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RESEARCH ARTICLE

INTERPLANETARY PARAMETERS AND THEIR CORRELATION WITH GEOMAGNETIC STORMS

***Gupta C. Rashmi, Suryanshu, C. and Gwal, A. K.**

Centre for Earth & Space Sciences, Department of Physics, AISECT University Raisin, India

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ABSTRACT

It has been established that the main cause of the geomagnetic storm is believed a large Interplanetary Magnetic Field (IMF) structure which has an intense and long duration southward magnetic field component. The previous study suggests that the strength of geomagnetic storm is strongly dependent on the total magnetic field B total. They interact with Earth's magnetic field and facilitate the transport of energy into the Earth's atmosphere by reconnection process. Present paper shows the study of the Interplanetary Magnetic Field (IMF) parameters during geomagnetic storms. We have studied more than 200 geomagnetic storms weighed by disturbance storm time (Dst) <-50 nT, observed during the year of 2007 to 2016.

INTRODUCTION

Space weather and its terrestrial effects is being studied for a long time in space sciences. Parker *et al.,* 1959 showed theoretically that the sun must be emitting material all the time known as 'solar wind'. It is a continuous flow of plasma and it compressed the terrestrial magnetic field and confined it into a magnetosphere. The solar wind could not be normally penetrate into the magnetosphere but on certain occasions specially after solar flares Interplanetary structure with high number density and increased wind speed caused geomagnetic storms but only when the magnetic field structure had southward component antiparallel to geomagnetic field . Burns *et al.* (1995) found that increase in temperature throughout the winter in low-to-mid latitude region during geomagnetic storms. The temperature of Earth is raised by the hot, magnetized, supersonic collision. Plasma carrying a large amount of kinetic and electrical energy. Some of this energy finds its way into our magnetosphere creating turmoil in geomagnetic activity into geomagnetic storms, substorms. It has been investigated the yearly occurrence of geomagnetic storms exactly follows the yearly occurrence of Halo CMEs (Rathor *et al.,* 2011). According to Gonzalez *et al.* (1987) and Vieira *et al.* (2002), the dominant interplanetary phenomenon causing intense magnetic storms are fast CMEs (Coronal Mass Ejection). CMEs are eruption of the solar magnetic field and plasma into interplanetary space, which occur following a large scale magnetic rearrangement in the solar atmosphere Cremades *et al.,* (2006). Magnetic field frozen into plasma coming out from Sun is called Interplanetary Magnetic Field (IMF) in interplanetary medium. The intensity of geomagnetic storm depends upon the orientation of magnetic field in CME. When CME enters into the interplanetary medium it is known as ICME. The increase/decrease in geoeffectiveness of the ICMEs effects through different phases of individual geomagnetic storm, the sunspot cycle and seasons. Geomagnetic storms as seen in Dst, mainly have three phases, a sudden commencement, a main phase, and a recovery phase. Piddington *et al.* (1963) noted that the size of sudden commencements was independent of the main phase minimum. Hirshberg *et al.* (1963) found evidence for ring current enhancement without sudden commencements are not always followed by storms main phases or auroral activity. The 'ring current' circling the Earth and we now know that such a current does exist, carried by the outer radiation belt. In magnetic storms the outer belt comes much more intense, reinforced by protons coming from the tail, as well as by O+ ions from the ionosphere. The prime indicator of a magnetic storm is a southward magnetic field, weakening the northward field usually observed in equatorial regions. The southward field of IMF causes magnetic reconnection of the dayside magnetopause, rapidly injecting energetic particles into the Earth's nightside magnetosphere, which are also subjected to forces due to the magnetic field curvature and gradient as well as gyration effects. For charges of the same sign these forces act in unison, with the net effect of the protons drifting from midnight towards dawn. This oppositely directed drift comprises a ring of current around the Earth (Gonzalez *et al.,* 1994). The initial feature of a geomagnetic disturbance is a sudden increase or depression in the horizontal component of geomagnetic field H.

****Corresponding author:*** **Gupta C. Rashmi,**
Centre for Earth & Space Sciences, Department of Physics, AISECT University Raisin, India.

The z-component of the interplanetary magnetic field (IMF) has been associated with geomagnetic activity (Rostoker and Falthammar, 1967; Russell *et al.,* 1974). Found that the storm main phase was associated with a sustained southward Bz. (Russell *et al*., 1974) found that southward Bz had to exceed an opponent threshold level.

