	na	nd	nd	nd	nd	nd	nd	nd
13.03.89	18(00)	15	13(01)	nd	nd	nd	nd	nd	nd	nd
27.03.89	27(00)	6	27(14)	nd	nd	nd	nd	nd	nd	nd
01.07.89	01(06)	3	01(07)	nd	nd	nd	nd	nd	nd	nd
08.11.89	08(13)	6.5	08(11)	nd	nd	nj	nj	nd	nd	nd
28.11.89	28(06)	14	27(22)	27(20)	401301	27(19)	195	nd	nd	nd
30.03.90	30(06)	8	30(07)	30(00)	13004	nj	nj	nd	nd	nd
08.04.90	08(13)	10.5	09(09)	nd	nd	nd	nd	nd	nd	nd
27.07.90	27(10)	5	28(01)	nd	nd	nd	nd	nd	nd	nd
01.08.90	01(13)	4.5	01(08)	01(07)	526211	01(06)	169	nd	nd	nd
09.10.90	09(13)	4	09(13)	08(19)	58997	08(21)	114	nd	nd	nd
02.01.91	02(16)	3	na	nd	nd	nd	nd	dn	nd	nd
24.01.91	24(12)	4	23(21)	23(09)	31788	nj	nj	nd	nd	nd
24.03.91	24(02)	16	24(02)	nd	nd	nd	nd	nd	nd	nd
24.04.91	24(20)	8.5	24(21)	24(17)	326958	24(17)	158	nd	nd	nd
23.05.91	23(18)	6	22(00)	23(13)	154262	23(06)	116	nd	nd	nd
12.06.91	12(12)	18	12(10)	11(19)	140534	11(12)	32	nd	nd	nd
08.07.91	08(12)	9	08(17)	08(01)	156329	07(15)	37	nd	nd	nd
12.07.91	12(09)	7	12(09)	12(03)	513598	12(02)	112	nd	nd	nd
18.08.91	18(20)	9.5	18(19)	18(10)	524912	18(11)	204	nd	nd	nd
27.08.91	27(13)	4.5	27(15)	27(13)	319599	27(13)	129	nd	nd	nd
10.09.91	10(16)	3.5	na	10(10)	226419	10(11)	85	nd	nd	nd
28.10.91	28(08)	17	28(11)	28(05)	1176686	10(06)	347	nd	nd	nd
08.11.91	8(04)	8	08(13)	nd		nd	nd	nd	nd	nd
03.02.92	03(02)	3	na	nd	nd	nd	nd	nd	nd	nd
07.02.92	07(12)	5.5	na	06(22)	27029	07(00)	38	nd	nd	nd
26.02.92	26(18)	8	26(17)	nd	nd	nd	nd	nd	nd	nd
01.03.92	01(06)	4	na	nd		nd		nd	nd	nd
17.03.92	17(10)	5	17(10)	nj	nj	17(07)	201	nd	nd	nd
09.05.92	09(13)	8.5	09(20)	08(19)	264466	nj	nj	nd	nd	nd
10.06.92	10(06)	4	10(04)	09(11)	171411	09(08)	88	nd	nd	nd
20.08.92	20(10)	8	19(22)	19(12)	21895	nj	nj	nd	nd	nd
08.09.92	08(10)	7	09(02)	08(22)	67832	09(00)	163	nd	nd	nd
08.10.92	08(06)	5	08(19)	nd	nd	nd	nd	nd	nd	nd
03.11.92	3(12)	4	na	02(17)	291417	nj	nj	nd	nd	nd
09.11.92	09(13)	4	na	09(04)	41619	09(04)	38	nd	nd	nd
02.01.93	02(03)	3.5	na	nd	nd	nd	nd	nd	nd	nd

