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GEOMAGNETIC STORMS ASSOCIATED WITH IV-RADIO BURSTS AND THEIR RELATION WITH SOLAR AND INTERPLANETARY PARAMETERS

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ABSTRACT

I have studied geomagnetic storms (Dst ≤-75nT), associated with Type IV radio bursts, observed during the period 1997 to 2007 with solar and interplanetary parameters. We have observed 33 geomagnetic storms associated with type IV radio bursts, out of which most of the geomagnetic storms (85.00%) are intense or sever geomagnetic storms. All the geomagnetic storms are found to be associated with halo and partial halo coronal mass ejections (CMEs).The association rates of halo and partial halo CMEs are 27 (81.82%) and 06 (18.18%) respectively .All the type IV radio bursts associated geomagnetic storms are found to be associated with X-ray solar flares of different categories .The association rates of geomagnetic storms with different types of flare related CMEs are found 08 (24.24)% X class flare related CMEs,15 (45.46%) M class flare related CMEs ,08 (24.24)% C class flare related CMEs and 02(6.06)% B class flare related CMEs. Some of the type IV radio bursts associated geomagnetic storms are found to be associated with magnetic clouds 13 (39.39 %).Majority of the geomagnetic storms are found to be related with interplanetary shocks 31 (93.94) .We have inferred that geomagnetic storms are closely related to interplanetary magnetic fields. We have determined positive co-relation with correlation coefficient 0.70 between magnitude of geomagnetic storms and maximum value of IMF and 0.77 between magnitude of geomagnetic storms and magnitude of maximum value of southward component of interplanetary magnetic fields (IMF Bz).

Keywords –Coronal mass ejections, X-ray solar flares, radio bursts, solar wind plasma parameters and geomagnetic storms.

INTRODUCTION

The solar disc exhibits a variety of drastic solar features, many of which have a direct influence on interplanetary space and earth's magnetosphere. Coronal mass ejections associated with solar flares, filaments, and type II and type IV radio burst are the most energetic solar features which derive solar wind disturbances and these disturbances cause geomagnetic disturbances at the earth. The recurrent storm activity is due to coronal holes that cause fast solar wind streams [1].Geomagnetic storms which are characterized by a prolonged period in which the horizontal component of geomagnetic field is depressed in the mid to low latitudes in the range of several tens to several hundred nT with such periods lasting from one-half to several days and are classified as recurrent (periodic) and non recurrent (sporadic). Recurrent geomagnetic storms occur most frequently in the declining phase of the solar cycle when equatoward extensions of the polar coronal holes are prominent [2, 3]. The non recurrent (sporadic) geomagnetic storms are caused by interplanetary disturbances driven by fast coronal mass ejections (CMEs) and typically involve an encounter with both interplanetary shock wave and the CME that drive it. Since the CME rate tracks the sun spot cycle [4], the non recurrent geomagnetic storms occur most frequently near solar maximum.Landi and Moreno et al (5) have investigated the role of the coronal mass ejections in producing non recurrent geomagnetic storms in period 1969-1974. They have concluded that coronal mass ejections associated with chromospheric flares, accompanied by type IV radio emission, are the most effective in perturbing the geomagnetic field. Webb et al (6) have studied geomagnetic storms with halo coronal mass ejections and concluded that halo coronal mass ejections are very much effective in producing geomagnetic storms.Yurchyshyn [7] have analyzed data for major geomagnetic storms and found a relationship between hourly averaged magnitude of the Bz component of IMF and projected speed of CMEs launched from the central part of the solar disk. They have concluded that CMEs with V> 1000 Km/s are capable of furnishing. Lepping (8) has studied geomagnetic storms with southward directed magnetic field; they have determined that intense geomagnetic storms are caused by intense southward directed magnetic field. They have found high co-relation between Bz and Dst index. Zhag et al [9] have studied major geomagnetic storms for the period 1996-2000 with coronal mass ejections and concluded that 59% major geomagnetic storms are associated with front side halo (FSH) CMEs and 22% are associated with multiple FSH CMEs. The events which are associated with multiple FSH CMEs show complex solar wind flows and complex geomagnetic storms which are probably the result of halo CMEs interacting in interplanetary space. 15% events are found to be associated with partial halo gradual CMEs emerging from the east limb. Michalek, and Gopalswamy et al [10] have studied geomagnetic storms with properties of halo coronal mass ejections (H-CMEs) and concluded that only fast halo CMEs (with space velocity higher than 1000 km/s) an originating from the western hemisphere close to the solar centre could cause intense geomagnetic storms. Gopalswamy et al [11] have studied geoeffectiveness, speed, solar source, and flare association of a set of 378 halo coronal mass ejections (CMEs) of solar cycle 23 (1996-2005). They have compiled the minimum Dst values occurring within 1 - 5 days after the CME onset. They have compared the distribution of such Dst values for the subset of halo CMEs as disk halos, limb halos, and back side halos CMEs. Defining that a halo CME is geoeffective if it is followed Dst $\leq$ -50 nT, moderately geoeffective if -50nT < Dst < -100nT, and strongly geoeffective if Dst $\leq$ -100nT, they have found that the disk halos are followed by strong geomagnetic storms, limb halos are followed by moderate storms, and back side halos are not followed by significant storms.