METERIALS AND METHODS

In the present study, minimum value (maximum depression) of the Dst has been considered as storm indicator which are further correlated with the various parameters of solar wind at the time of Dst minimum. The solar wind plasma and field measurements were obtained from the OMNI Website. The number of storms for Dst<or = 50nT have been recorded over the time period 2007 to 2016. The correlation coefficients (r) for all the individual parameters with the Dst (Dst verses Btotal, Dst verses Bz, Dst verses Proton Density, Dst verses Plasma beta, Dst verses Plasma temperature T, Dst verses Plasma speed, Dst verses solar wind velocity V) have been calculated. These values are depicted in figures.

RESULTS AND DISCUSSION

The relationship of Dst index with interplanetary plasma parameters (solar wind parameters) Have been studied and the observations ara as followes- The Fig. 1. Shows the correlation between Btotal and Dst is as strong as (r = -0.5005552017), which implies that the strength of the geomagnetic storm is strongly depends upon the total magnetic field at the instant of Dst minimum. Therefore as stronger the solar wind and interplanetary magnetic field, stronger is the geomagnetic storm. The z-component of IMF (Interplanetary Magnetic Field) will be either southward or northward. The component of IMF denoted by negative sign is the southward polarity. The large negative Bz gives the stronger negative Dst. Therefore the stronger the southward polarity field orientation, the more the depression in geomagnetic disturbance storm time is generally expected.

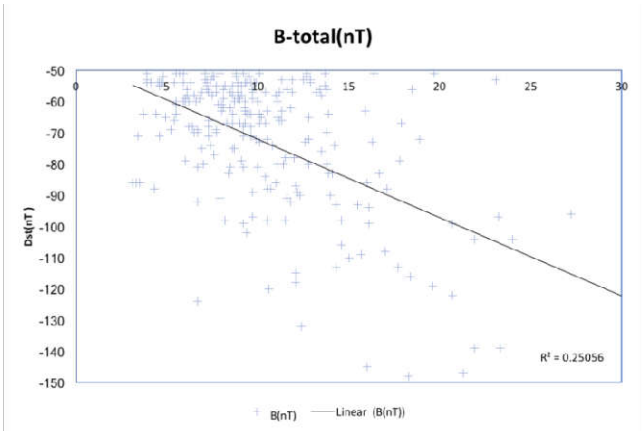

Fig. 1. Dst minimum versus Interplanetary magnetic field Btotal (R= -0.5005552017)

Fig. 2 exhibits Dst and corresponding value of z-component of interplanetary magnetic field Bz at the instant of Dst minimum. When magnetic storms gain its peak value, which is called main phase of the storm. In the figure scattered points are large and large Bz values are associated with wide range of Dst values in figure.

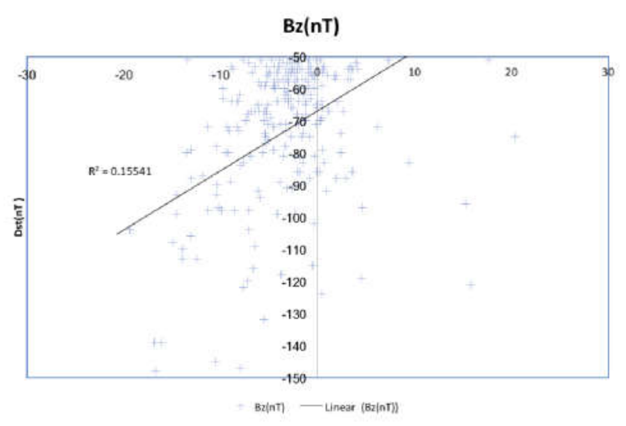

Fig. 2. Dst minimum versus Bz (southward component of IMF) (R = -0.3942216028)