20.02.93	20(08)	6.5	20(00)	nj		20(00)	163	nd	nd	nd
09.03.93	09(00)	4.5	08(22)	08(18)	995651	08(20)	263	nd	nd	nd
23.03.93	23(06)	4.5	23(22)	nd	nd	nd	nd	nd	nd	nd
01.07.93	01(03)	3.5	na	nd	nd	nd	nd	nd	nd	nd
16.08.93	16(12)	3	15(16)	15(13)	64951	15(13)	45	nd	nd	nd
22.10.93	22(18)		22(12)	nd	nd	nd	nd	nd	nd	nd
03.11.93	03(06)	3	03(17)	nd	nd	nd	nd	nd	nd	nd
18.11.93	18(06)	3.5	18(12)	nd	nd	nd	nd	nd	nd	nd
07.12.93	07(10)	4	07(12)	nd	nd	nd	nd	nd	nd	nd
05.02.94	05(19)	6	06(09)	nd	nd	nd	nd	nd	nd	nd
21.02.94	21(09)	6.5	21(09)	21(07)	2012229	21(08)	414	nd	nd	nd
16.04.94	16(16)	5	na	nd	nd	nd	nd	nd	nd	nd
24.04.94	24(10)	2	na	23(12)	73812	nj	nj	nd	nd	nd
19.06.94	19(10)	3	na	nd	nd	nd	nd	nd	nd	nd
14.07.94	14(10)	3.5	na	nd	nd	nd	nd	nd	nd	nd
22.03.95	22(03)	3.5	na	nj	nj	nj	nj	nd	nd	nd
10.04.97	10(18)	5	na	09(20)	23450	nj	nj	07(14)	H	905
01.05.98	01(20)	6	01(22)	01(19)	326112	01(10)	255	29(16)	H	1602
04.07.98	04(16)	3	na	03(17)	256121	nj	nj	nd	nd	nd
25.08.98	25(12)	8	26(07)	25(00)	86675	25(10)	77	nd	nd	nd
24.09.98	24(12)	10	24(24)	23(17)	209323	23(17)	152	nd	nd	nd
08.11.98	08(04)	7	08(05)	07(00)	250723	07(07)	42	05(21)		1118
22.01.99	22(20)	7	na	22(03)	522927	22(12)	211	nd	nd	nd
12.12.99	12(16)	8	12(16)	12(15)	660214	12(15)	332	na	na	na
11.01.00	11(12)	6	11(14)	11(12)	285691	11(12)	193	na	na	na
07.04.00	07(00)	3	na	06(15)	325941	06(15)	221	04(17)	H	1199
08.06.00	08(08)	8	08(09)	08(03)	781686	08(08)	253	06(16)	H	1130
15.07.00	15(12)	12	15(15)	14(07)	583648	14(12)	209	14(11)	H	1674
14.09.00	14(20)	3	15(05)	15(14)	92477	15(01)	90	12(12)	H	1839
17.09.00	17(12)	8	na	17(13)	803820	17(15)	298	15(22)	H	537
28.10.00	28(00)	7	28(10)	nj	nj	nj	nj	25(08)	H	948
06.11.00	06(16)	7	06(10)	06(09)	382785	06(07)	41	03(18)	H	643
26.11.00	26(12)	8	26(08)	26(08)	552597	26(03)	252	24(05)	H	1298
03.03.01	3(18)	3	03(11)	03(10)	152228	03(10)	69	01(18.2 6)	P	947
19.03.01	19(03)	4	19(11)	18(04)	58806	19(08)	169	18(02.2 6)	H	785
26.03.01	26(06)	6	na	nj	nj	nj	nj	24(21)	H	1185
04.04.01	04(16)	8	04(15)	04(12)	1044352	04(14)	282	01(11)	H	1683
07.04.01	07(12)	6	08(11)	06(12)	42862	nj	nj	05(17)	H	1390
11.04.01	11(16)	8.5	11(14)	11(10)	729729	11(12)	233	09(16)	H	1198
28.04.01	28(04)	6	28(05)	27(19)	787156	27(22)	297	26(12)	H	1171
27.05.01	27(12)	4	27(15)	26(13)	531253	26(18)	194	25(17)	P	962
17.08.01	17(16)	7	17(11)	17(08)	299070	17(09)	264	15(24)	H	1575
27.08.01	27(18)	7	27(20)	27(07)	160985	27(07)	34	25(17)	H	1433
25.09.01	25(20)	8	25(20)	25(20)	974243	25(20)	274	23(20)	H	478
11.10.01	11(16)	6	11(17)	11(14)	544030	11(16)	198	09(11)	H	973
21.10.01	21(16)	5	21(17)	21(15)	422395	21(10)	360	19(170	H	901
06.11.01	06(00)	12	06(02)	5(10)	105551	05(14)	141	04(17)	H	1810
24.11.01	24(12)	10	24(06)	24(03)	2292789	24(03)	504	22(20)	H	1443
15.12.01	15(00)	5	na	14(18)	105398	14(19)	69	13(15)	H	864
30.12.01	30(16)	5.5	30(20)	30(02)	61712	nj	nj	28(20)	H	2239
10.01.02	10(16)	4.5	na	10(04)	396719	10(01)	289	08(18)	H	2210
23.05.02	23(12)	5	23(11)	23(03)	1887414	23(03)	468	21(22)	P	900

