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Statistical analysis of the CMEs causing Geomagnetic storms (1996-2003)

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We present here in statistical study of the characteristics of 117 SOHO/LASCO CMEs and its effect on 138 geomagnetic storms from the period 1996-2003. 84.78% GMSs are associated with CMEs. Geomagnetic storm events are characterized by the Disturbance storm time (Dst) index during the periods 1996-2003. A storm is said to be Intense if (Dst <-100 nT), Major if (-50 nT >Dst>-100 nT) and Minor if (-20 nT >Dst>-50 nT). We have examined the important parameters of CMEs such as speed and acceleration.CMEs causing Major GMSs are relatively bigger in size (mean width 116.92^o) with higher speed (mean=578.06 km/s) than those of CMEs causing Intense GMSs (mean width =92.92^o and mean speed 487.95) and Minor GMSs (mean width =63.37^o and mean speed 443.32 km/s) In many individual events the travel time between the explosion on the sun and the maximum activity is lying between 42.12 to 147.05 hours. CMEs causing Intense GMSs have mean acceleration = –2.15 m/s ^{2} which are more effective as compared to Major (mean acceleration= 2.2 m/s ^{2}) and Minor (mean acceleration =0.74 m/s ^{2}). It is observed that CMEs caused major role in creating the Minor geomagnetic storms (66) followed by Major (45) and Intense (27) GMSs.

1. Introduction

The geospace environment is dominated by disturbances created by the Sun, It is observed that CMEs are the key casual link to solar activity that produces GMSs [1] CMEs are large Scale magneto-plasma structures that erupt from the Sun and propagate through the interplanetary medium with speeds ranging from only a few Km S^{-1} to nearly 3000 Km S^{-1} CMEs Carry typically 10^{15} g of coronal material [2] CMEs originate from active regions, filament regions or from complex eg containing filaments and active regions. When CMEs occurs the closed magnetic structures are flown off, which expand into the inner heliosphere following a CME, the coronal near the sun restructures itself, producing post eruption arcades or flare loops.CMEs originating on the visible solar disk are known as Earth directed CMEs. Geomagnetic storms occur when the interplanetary magnetic field associated with CMEs (ICMEs) impinges upon the Earth's magnetosphere and reconnect [4]. There is statistical evidence favouring the association of GMSs with the magnetic clouds produced by coronal mass ejections (CMEs) [5,6]. In this paper, a detailed analysis of GMSs has been presented and attempts have been made to understand the association of GMSs with CMEs.

2. Data Analysis

In the present data analysis, geomagnetic storm events are characterized by the Disturbance storm time (Dst) index measured in terms of nano Tesla (nT) during the periods 1996-2003. A storm is said to be Intense if (Dst<-100 nT), Major if (-50nT>Dst≥-100nT) and Minor if (-20nT≥Dst≥-50nT). Solar geophysical and interplanetary data and SOHO/LASCO CME Catalog are used to study the Manifestations of CMEs causing the GMSs from 1996-2003. The high sensitivity and advanced features of SOHO/LASCO provide a more detailed analysis than the previous instruments [7]. The CME observation rate of SOHO/LASCO is a factor of two more than those of earlier instruments [8]. On the basis of Solar Wind Velocity (V) Solar features have been investigated such that $1 \leq \Delta t \leq 5$ days prior to the occurrence of GMSs on the Earth. Here the time Δt taken by the Solar wind in reaching the Earth from the Sun depend upon V.

3. Results and Discussion

Coronal Mass Ejections (CMEs) are energetically the most important transient phenomenon on the Sun causing geomagnetic disturbances [3,9,10,11,12]. Table1.shows CMEs properties causing geomagnetic storms. The major angular width and the linear speed of the Major GMSs found to be 116.92^0 and 578 km/s which is wider then the 92.92^0 and 487.95 km/s for Intense and 63.37^0 and 443.32 km/s for Minor GMSs. .The maximum intial and final speed from second order fit for Major GMSs is 2510 km/s and 2511 km/s which is also much higher then the 1162 km/s and 1192 km/s for Intense, 1175 km/s and 1183 km/s for Minor GMSs. The tricohotomy suggests that the CMEs associated with Geomagnetic Storms undergo severe changes in their evolution [8]. The mean acceleration of Intense, Major and Minor GMSs found to be –2.15m/s, 2.22 m/s and 0.74m/s. About 50% of the CME associated with Intense GMSs have negative acceleration that is they decelerated in the LASCO C2-C3 field of view.This result is consistent to[13].
The polar angles of CMEs observed from 0^0 to 306^0 for Intense, 14^0 to 347^0 for Major and 94^0 to 356^0 for Minor GMSs that implies that CMEs were observed in all regions but mostly in equatorial regions.This result is similar to[3,8] In many individual events the travel time between the explosion on the Sun and the maximum activity is lying between 42.12 to 112.57 hours for Intense,54.86 to 129.44 hours for Major and 46.18 to 147.05 hours for Minor GMSs..This result is consistent with [14,15]. It is observed that CMEs caused major role in creating the Minor geomagnetic storms (66) followed by Major (45) and Intense (27) GMSs.

4. Conclusions

From the rigorous analysis of data, the following conclusions are drawn:

1. The CMEs causing Major GMSs are relatively bigger in size (mean width =116.92^0) and faster (mean speed=578.06 km/s) than those of CMEs causing Intense and Minor GMSs.
2. In many individual events the travel time between the explosion on the Sun and the maximum activity is lying between 42.12 to 147.05 hours.
3. About 50% of CMEs are associated with Intense GMSs have negative acceleration.
4. CMEs causing GMSs are observed in all regions but mostly in equatorial regions.
5. CMEs causing Major GMSs are more energetic events.
6. It is observed that CMEs caused major role in creating the Minor geomagnetic storms (66) followed by Major (45) and Intense (27) GMSs

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Table 1. CMEs properties causing Geomagnetic storms

STORMS	CMEs PROPERTIES	MAX	MIN	MEAN	MEDIAN	σ
INTENSE	Angular Width	360.00	16.00	92.92	65.50	78.99
	Speed from linear fit (Km /s)	1215.00	27.00	487.95	456.00	301.59
	Intial speed from second order fit(km/s)	1162.00	27.00	487.00	459.50	294.78
	Final speed from second order fit(km/s)	1192.00	0.00	473.58	452.00	314.21
	Acceleration	32.50	-26.00	-2.15	-0.15	11.31
	Polar Angle	306.00	0.00	174.65	201.00	104.77
MAJOR	Angular Width	360.00	11.00	116.92	68.00	124.20
	Speed from linear fit (Km /s)	2519.00	114.00	578.06	412.00	469.25
	Intial speed from second order fit(km/s)	2510.00	82.00	572.89	428.00	442.86
	Final speed from second order fit(km/s)	2511.00	0.00	628.14	542.00	531.94
	Acceleration	44.80	-44.80	2.22	-1.95	20.62
	Polar Angle	347.00	14.00	207.55	257.00	102.75
MINOR	Angular Width	360.00	5.00	63.37	46.00	71.22
	Speed from linear fit (Km /s)	1230.00	66.50	443.32	405.00	241.50
	Intial speed from second order fit(km/s)	1175.00	112.00	476.45	419.00	252.75
	Final speed from second order fit(km/s)	1183.00	0.00	492.60	461.00	340.69
	Acceleration	57.50	-101.60	0.74	0.80	23.60
	Polar Angle	356.00	-94.00	182.40	212.00	107.93