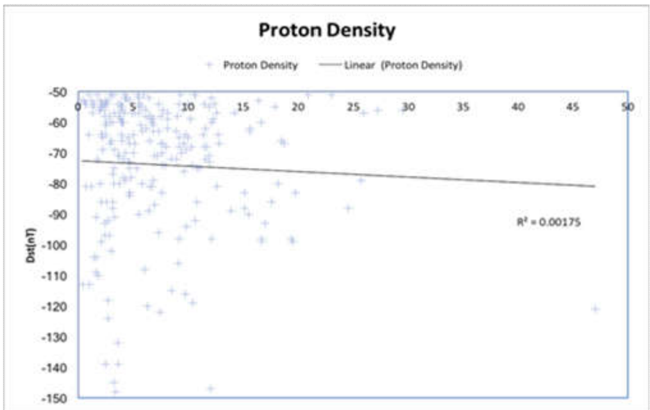

Fig. 3 – Dst minimum versus Proton density (R = -0.0417856)

This indicates either there may be some relationship between Dst and southward direction of Bz or may be some relation between Dst and northward directed Bz. As the value of Bz increases in southward direction, the intensity of geomagnetic storm increase while it decreases as the value of z- component of interplanetary magnetic field increases in northward direction. Fig.3 is a graph between Dst minimum and proton density. Studies shows that strong geomagnetic storms are not necessarily associated with high values of solar wind density or proton density. This means that the intensity of a geomagnetic storm is not determined by the variation of proton density. The weak correlation (-0.0417) between Dst and proton density was expected. As the proton density increases very small increase in the intensity of geomagnetic storm has been observed.

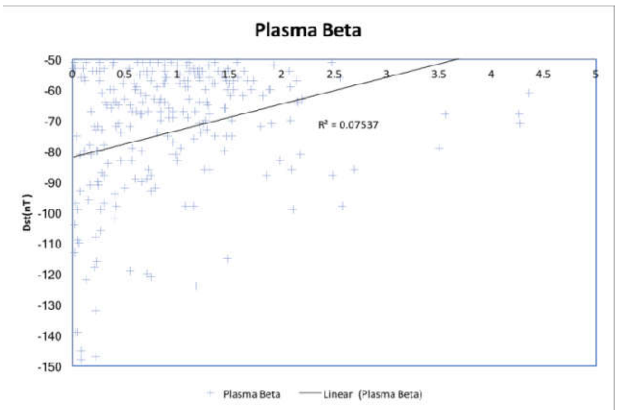

Fig. 4. Dst minimum versus Plasma beta (R = 0.274533)

Fig.4. shows the plasma beta versus Dst. at the instance of Dst. minimum. The plasma beta is defined as the ratio of the plasma pressure to the magnetic pressure. The correlation occurred very low only (0.27) but it is very clear from figure, the Dst. value is high at low plasma beta. It has been observed that the intensity of geomagnetic storm decreases with the increase of plasma beta. Fig. 5 shows the temperature versus the maximum Dst. at the time of Dst. peak. For selected event the value of solar wind temperature has large range but most of event occurred when temperature value less than 4000000 K. Weak correlation (-0.145) found between plasma temperature and Dst. From Fig.5 it is very clear that intense storms produced at low plasma temperature. The result agrees with Rathor, Gupta and Parashar (Verma *et al.,*). The intensity of geomagnetic storm very slowly decreases with the increase of plasma temperature.

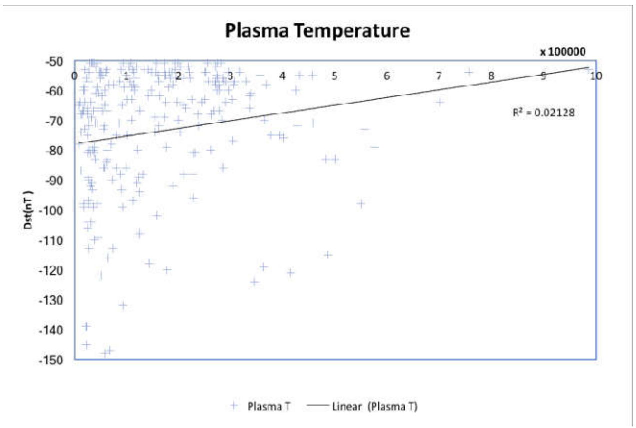

Fig. 5. Dst minimum versus Plasma temperature (R = 0.145873)

Fig.6 is a plot between Dst minimum and plasma speed. We have found the correlation (-0.0617) unexpectedly weak. Very small increase in Dst has been observed with the increase in plasma speed. Rathore, Gupta and Parashar (Verma *et al.,*) found that it remains unaffected with the change in plasma speed Fig. 7.