Experimental Data

In this investigation hourly Dst indices of geomagnetic field have been used over the period 2003 through 2007 to determine onset time, maximum depression time, magnitude of geomagnetic storms. This data has been taken from the NSSDC omni web data system which been created in late 1994 for enhanced access to the near earth solar wind, magnetic field and plasma data of omni data set, which consists of one hour resolution near earth, solar wind magnetic field and plasma data, energetic proton fluxes and geomagnetic and solar activity indices. The data of coronal mass ejections (CMEs) have been taken from SOHO – large angle spectrometric, coronagraph (SOHO / LASCO) and extreme ultraviolet imaging telescope (SOHO/EIT) data. To determine disturbances in interplanetary magnetic fields, hourly data of interplanetary magnetic field has been used and these data has also been taken from omni web data (http;//omniweb.gsfc.nasa.gov/form/dxi.html)).

The data of X ray solar flares radio bursts, prominences and other solar 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. The data of interplanetary shocks has taken from shocks arrival derived by WIND group from WIND observations, ACE list of transient and disturbances.

Table-1-Association of Geomagnetic Storms with IV-Radio Bursts with Coronal Mass Ejections, X -Ray Solar Flares and Magnetic Clouds for the Period of 1997-2007

Geomagnetic Storms				CMES		S0lar Flares		Radio burts		Magnetic Clouds	
S. NO.	Date	Onset time in dd(hh)	Magnitude in nT	Start time in dd(hh)	types H/P	Start time in dd(hh)	Class	Start time in dd(hh)	Type	Start time in dd(hh)	Quality
1	22.11.97	22(10)	-106	19(12.27)	H	19(14)	C-16	19(20.17)	IV	22(15)	3
2	07.11.98	07(11)	-139	05(02.02)	H	05(03)	C-54	05(20.15)	IV	na	na
3	08.11.98	08(20)	-126	05(20.24)	H	05(19)	M-84	05(20.15)	IV	08(23)	1
4	24.05.00	24(00)	-151	22(01.50)	H	22(01)	C-63	22(01.28)	IV	na	na
5	08.06.00	08(15)	-89	06(15.54)	H	06(15)	X-23	06(14.49)	IV	na	na
6	17.09.00	17(20)	-197	16(05.18)	H	16(04)	M-59	16(04.33)	IV	18(02)	3
7	10.11.00	10(07)	-102	08(04.50)	H	08(06)	C-52	08(22.51)	IV	na	na
8	27.03.01	27(21)	-86	24(20.50)	H	24(20)	M-17	24(20.20)	IV	na	na
9	31.03.01	31(04)	-379	28(01.27)	H	28(02)	M-17	28(11.13)	IV	na	na
10	11.04.01	11(15)	-269	09(15.54)	H	09(15)	M-79	09(15.58)	IV	12(08)	2
11	18.04.01	18(01)	-106	15(14.06)	P	15(13)	X-144	15(14.06)	IV	na	na
12	28.10.01	28(01)	-142	25(15.26)	H	25(15)	X-13	25(15.05)	IV	na	na
13	31.10.01	31(14)	-104	30(03.30)	P	30(03)	C-60	30(13.50)	IV	31(21)	3
14	05.11.01	05(19)	-297	04(16.35)	H	04(16)	X-10	04(16.12)	IV	na	na
15	17.04.02	17(11)	-149	15(03.50)	H	15(03)	M-12	15(04.32)	IV	18(04)	1
16	01.08.02	01(23)	-105	29(23.30)	P	29(23)	C-42	29(11.00)	IV	01(12)	3
17	02.06.03	02(02)	-85	31(02.30)	H	31(02)	M-93	31(02.18)	IV	na	na
18	16.06.03	16(10)	-136	14(05.30)	P	14(05)	M-15	15(23.45)	IV	na	na
19	28.10.03	28(06)	-384	27(08.30)	P	27(08)	M-27	27(08.19)	IV	na	na
20	20.11.03	20(02)	-461	18(08.05)	H	18(09)	M-45	18(08.11)	IV	20(11)	2
21	22.07.04	22(00)	-106	20(13.31)	H	20(12)	M-86	20(12.26)	IV	22(15)	3
22	07.11.04	07(20)	-376	04(09.54)	H	04(09)	C-63	04(08.49)	IV	08(03)	2