10.11.02	10(02)	7	9(18)	09(15)	68657	01(15)	50	09(13.31)	H	1838
17.11.02	17(00)	8	na	16(23)	82834	16(23)	52	16(07)	H	1250
22.12.02	22(12)	4	22(13)	22(16)	231230	22(10)	59	19(22.06)	H	1318
01.02.03	01(16)	5	na	01(13)	612954	01(06)	393	30(10)	P	869
29.05.03	29(16)	7	29(12)	29(14)	489103	29(14)	103	27(24)	H	964
29.10.03	29(00)	25	29(06)	28(08)	979536	nj	nj	28(11)	H	2686
07.01.04	07(00)	8	06(20)	06(18)	555367	06(18)	155	06(06)	P	1469
21.01.04	21(16)	8	22(01)	21(12)	509255	21(16)	163	20(00)	H	1074
26.07.04	26(16)	10	26(23)	26(15)	1532645	26(15)	417	23(16)	H	824
07.11.04	07(08)	12	07(03)	07(10)	786124	07(09)	386	07(17)	H	1759
08.05.05	08(06)	6	07(19)	07(18)	866682	07(17)	215	06(17)	H	1128
15.05.05	15(00)	7	15(02)	14(18)	117968	14(20)	557	13(17)	H	1689
28.05.05	28(20)	10	28(04)	28(07)	187910	28(04)	188	26(15)	H	586
23.08.05	23(20)	7	24(06)	23(19)	2718176	24(00)	308	22(01)	H	1194
11.09.05	11(00)	12	11(01)	11(00)	1876759	10(20)	346	09(20)	H	2257
14.12.06	14(18)	10	14(14)	13(12)	240834	13(06)	312	13(02.54)	H	1931

3. Data Analysis and Results

The number of asymmetric cosmic ray intensity decreases (Fds), associated coronal mass ejections and disturbances in solar wind plasma parameters observed during the period of period of 22nd and 23rd solar cycle are listed in table. The total number of asymmetric cosmic ray intensity decreases (Fds are 112.From the data analysis of asymmetric cosmic ray intensity decreases(Fds) and coronal mass ejections it is observed that out of 112 asymmetric cosmic ray intensity decreases (Fds) we have no data of CMEs for 47 asymmetric cosmic ray intensity decreases (Fds) for association. We have CMEs data for 52 asymmetric cosmic ray intensity decreases (Fds) in which 46 (88.46%) are found to be associated with coronal mass ejection (CMEs). From the further analysis these CMEs associated asymmetric cosmic ray intensity decreases (Fds) 05 (10.87%) are found to be associated with partial halo CMEs and 41 (89.13%) are found to be associated with full halo coronal mass ejections. To know the relationship between magnitude of asymmetric cosmic ray intensity.