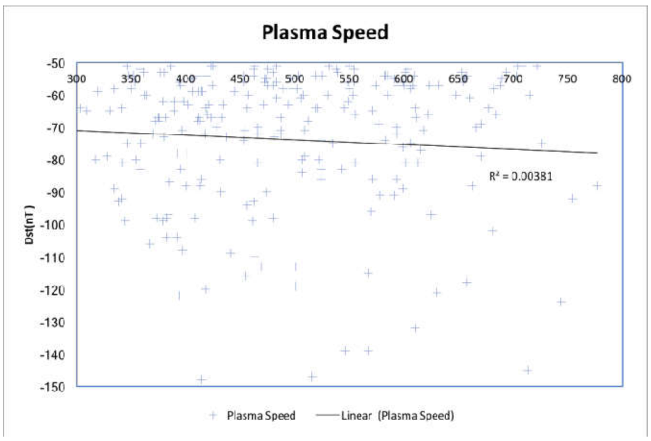

Fig. 6 – Dst minimum versus Plasma speed (R = - 0.061735)

Shows a plot of Dst versus solar wind velocity V. The linear trend indicated by the thick line, represents the regression equation [A linear regression line has an equation of the form Y=a+bX, where X is the explanatory variable and Y is the dependent variable. The slope of the line is 'b' and 'a' is the intercept (the value of Y when X=0).

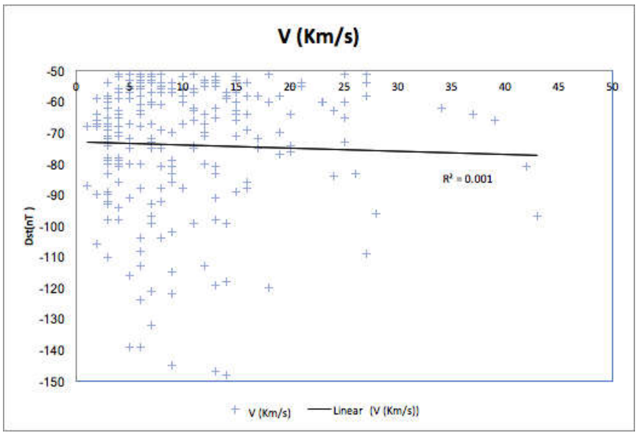

Fig. 7. Dst minimum versus Solar wind speed V (R = -0.031646)

In Fig.7 the correlation for overall storms was (-0.031), which shows the moderate relationship between Dst. and V. This indicates very fair relationship between Dst. and V for intense storm. Kane (Ballatore *et al.,* 2002) Ballatore (Balveer *et al.,* 2004) points out that there is a saturation effect of fast solar wind on geomagnetic storms (Dst not keeping up with larger solar wind speed). Very small increase in the geomagnetic storm has been observed with the increase in solar wind velocity V.

Conclusion

The interplanetary disturbances directed towards the Earth are geo-effective and they give at least a storm sudden commencement (SSC). Previous studies has investigated that the more geoeffective interplanetary parameter is Bz-component of IMF. The strength of geomagnetic storm is strongly dependent on the total magnetic field Btotal, is observed in present study as the correlation coefficient has been found reasonably high (-0.500). According to present study the correlation coefficient between Dst and southward component of magnetic field Bz has been found low (-0.39), while previous studies says that strength of geomagnetic storm is strongly dependent on the southward component Bz. Bz is not essentially peak at the time of Dst peak value. This shows time delay between Bz and Dst peak. This results may be obvious because solar wind southward magnetic field component Bz has significant growth mainly before the main phase of the geomagnetic storm. Thus this study found something special which pulls attention to understand. It has been seen in the study the negative Bz are more effective than positive Bz. Due to positive Bz, geomagnetic storm can occur. The total interplanetary magnetic field is found the most effective parameter for producing the large scale geomagnetic disturbances. The proton density, plasma temperature remains likely to be unaffected due to geomagnetic storm. Plasma beta and solar wind speed V are quite effective in producing large-scale geomagnetic disturbance. However it is clear that present analysis should be considered preliminary, mainly because of the uncertain time delay, which should be investigated in detail for prediction purpose

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