23	07.01.05	07(12)	-94	05(15.30)	H	05(04)	B-82	04(11.03)	IV	na	na
24	16.01.05	16(20)	-117	15(06.30)	H	15(06)	M-86	15(22.33)	IV	na	na
25	21.01.05	21(19)	-103	19(08.29)	H	19(08)	X-13	19(08.12)	IV	na	na
26	15.05.05	15(05)	-293	13(17.12)	H	13(16)	M-80	13(17.03)	IV	15(06)	2
27	20.05.05	20(04)	-101	16(13.50)	P	16(13)	C-12	16(13.50)	IV	20(07)	2
28	29.05.05	29(22)	-150	26(15.06)	H	26(13)	B-75	26(21.44)	IV	na	na
29	10.07.05	10(11)	-100	07(17.06)	H	07(16)	M-49	07(13.10)	IV	na	na
30	17.07.05	17(06)	-77	14(10.54)	H	14(10)	X-12	14(10.23)	IV	na	na
31	24.08.05	24(08)	-219	22(01.31)	H	22(01)	M-26	22(01.00)	IV	na	na
32	11.09.05	11(02)	-127	09(19.48)	H	09(19)	X-62	09(19.48)	IV	na	na
33	14.12.06	14(21)	-143	13(02.54)	H	13(02)	X-34	13(02.47)	IV	14(23)	3

Table-2- Association of Geomagnetic Storms Associated with IV-Radio Bursts with Interplanetary shocks and Interplanetary Magnetic Field for the Period of 1997-2007

Geomagnetic Storms				**Shocks**	**IMF (nT)**		**IMFBz (nT)**	
S. NO.	Date	Onset time in dd(hh)	Magnitude in nT	Start time in dd(hh)	Start time in dd(hh)	Magnitude of maximum IMF in nT	Start time in dd(hh)	Magnitude of maximum IMFBz in nT
1	22.11.97	22(10)	-106	22(09)	21(19)	27.1	22(20)	-12.8
2	07.11.98	07(11)	-139	07(08)	07(19)	35.4	07(22)	-19.7
3	08.11.98	08(20)	-126	08(05)	07(20)	35.4	07(20)	-11.6
4	24.05.00	24(00)	-151	24(17)	23(15)	32.1	23(16)	-24.1
5	08.06.00	08(15)	-89	08(09)	08(05)	24.9	08(13)	-6.9
6	17.09.00	17(20)	-197	17(17)	17(14)	39.5	17(15)	-23
7	10.11.00	10(07)	-102	10(06)	10(05)	17.8	10(08)	-8
8	27.03.01	27(21)	-86	27(01)	27(15)	25.1	27(19)	-8.4
9	31.03.01	31(04)	-379	31(00)	30(21)	47.1	31(03)	-44.7
10	11.04.01	11(15)	-269	11(14)	11(09)	34.5	11(18)	-20.5
11	18.04.01	18(01)	-106	18(00)	17(23)	23.8	17(20)	-19.6
12	28.10.01	28(01)	-142	28(03)	27(22)	19.5	27(22)	-14.5
13	31.10.01	31(14)	-104	31(14)	31(18)	13.9	31(19)	-13
14	05.11.01	05(19)	-297	06(02)	05(12)	65.6	06(18)	-64
15	17.04.02	17(11)	-149	17(11)	17(07)	30.4	17(07)	-18.1
16	01.08.02	01(23)	-105	01(05)	01(01)	14.4	01(02)	-13.2
17	02.06.03	02(02)	-85	na	01(22)	11.4	02(04)	-8.9
18	16.06.03	16(10)	-136	na	15(17)	14.4	16(09)	-9.7
19	28.10.03	28(06)	-384	28(02)	28(01)	19.2	28(01)	-10.2