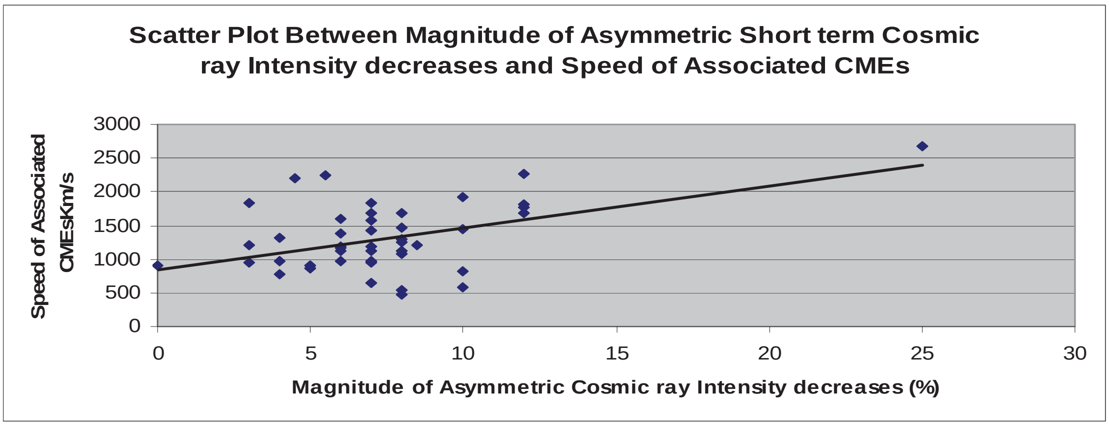

Figure 1 Shows scatter plot between magnitude of asymmetric cosmic ray intensity decreases and speed of associated CMEs showing positive correlation with correlation coefficient 0.46

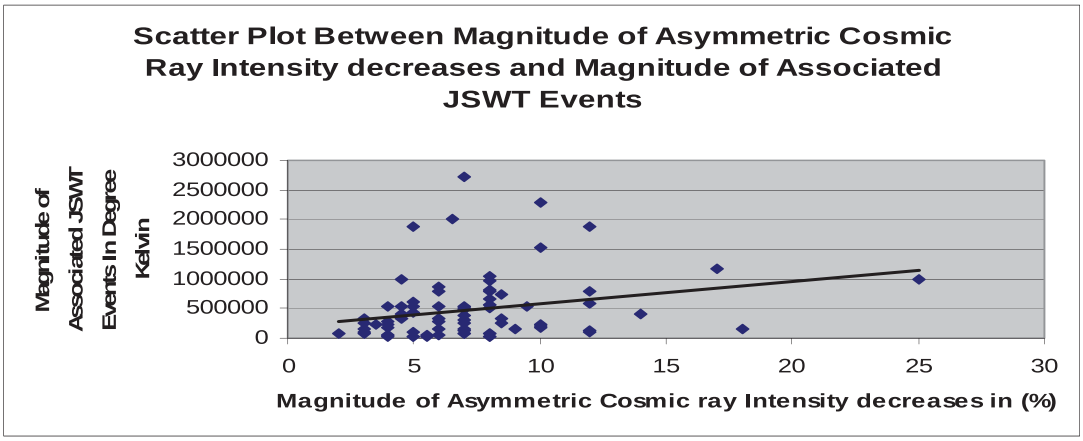

Figure 2 Shows Scatter plot between magnitude of geomagnetic storms and magnitude of Jump in solar wind plasma temperature (JSWT) showing positive correlation with correlation coefficient 0.25

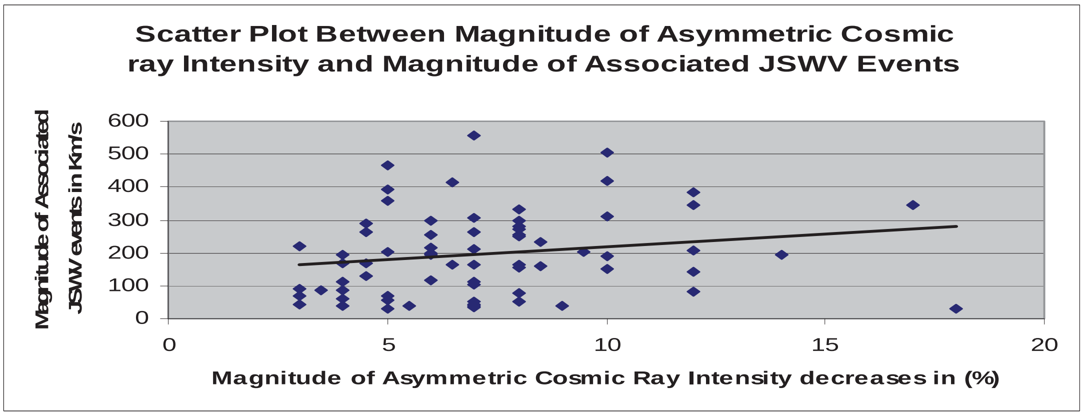

Figure 3 Shows Scatter plot between magnitudes of geomagnetic storms and magnitude of Jump in solar wind plasma velocity (JSWV) showing positive correlation with correlation coefficient 0.37