20	20.11.03	20(02)	-461	20(07)	20(05)	55	20(11)	-50.9
21	22.07.04	22(00)	-106	22(10)	22(14)	18.9	22(19)	-15.5
22	07.11.04	07(20)	-376	07(02)	07(12)	47.8	07(22)	-44.9
23	07.01.05	07(12)	-94	07(09)	07(07)	20.6	07(20)	-18.5
24	16.01.05	16(20)	-117	17(07)	17(07)	35.3	16(08)	-5.1
25	21.01.05	21(19)	-103	21(17)	21(15)	29.5	22(18)	-2.6
26	15.05.05	15(05)	-293	15(02)	15(01)	54.2	15(05)	-38
27	20.05.05	20(04)	-101	20(04)	20(06)	15	20(02)	-9.1
28	29.05.05	29(22)	-150	19(09)	29(01)	19.2	30(05)	-16.1
29	10.07.05	10(11)	-100	10(03)	10(02)	25.2	10(10)	-13.9
30	17.07.05	17(06)	-77	17(01)	17(12)	14.6	17(21)	-8.7
31	24.08.05	24(08)	-219	24(06)	24(04)	52.2	24(05)	-38.3
32	11.09.05	11(02)	-127	11(01)	10(21)	18.2	11(00)	-6.4
33	14.12.06	14(21)	-143	14(14)	14(11)	17.9	14(22)	-14.7

DATA ANALYSIS AND RESULTS

In this study I have observed 33 geomagnetic storms associated with type IV type radio bursts, occurred during the period 1997 to 2007.I have divided observed geomagnetic storms in three categories, geomagnetic storms Dst ≤-75nT >100 nT as moderate, Dst≤-100 nT >200nT as intense and Dst≤-200 nT as severe .It is found that most of most of the type IV associated geomagnetic storms (85.00%) are intense or severe geomagnetic storms .I have 33 geomagnetic storms in list out of which 28 geomagnetic storms have been found to be associated with intense or severe geomagnetic storms .The association rates of moderate, intense and severe geomagnetic storms have been found 15.15%,60.60% and 24.25% respectively. From the data analysis of observed geomagnetic storms associated with type IV radio bursts and coronal mass ejections, all the geomagnetic storms associated with type IV radio bursts have been found to be associated with halo and partial halo coronal mass ejections and majority of them are halo coronal mass ejections. The association rates of halo and partial halo CMEs have been found 27(81.82%) and 06(18.18%) respectively .From the further analysis it is observed that ,CMEs which are associated with geomagnetic storms associated with type IV radio bursts are related with X-ray solar flares of different categories and majority of them are M class solar flares . The association rates of geomagnetic storms associated with type IV radio bursts with different types of flare related CMEs are found 08(24.24)% X class flare related CMEs,15(45.46%) M class flare related CMEs ,08(24.24)% C class flare related CMEs and 02(6.06)% B class flare related CMEs respectively .The data analysis of observed geomagnetic storms associated with type IV radio bursts and magnetic clouds, some of the geomagnetic storms associated with type IV radio bursts have been found to be associated with excellent, good and poor quality magnetic clouds 13 (39.39 %). Majority of the geomagnetic storms associated with type IV radio bursts are found to be related with interplanetary shocks 31 (93.94) .From the data analysis of geomagnetic storms associated with type IV radio bursts and interplanetary magnetic field ,I have found that geomagnetic storms associated with type IV radio bursts are closely related to disturbances in interplanetary magnetic fields and southward component of interplanetary magnetic field. Further to see how the magnitude of geomagnetic storms associated with type IV radio bursts are correlated with the maximum values of Jimf events, a scatter diagram have been plotted between the magnitude of geomagnetic storms associated with type IV radio bursts and maximum value of Jimf events in fig.1.From the fig it is clear that maximum geomagnetic storms associated with type IV radio bursts which have large magnitude are associated with such Jimf events which have relatively large maximum value. I have determined positive co-relation between magnitude of geomagnetic storms associated with type IV radio bursts and maximum value of IMF with correlation coefficient 0.70 .Further to see how the magnitude of geomagnetic storms associated with type IV radio bursts are correlated with maximum value of Jimfbz events, a scatter diagram have been plotted between the magnitude of geomagnetic storms associated with type IV radio bursts and maximum value of Jimfbz events in fig.2. From the fig it is clear that maximum geomagnetic storms associated with type IV radio bursts which have large magnitude are associated with such Jimfbz events which have relatively large maximum values .Positive correlation with correlation coefficient 0.77 have also been found between and magnitude of geomagnetic storms associated with type IV radio bursts and maximum value of southward component (IMF Bz) .

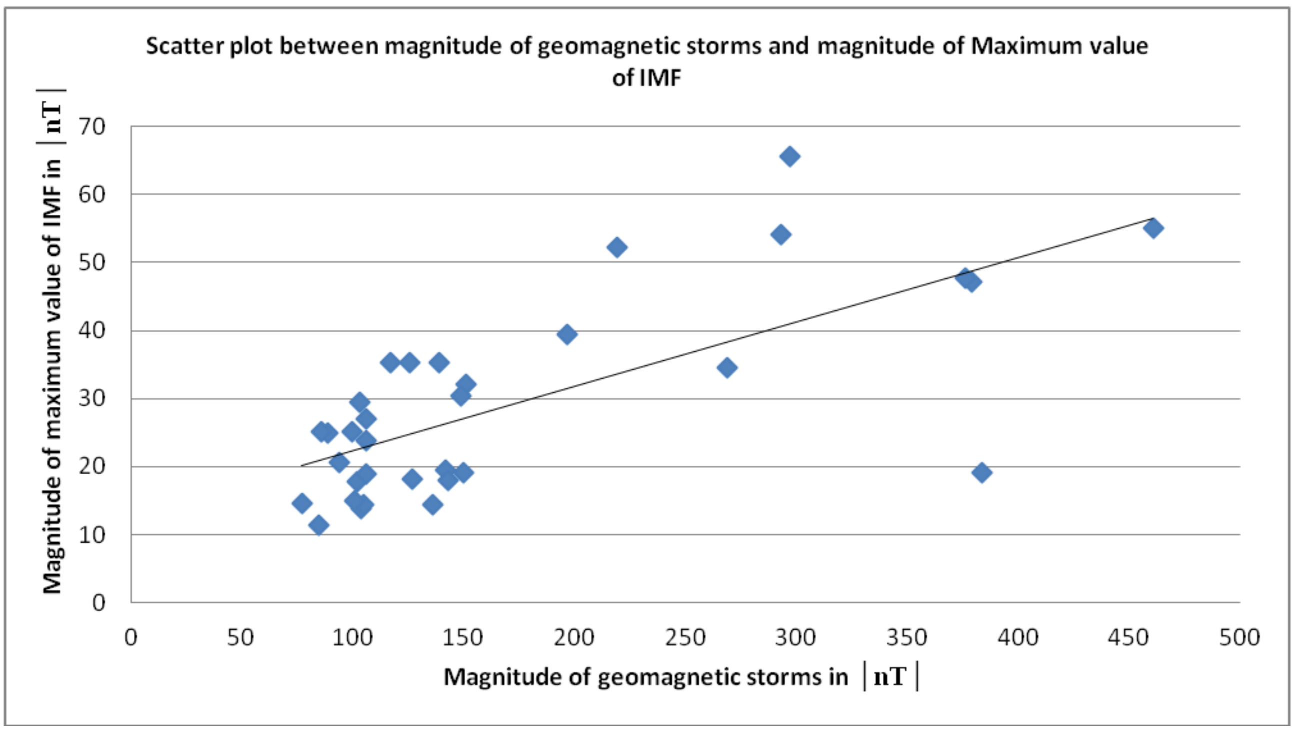

Figure-1 Shows Scatter plot between magnitudes of geomagnetic storms associated with type IV radio bursts and magnitude of maximum value of IMF showing positive correlation with correlation coefficient 0.70.