decreases and speed of associated CMEs we have plotted scatter diagram between magnitude of asymmetric cosmic ray intensity 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 .46 have bee found between magnitude of asymmetric cosmic ray intensity decreases (Fds) and speed of associated coronal mass ejections.

From the data analysis of asymmetric short term cosmic ray decreases (Fds)and jump in solar wind plasma temperature we have found that the most majority of Asymmetric (Fds) short term cosmic ray decreases are found to be associated with JSWT events. We have 112 Asymmetric (Fds) short term cosmic ray decreases data for which is available for association with JSWT events are 85 .Out of these 85 events, 78 asymmetric (Fds) short term cosmic ray decreases are (91.76%) found to be associated with jump in solar wind plasma temperature.

To sees how the magnitude of asymmetric cosmic ray intensity decreases (Fds) is correlated with JSWT events. We have plotted a scatter diagram between the magnitude of asymmetric cosmic ray intensity decreases (Fds) and magnitude JSWT events in fig.2 It is clear from the fig that most of the asymmetric cosmic ray intensity decreases (Fds) which have large magnitude are associated with such JSWT events which have large magnitude, but the magnitude of these two events do not have any fixed proportion, we have found some asymmetric cosmic ray intensity decreases (Fds) which have large magnitude but they are associated with such JSWT events which have small magnitude. Positive co-relation has been found between magnitudes of asymmetric cosmic ray intensity decreases (Fds) and magnitude of jump in temperature of associated JSWT events. Statistically calculated co-relation co-efficient is .25 between these two events.

The asymmetric cosmic ray intensity decreases are also associated with jump in Solar wind plasma velocity (JSWV). From the analysis we have112 asymmetric cosmic ray intensity decrease (Fds) but data of JSWV events for association are available for 86 asymmetric cosmic ray intensity decrease (Fds). From the data analysis we have obtained that asymmetric cosmic ray intensity decrease (Fds) are closely associated with JSWV events. .Out of these, 86, 69 (80.23%) asymmetric cosmic ray intensity decrease (Fds) are associated with JSWV events.

To see how the magnitude of asymmetric cosmic ray intensity decreases (Fds) are correlated with the magnitude of JSWV events, we have plotted a scatter diagram between the magnitude of asymmetric cosmic ray intensity decreases (Fds) and JSWV events in fig.3 From the figure it is clear that maximum asymmetric cosmic ray intensity 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 their amplitude do not have any fixed proportion. We have found some asymmetric cosmic ray intensity 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 asymmetric cosmic ray intensity decreases (Fds) and magnitude of associated JSWV events. Statistically calculated co-relation co-efficient is. 37 between these two events.

4. Conclusion

From our study 46 out of 52 asymmetric cosmic ray intensity decreases (Fds) (88.46%) are found to be associated with coronal mass ejection (CMEs). The association rates of halo and partial halo coronal mass ejections have been found 89.13% and 10.87 % respectively. Positive co-relation with co-relation co-efficient .46 have bee found between magnitude of asymmetric cosmic ray intensity decreases (Fds) and speed of associated coronal mass ejections. Most of the asymmetric cosmic ray intensity decreases have been found associated with interplanetary shocks. Positive correlation have also been found between magnitude of asymmetric cosmic ray intensity decreases and associated jump in solar wind temperature and solar wind velocity .From theses results it is concluded that majority of the asymmetric cosmic ray intensity decreases(Fds) are caused by halo coronal mass ejections and interplanetary shocks, disturbances in solar wind plasma parameters that they generate .

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