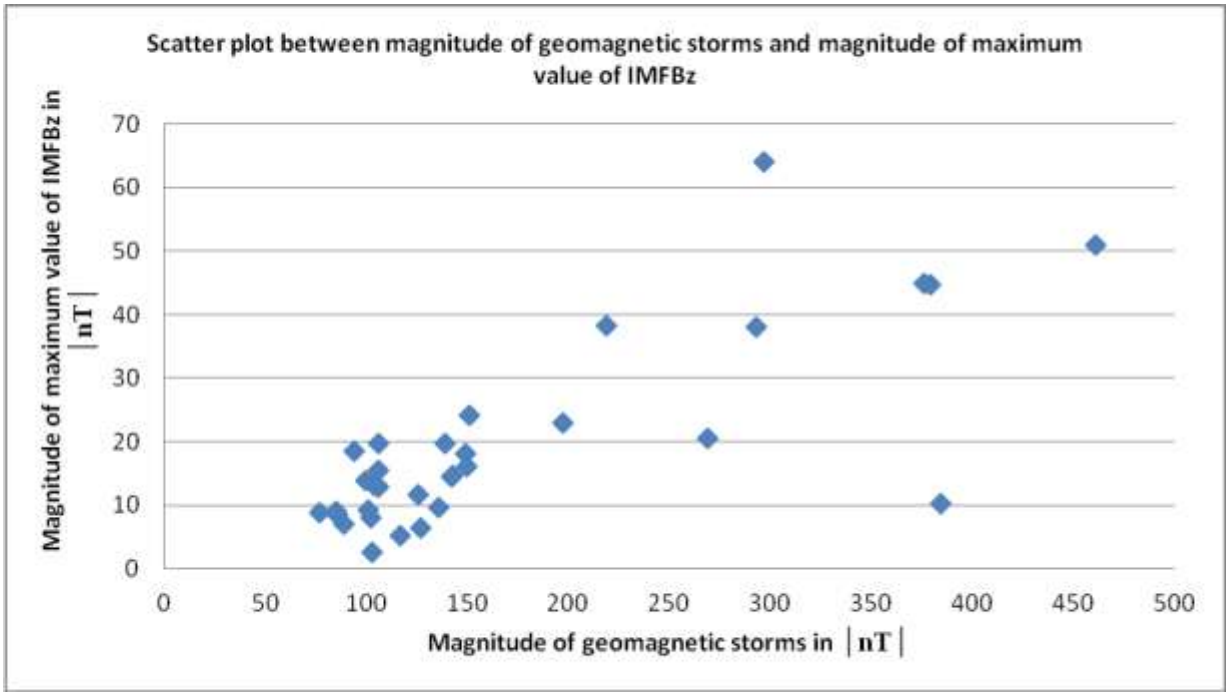

Figure-2 Shows Scatter plot between magnitudes of geomagnetic storms associated with type IV radio bursts and magnitude of maximum value of IMFBz showing positive correlation with correlation coefficient 0.77.

CONCLUSION

From our study, most of the radio bursts related geomagnetic storms have been identified as intense or severe geomagnetic storms and associated with coronal mass ejections (CMEs) related to different types of X ray solar flares. Majority of the geomagnetic storms associated with type IV radio bursts are found to be related with interplanetary shocks and some of them are found to be related with magnetic clouds. Large positive co-relation have been determined between magnitude of geomagnetic storms associated with type IV radio bursts and maximum value of IMF with correlation coefficient 0.70 and magnitude of geomagnetic storms associated with type IV radio bursts and magnitude of maximum value of southward component of IMF Bz with correlation coefficient 0.77.These results shows that geomagnetic storms associated with type IV radio burst are mainly caused by coronal mass ejections related with X- ray solar flares and related with X-ray solar flares and their interplanetary manifestations (interplanetary shocks and magnetic clouds).Further it is concluded that disturbances in interplanetary magnetic fields are closely related to geomagnetic storms associated with type IV radio bursts .

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